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GEOHERITAGE ASSESSMENT AND SOCIAL MEDIA ENGAGEMENT: A CASE STUDY OF TEN GEOSITES IN THE CILETUH-PALABUHANRATU UNESCO GLOBAL GEOPARK, WEST JAVA, INDONESIA

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Abstract: The Ciletuh-Palabuhanratu UNESCO Global Geopark (CP-UGGp) in West Java, Indonesia, demonstrates the integration of geoheritage conservation and community development, ensuring the sustainable management of geological resources. Despite its recognition as a UNESCO Global Geopark in 2018 and its diverse geological features, the CP-UGGp still needs a well-defined approach to assessing and prioritizing its geosites. This study evaluates ten key geosites using a multi-criteria approach, focusing on scientific value (SV), educational potential (PEV), tourism potential (PTV), and degradation risk (DR). Social media analytics, particularly Instagram metrics, provide insights into public interest, visitation patterns, and user engagement with geosites. The findings present notable variations in the significance and vulnerability of the sites. Sodong Waterfall received the highest score, reflecting its significant educational and tourism potential, whereas Batu Nunggul Beach ranked the lowest. Kunti Island and Karang Daeu Beach are highly significant in geological elements, yet their attractiveness as tourist destinations is relatively limited. Citepus Beach is highly vulnerable to environmental degradation, highlighting the urgent need for conservation. Instagram engagement strongly correlates with site visitation, indicating that social media influences public interest. The geosites need improved accessibility, enriched interpretive resources, and enhanced educator development to support geotourism effectively. Preserving vulnerable sites is vital for sustainable conservation and utilizing social media analytics can improve the strategic management of geosites.

Keywords: Ciletuh-Palabuhanratu UGGp, geoheritage, social media, sustainable geotourism

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INTRODUCTION

Geodiversity refers to the variety of natural geological elements, including rocks, minerals, fossils, landforms, and soils, as well as the dynamic processes that influence their formation (Brilha et al., 2018; Gray, 2008). It forms the basis of landscapes and ecosystems, supporting natural processes and enhancing human well-being. Geoheritage, closely linked to geodiversity, emphasises geological features with notable scientific, educational, cultural, or aesthetic importance (Brocx & Semeniuk, 2007; Reynard & Brilha, 2018). Preserving geoheritage is crucial for advancing scientific research and education, fostering public appreciation of Earth's history, and promoting sustainable development. Geoparks have become a valuable framework for protecting geoheritage while fostering local economic development and encouraging community participation. UNESCO Global Geoparks (UGGp) comprise discrete, unified geographic areas in which internationally significant geological sites and landscapes are managed according to an integrated approach of conservation, education and sustainable development (UNESCO, 2015). Geoparks combine geological heritage conservation with initiatives that support local communities, particularly through geotourism and education (Farsani et al., 2011). In addition, geotourism, a type of sustainable tourism, highlights scenic landscapes and geological features while encouraging the conservation of natural resources. Promoting awareness and appreciation of natural processes supports regional and national economic development (Farsani et al., 2011; Henriques & Brilha, 2017; Kubalíková, 2013; Newsome & Dowling, 2018).

The Ciletuh-Palabuhanratu UNESCO Global Geopark (CP-UGGp) in West Java, Indonesia, is a leading example of geoheritage conservation integrated with community development. The CP-UGGp, designated as a UNESCO Global Geopark in 2018 (Setiawan et al., 2025; Yuniarti et al., 2022), covers an area of around 1,260 km² and is notable for its geological diversity, featuring waterfalls, beaches, and distinctive rock formations. Geographically, the geopark is located

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between coordinates 106°22'10"–106°40'56" E and 6°46'04"–7°25'07" S, situated at the intersection of tectonically active zones, specifically the subduction zone between the Indo-Australian and Eurasian plates, which converge at a rate of approximately 4 mm per year (Ardiansyah et al., 2019; CP-UGGp, 2024; Hamilton, 1979; Ikhram et al., 2025) (Figure 1).

The geopark features 24 geosites, nine biosites, and 11 cultural sites, highlighting its diverse importance (Ardiansyah et al., 2019; Ikhram et al., 2018). A key challenge in geopark management is effectively evaluating and prioritising geoheritage sites. A systematic, multi-criteria framework is crucial for assessing their significance and vulnerability, utilising quantitative methods to evaluate geosites within a geopark (Brilha, 2016). This approach identifies sites of scientific significance and supports a well-balanced conservation strategy that upholds scientific integrity while delivering broader societal benefits (Gordon et al., 2018; Németh et al., 2021).

Figure 1. The map shows the Ciletuh-Palabuhanratu UNESCO Global Geopark in southern West Java, Indonesia. Highlighted in yellow, it lies within Sukabumi Regency, with nearby cities and key landmarks also marked. An inset map indicates its location within Indonesia.

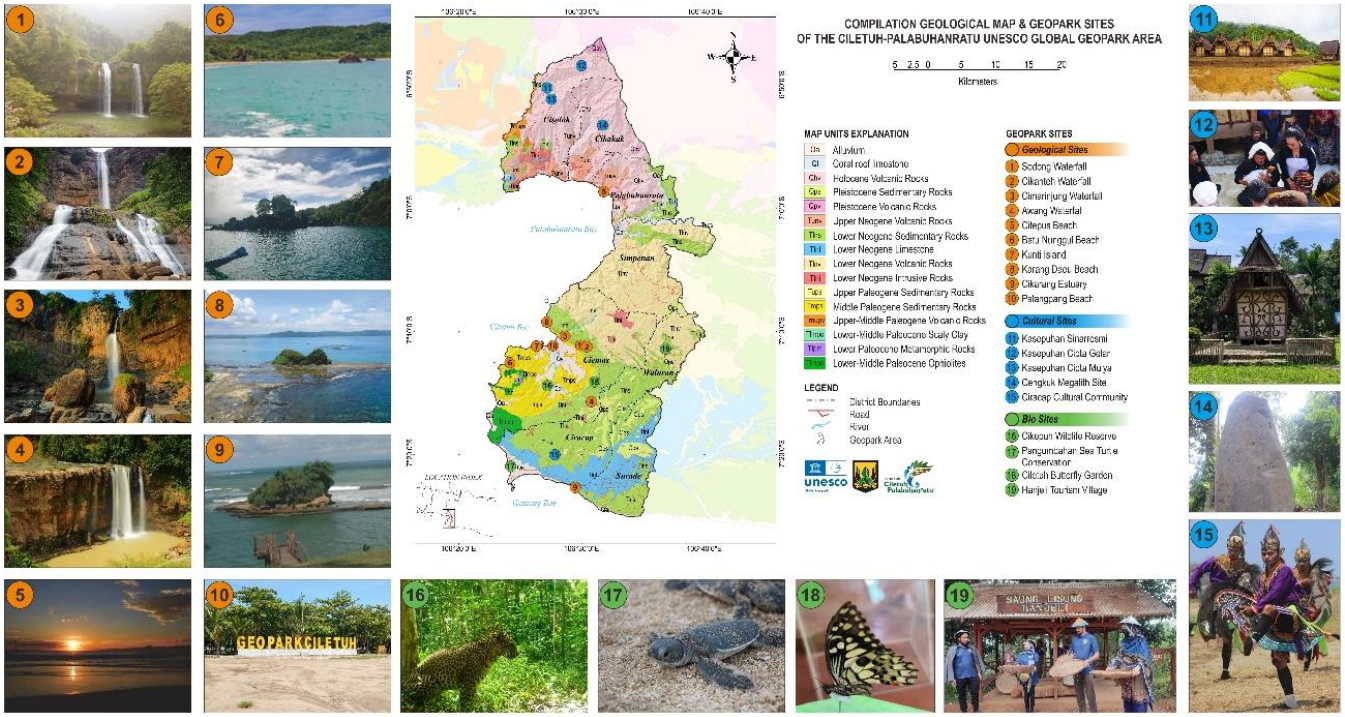

Figure 2. The figure outlines the geological, biological, and cultural features of the Ciletuh-Palabuhanratu UNESCO Global Geopark. Numbered photographs show key geosites and cultural landmarks, and the map is provided by the Geopark Management Board (2022)

In recent years, social media has become crucial for promoting geoheritage and engaging diverse audiences. Platforms like Facebook, Instagram, and YouTube enable geoparks to share information, virtual tours, and educational content globally, fostering awareness, community involvement, and responsible tourism (Fox, Chamberlain, et al., 2022). Additionally, the increasing use of social media as a data source offers new opportunities to analyse visitor engagement with geosites. Social media data, including geotagged text, photographs, and videos, provides cost-effective insights with high spatial and temporal resolution (Gao et al., 2017; Illingworth et al., 2018; Owuor & Hochmair, 2020). Compared to traditional assessment methods such as surveys and interviews, which have long been used to evaluate visitor preferences for geological diversity and activities, social media offers greater flexibility and mitigates spatial and temporal constraints often faced by conventional approaches due to limited resources and time (Greenberg et al., 2005; Reveilhac et al., 2022).

This study investigates the geoheritage of ten geosites within the CP-UGGp, emphasising the challenge of prioritising sites for effective geopark management (Figure 2). It highlights the scientific, educational, and tourism value of the geosites while promoting a conservation strategy that balances scientific integrity with societal benefits. Furthermore, the study incorporates social media insights to examine visitor preferences and behaviours, uncovering interaction patterns based on user characteristics and nature-related content shared online. This approach enhances geotourism and educational initiatives, offering new opportunities to preserve and promote the unique geological heritage of the geopark.

Geological setting

Ciletuh region is one of Java's three oldest rock formations, holding significant geological importance (Ikhram et al., 2025; Satyana, 2014). The mélange complex in this region preserves remnants of a Late Cretaceous to Eocene subduction setting that once spanned western Indonesia, including Sumatra and Kalimantan (Hall, 2002; Hamilton, 1979; Ikhram et al., 2025; Katili, 1973; Satyana, 2014). Comparable geological features appear in Luk Ulo and Jiwo Hills (Ikhram et al., 2025; Satyana & Purwaningsih, 2011). Geological data from Ciletuh offers crucial insights into the geological evolution of Java, particularly in its western region (Hall, 2012). The Ciletuh complex contains diverse rock formations, including ophiolites, metamorphic rocks, mélanges, and olistostrome deposits, underscoring its scientific significance (Ikhram et al., 2025; Satyana et al., 2021; Sukamto, 1975), as shown in Figure 3. Sukamto (1975) identified the oldest rock formation in Ciletuh as an ophiolite basement derived from mantle rock. This formation is part of a mélange bedrock that developed in a deep trench during the subduction of the Indian Oceanic Plate beneath the Eurasian Continental Plate approximately 60 million years ago in the Cretaceous period (Hall, 2012; Hamilton, 1979). The exposed rock formations in Ciletuh are distributed across three sectors: Gunung Badak in the north, a central sector encompassing Tegal Pamidangan, Tegal Cicalung, Tegal Butak, Gunung Beas, and Citisuk River, and Cibuaya in the south. The Cretaceous rocks are grouped into three categories: ophiolite, sedimentary, and metamorphic. The ophiolitic assemblages include peridotite, gabbro, and basaltic pillow lava, while the sedimentary rock consists of greywacke, chert, red shale, and limestone.

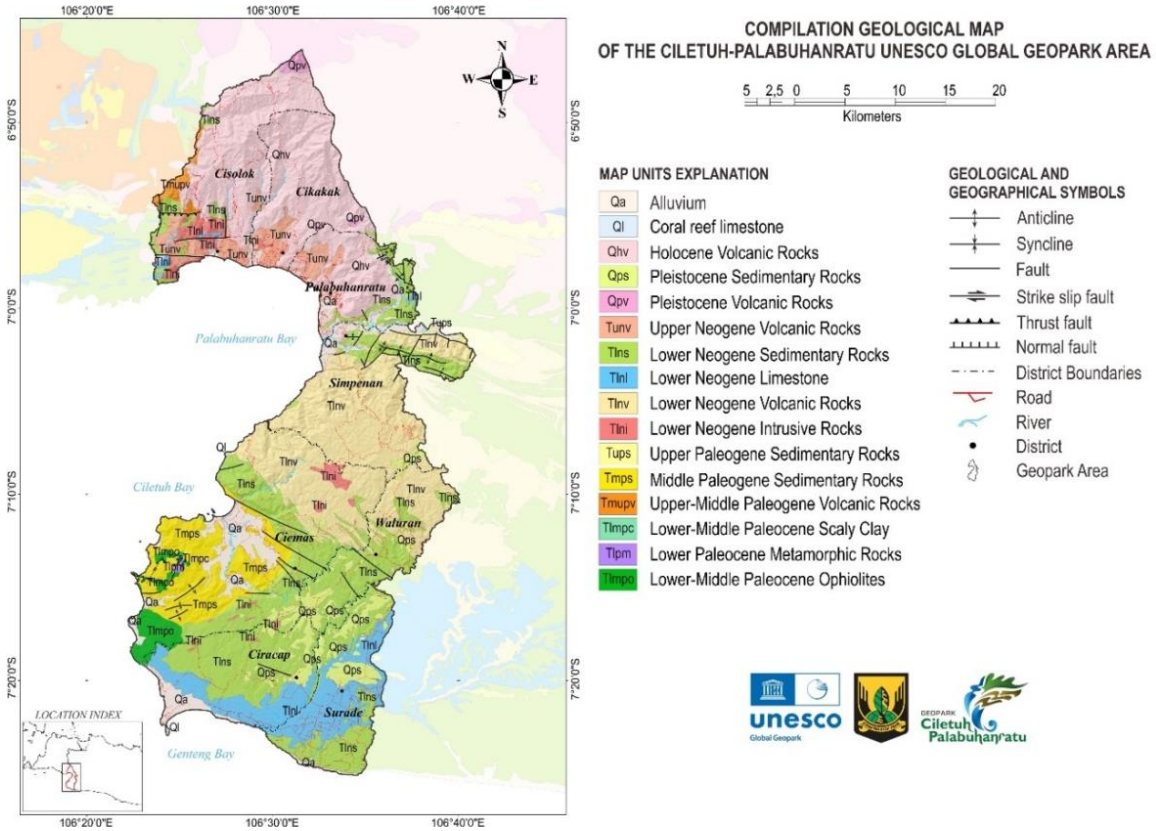

Figure 3. The compilation geological map of the CP-UGGp area shows the main lithological and structural features of the geopark (CP-UGGp, 2024). Paleogene mélange forms the basement, overlain by Neogene and Quaternary volcanic and sedimentary deposits

The metamorphic rocks, part of the Pasir Luhur Formation, comprise serpentinite, phyllite, greenschist, mica schist, and serpentinite (Sudjatmiko, 1972). The tectonic emplacement of rock formations in Ciletuh led to the intricate mixing of materials within a scaly-clay matrix, characteristic of the Pre-Middle Eocene mélange complex (Hall, 2002; Hamilton, 1979; Thayyib et al., 1977). This mélange is overlain by sedimentary formations, including limestone, conglomeratic quartz sandstone, and polymictic breccia, which were deposited in a transition zone between marine and fluvial environments (Satyana, 2014). Sukamto (1975) classified this complex as part of the Ciletuh Formation. The Bayah Formation, composed of Late Eocene sedimentary rocks, also consists of intercalated layers of conglomerates, sandstones, and conglomeratic quartz sandstones (Hall & Morley, 2004). The geological diversity of this region enriches its historical narrative and contributes to a deeper understanding of Java's geological evolution. The Cimandiri Fault separates the Ciletuh and Bayah Formations, with Ciletuh formed in a deep ocean transitional environment and Bayah originating in a shallow water environment (Hall et al., 2007; Haryanto et al., 2017). During the Late Eocene, the subduction zone beneath Java Island shifted southwards, forming submarine volcanoes in southern Java during the Early Miocene. This geological transition marked the emergence of the "old andesite," known as the Jampang Formation in West Java, which is divided into the Upper Jampang and Lower Jampang Series (Clements & Hall, 2007; Sukamto, 1975; van Bemmelen, 1949). The geomorphological landscape of the Jampang Formation features a highland plateau with a horseshoe-shaped western edge, commonly referred to as the amphitheatre. It is considered Indonesia's largest known structure of this type and was formed by a gravity collapse (Ardiansyah et al., 2019; Ikhram et al., 2018). This collapse produced triangular facets and multiple waterfalls along the amphitheatre walls, exposing flat sedimentary layers at sites such as Awang, Cimarinjung, Sodong, and Cikanteh.

Tectonic activity on Java Island, primarily driven by subduction, continuously reshapes the magmatic zone. The magmatic pathway in southern West Java is relatively ancient, as indicated by volcanic deposits from the Jampang Formation (Clements & Hall, 2007; Hall et al., 2007). A gradual northward shift is evident in younger volcanic deposits and the present locations of active volcanoes in the northern region (Rosalia et al., 2022). In the Cisolok area, volcanic lava deposits dominate, forming structures composed of Pleistocene andesite basalt and volcanic breccias. These formations are believed to have originated from Pleistocene volcanic activity (Setijadji et al., 2006). The ongoing volcanic processes in the region are further demonstrated by the presence of hot springs, geysers, and travertine deposits (Mandradewi & Herdianita, 2010).

MATERIALS AND METHODS

This study uses specific criteria, indicators, and quantitative parameters to assess the significance of geological heritage sites within the Ciletuh-Palabuhanratu UNESCO Global Geopark (CP-UGGp). Field observations were conducted to examine the geological, ecological, and cultural attributes of CP-UGGp. The quantitative analysis of geological features within the geopark includes evaluations of Scientific Value (SV), Potential Educational Value (PEV), Potential Tourism Value (PTV), and Degradation Risk (DR). The quantitative analysis of geological features within the geopark includes evaluations of Scientific Value (SV), Potential Educational Value (PEV), Potential Tourism Value (PTV), and Degradation Risk (DR). The specific criteria and indicators used to evaluate SV, PEV, PTV and DR are listed in Table 2 and follow the methodology and formulae proposed by Brilha (2016). Visitor preferences for geological diversity in the Ciletuh-Palabuhanratu UNESCO Global Geopark (CP-UGGp) were analysed using Instagram data, a platform visitors use to share visual and textual content via mobile applications. The study examined the frequency of uploaded photos, reflecting tourist interests and site popularity. Visitor counts were calculated based on observed photo upload patterns, following these criteria: (1) Multiple photos uploaded by the same user on a single day were counted as one upload, whereas posts made by the same user on different days were treated as separate entries. (2) User engagement was assessed by analysing the number of posts uploaded between 1 August 2022 and 30 August 2023. (3) Photos were retrieved using searches for keywords or hashtags such as "Ciletuh". The clarity of photo backgrounds was evaluated based on geological features across ten assessed geosites. Irrelevant content, including advertisements, was excluded from the analysis. Recognising that social media engagement can be disproportionately influenced by a small number of highly active users (Trunfio-Rossi, 2021), the study focused on identifying active users, defined as individuals who uploaded at least one form of media content during the study period.

RESULTS

Quantitative evaluation of geosites

The detailed quantitative assessment of ten geosites within the CP-UGGp, as outlined in Tables 1 and 2, revealed variations in scientific importance, educational value, tourism potential, and vulnerability to degradation across the sites (Figure 4). The data showed that the Scientific Value (SV) assessment of the ten geosites varied significantly, with SV scores ranging from 43.75 to 60. Kunti Island and Karang Daeu Beach recorded the highest SV scores (60), indicating their considerable geological significance. These geosites displayed rare or exceptionally well-preserved features, demonstrating important geological processes, including unique stratigraphic sequences and tectonic features.

Both sites exhibited high scores in representativeness and geological integrity (15 points each). Rarity scores were 7.5 for Kunti Island and 15 for Karang Daeu Beach. However, both sites had lower scores for scientific knowledge (2.5) and key locality (10 and 5, respectively). Kunti Island achieved a geological diversity score of 5. In contrast, Palangpang Beach obtained the lowest SV score (43.75), with reduced values across key indicators, particularly in geological diversity (1.25). The site demonstrated low scores in geological diversity (1.25), representativeness (7.5), and key locality (5). These findings suggested its limited contribution to advancing scientific research. A low geological diversity value indicated that the site contained at least two features related to landform shapes and sedimentological aspects.

Table 1. A Summary of the location, geological features, and assessment results of the assessed geosites. Each site is described by its coordinates, geological features, and scores for Scientific Value (SV), Potential Educational Value (PEV), Potential Tourism Value (PTV), and Degradation Risk (DR), with a total value calculated from these criteria.

No	Geosite	Longitude (E)	Latitude (S)	Geological features	SV	PEV	PTV	DR	Total Value
1	Sodong Waterfall	106°29'52.94"	8°03'35.64"	The waterfall morphology is thought to have formed during the Early Miocene due to a large-scale gravitational collapse of the Jampang Plateau, resulting in an amphitheatre-like landscape. It primarily consists of rock sequences from the Cikarang Member of the Jampang Formation, representing the stratigraphic sequence's lower section. External processes such as weathering and erosion have played a significant role in shaping its geological features.	53.75	91.25	87.5	50	282.5
2	Cikanteh Waterfall	106°30'07.48"	7°11'04.27"	The site shares morphological features with Sodong Waterfall but is likely part of the upper stratigraphic sequence of the Cikarang Member in the Jampang Formation. The waterfall is believed to have developed during the Early Miocene, shaped by the large-scale gravitational collapse of the Jampang Plateau, which created its distinctive amphitheatre-like formation.	56.25	86.25	82.5	46.25	271.25
3	Cimarinjung Waterfall	106°28'24.07"	7°10'13.08"	Like Sodong and Cikanteh Waterfalls, Cimarinjung Waterfall primarily consists of Early Miocene rock sequences from the Cikarang Member of the Jampang Formation. Its geomorphological characteristics are likely shaped not only by the large-scale gravitational collapse of the Jampang Plateau but also by local fault activity. Natural processes like weathering and erosion continue to shape and refine the geological features.	46.25	88.75	87.5	46.25	268.75
4	Awang Waterfall	106°30'37.59"	7°15'34.26"	The site comprises an Early Miocene stratigraphic sequence, specifically part of the Ciseureuh Member within the Jampang Formation. The rock member primarily consists of volcaniclastic deposits. The waterfall morphology is associated with the horseshoe-shaped landscape, influenced by gravitational collapse and tectonic activity.	47.5	78.75	75	43.75	245
5	Citepus Beach	106°31'41.93"	6°58'33.37"	This rocky beach is primarily composed of Eocene sedimentary rocks from the Bayah Formation, consisting of intercalated conglomerate with conglomeratic sandstones, polymictic breccia, and quartz sandstones. The Bayah Formation overlies the Ciletuh Formation, though it is sometimes regarded as the upper part of the Ciletuh Formation, which was deposited in a fluvial environment. The site is covered by recent beach deposits featuring white sand sediments.	50	85	80	63.75	278.75
6	Batu Nunggul Beach	106°23'55.75"	7°12'25.96"	The dynamic interactions between waves, currents, and sediment deposition shape the beach morphology. Additionally, the site features window outcrops of basaltic rocks, which are believed to be part of an ophiolitic sequence.	45	71.25	62.5	33.75	212.5
7	Kunti Island	106°26'04.54"	7°11'03.82"	The site features diverse geological formations and evidence, including various rock types, exotic blocks, fossils, sea caves, and beaches. The rocks primarily consist of a mélange complex composed of polymictic breccias ranging from acidic to ultramafic compositions and from sedimentary to metamorphic origins. The site also contains upper mantle rocks such as peridotite, oceanic crust rocks including gabbro and pillow lava, nummulitic fossils, and deep marine sediments from the Ciletuh Formation.	60	83.75	75	33.75	252.5
8	Karang Daeu Beach	106°26'54.62"	7°09'12.08"	Karang Daeu Island comprises distinctive rock outcrops that resemble a crouching rabbit or a lying poodle. The area primarily comprises the Bouma stratigraphic sequence, which includes thick-bedded sandstone (ranging from 0.6 to 4.0 metres) that varies from medium to very coarse grain size, interstratified with finer sandstone layers. Clay-rich tuffaceous mudstone or marl covers the uppermost section.	60	82.5	77.5	36.25	256.25
9	Cikarang Estuary	106°29'15.67"	7°22'37.39"	This area marks the Cikarang River estuary, the region's second-largest river. At its centre lies a small, exotic, solitary island composed of stratified sandstone from the Cikarang Member of the Jampang Formation.	46.25	86.25	81.25	43.75	257.5

10	Palangpang Beach	106°27'38.03"	7°10'58.12"	The morphology of the beach is shaped by the dynamic interactions between waves, currents, and sediment along the coastline. This site serves as the downstream area for several rivers within the amphitheatre-shaped landscape, where sediment originating from the erosion of various rock types is transported to the coast.	43.75	87.5	85	55	271.25

Table 2. A summary of the quantitative assessment of ten geosites based on Scientific Value (SV), Potential Educational Value (PEV), and Potential Tourism Value (PTV) using the geoheritage assessment method from Brilha (2016). Each category includes several indicators with scores

	Criteria /Indicators	Sodong Waterfall	Cikanteh Waterfall	Cimarinjung Waterfall	Awang Waterfall	Citepus Beach	Batu Nunggul Beach	Kunti Island	Karang Daeu Beach	Cikarang Estuary	Palangpang Beach
SV	Representativeness	15	15	15	7.5	7.5	7.5	15	15	15	7.5
	Key locality	10	10	10	5	5	5	10	5	5	5
	Scientific knowledge	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Integrity	15	15	7.5	15	15	15	15	15	7.5	15
	Geological diversity	2.5	5	2.5	5	2.5	2.5	5	2.5	3.75	1.25
	Rarity	3.75	3.75	3.75	7.5	7.5	7.5	7.5	15	7.5	7.5
	Use limitations	5	5	5	5	10	5	5	5	5	5
	Total value	**53.75**	**56.25**	**46.25**	**47.5**	**50**	**45**	**60**	**60**	**46.25**	**43.75**
PEV	Vulnerability	7.5	7.5	10	10	5	10	10	10	10	7.5
	Accessibility	10	5	7.5	2.5	10	2.5	2.5	2.5	7.5	10
	Use limitations	5	5	5	5	5	5	2.5	2.5	2.5	5
	Safety	7.5	7.5	7.5	5	7.5	5	10	10	10	10
	Logistics	5	5	5	5	5	5	5	5	5	5
	Density of population	3.75	3.75	3.75	3.75	3.75	1.25	2.5	2.5	2.5	3.75
	Association with other values	3.75	3.75	3.75	3.75	5	3.75	3.75	5	5	5
	Scenery	5	5	5	5	5	2.5	3.75	3.75	3.75	5
	Uniqueness	3.75	3.75	3.75	1.25	1.25	1.25	3.75	3.75	2.5	1.25
	Observation conditions	10	10	10	10	10	7.5	10	10	10	10
	Didactic potential	20	20	20	20	20	20	20	20	20	20
	Geological density	10	10	7.5	7.5	7.5	7.5	10	7.5	7.5	5
	Total value	**91.25**	**86.25**	**88.75**	**78.75**	**85**	**71.25**	**83.75**	**82.5**	**86.25**	**87.5**
PTV	Vulnerability	7.5	7.5	10	10	5	10	10	10	10	7.5
	Accessibility	10	5	7.5	2.5	10	2.5	2.5	2.5	7.5	10
	Use limitations	5	5	5	5	5	5	2.5	2.5	2.5	5
	Safety	7.5	7.5	7.5	5	7.5	5	10	10	10	10
	Logistics	5	5	5	5	5	5	5	5	5	5
	Density of population	3.75	3.75	3.75	3.75	3.75	1.25	2.5	2.5	2.5	3.75
	Association with other values	3.75	3.75	3.75	3.75	5	3.75	3.75	5	5	5
	Scenery	15	15	15	15	15	7.5	11.25	11.25	11.25	15
	Uniqueness	7.5	7.5	7.5	2.5	2.5	2.5	7.5	7.5	5	2.5
	Observation conditions	5	5	5	5	5	3.75	5	5	5	5
	Interpretative potential	10	10	10	10	10	10	7.5	10	10	10
	Economic level	2.5	2.5	2.5	2.5	1.25	1.25	2.5	2.5	2.5	2.5
	Proximity of recreational areas	5	5	5	5	5	5	5	3.75	5	3.75
	Total value	**87.5**	**82.5**	**87.5**	**75**	**80**	**62.5**	**75**	**77.5**	**81.25**	**85**
DR	Deterioration of geological elements	17.5	17.5	17.5	17.5	26.25	17.5	17.5	17.5	17.5	17.5
	Proximity to areas	5	5	5	5	5	5	5	5	5	5
	Legal protection	5	5	5	10	10	5	5	5	5	10
	Accessibility	15	11.25	11.25	3.75	15	3.75	3.75	3.75	11.25	15
	Density of population	7.5	7.5	7.5	7.5	7.5	2.5	2.5	5	5	7.5
	Total value	**50**	**46.25**	**46.25**	**43.75**	**63.75**	**33.75**	**33.75**	**36.25**	**43.75**	**55**

Cikanteh and Sodong Waterfalls exhibited high SV scores of 56.25 and 53.75, respectively (Figure 4.a). Citepus Beach (50) and Awang Waterfall (47.5) were also classified in the moderate to high SV category. Cikanteh Waterfall showed high representativeness, integrity, key locality, geological diversity, and rarity scores. Sodong Waterfall had a slightly lower SV score of 53.75 but shared many features with Cikanteh. The site had a geological diversity score of 2.5.

Both sites primarily displayed sedimentological and geomorphological features. Citepus Beach scored 15 for integrity and 7.5 for rarity, with moderate values in representativeness (7.5) and key locality (5). Awang Waterfall had a rarity score of 7.5, while lower scores in scientific knowledge and key locality suggested limited documentation or recognition in geological studies. Among the other sites, Batu Nunggul Beach, Cimarinjung Waterfall, and Cikarang Estuary had SV scores ranging from 43.75 to 46.25. Batu Nunggul Beach scored 45, with integrity (15), representativeness (7.5), and rarity

(7.5) as the main factors. Its scientific knowledge and geological diversity scored 2.5, indicating limited research and geological variation at the site. Cimarinjung Waterfall and Cikarang Estuary received scores of 46.25, demonstrating high representativeness and integrity, along with moderate rarity and geological diversity values.

The evaluation of Potential Educational Value (PEV) across the geosites revealed scores between 71.25 and 91.25, reflecting their capacity to support geoscience education (Figure 4.b). Sodong Waterfall ranked highest, with a score of 91.25. Attaining the highest PEV score, Sodong Waterfall was highly rated in didactic potential (20), observational conditions (10), and geological richness (10). The site's strong accessibility (10), safety (7.5), and logistical support (5) contributed to its suitability for field-based education. Its high scenic value (5) and uniqueness score (3.75) enhanced its interpretive significance. The site contained distinct geological features, including sedimentological and geomorphological aspects, that were readily accessible. Conversely, Awang Waterfall (78.75) and Batu Nunggul Beach (71.25) had the lowest PEV scores. Awang Waterfall rated well in didactic potential and observational conditions but had lower accessibility (2.5) and uniqueness (1.25). Batu Nunggul Beach was primarily influenced by didactic potential (20), observational conditions (7.5), and geological density (7.5), although its uniqueness (1.25) and accessibility (2.5) posed challenges for educational purposes.

Geosites with PEV scores above 86, including Cimarinjung Waterfall (88.75), Palangpang Beach (87.5), Cikanteh Waterfall (86.25), and Cikarang Estuary (86.25), were characterised by well-preserved geological features and accessible pathways, demonstrating significant educational value. Cimarinjung Waterfall, which received a score of 88.75, excelled in didactic potential and observational conditions, supporting the study of stratigraphy, sedimentary structures, and tectonic phenomena. Despite slightly lower ratings in accessibility and geological density (both 7.5), these factors did not significantly reduce its educational value. Similarly, Palangpang Beach (87.5) was valued for accessibility, safety, and educational features. Though its geological density score was modest (5), it remained a safe and convenient site for geoscience education. In addition, Cikarang Estuary demonstrated a safety score of 10 and supported interdisciplinary education, including cultural, ecological, and historical themes.

Geosites such as Citepus Beach, Karang Daeu Beach, and Kunti Island illustrated significant educational value. Citepus Beach, with a PEV score of 85, had high accessibility (10) and safety (7.5). It was associated with additional values (5) due to nearby cultural or environmental features. Despite a low uniqueness score (1.25), the site's practicality and strong interdisciplinary learning capacity enhanced its appeal for education. Karang Daeu Beach (82.5) and Kunti Island (83.75) held educational value despite limited infrastructure and rugged terrain challenges. Their didactic potential and observational conditions made them suitable for advanced students. The geosites maintained consistent scores in key criteria, but accessibility (2.5) and usage limitations (2.5) remained concerns.

Figure 4. Representative geosites of the CP-UGGp: (a) Kunti Island shows varied oceanic and deep-marine lithologies; (b) Sodong Waterfall is an Early Miocene geomorphological feature; (c) Cikanteh Waterfall has a similar amphitheatre geomorphology; (d) Cikarang Estuary contains an isolated sandstone islet. All photos are from the Geopark Management Board

The Potential Tourism Value (PTV) scores indicated promising tourism prospects, with scores varying between 62.5 and 87.5. Sodong and Cimarinjung Waterfalls earned the highest score of 87.5, excelling in accessibility, scenic attractiveness, and interpretative potential. Palangpang Beach is followed by 85, and it was supported by strong values in accessibility (10), safety (10), and scenic aspects (15) (Figure 4.c). On the other hand, Batu Nunggul Beach recorded the lowest score at 62.5 due to lower uniqueness (2.5) and accessibility (2.5). It received scores of 7.5 for scenery, 10 for interpretative potential, and 5 for proximity to recreational areas, while accessibility (2.5) and economic factors (1.25) remained limiting factors. Despite these challenges, the site maintained considerable tourism potential, reinforcing the significance of the geosites. The other geosites demonstrated notable tourism potential based on their PTV scores and distinct characteristics. Cikanteh Waterfall scored 82.5, valued for its scenic (15) and unique (7.5) features. Cikarang Estuary followed with 81.25, standing out in safety (10) while emphasising environmental, cultural, and historical significance. Citepus Beach, with a PTV score of 80, benefited from accessibility (10) and ties to cultural and environmental values. However, its common coastal traits and less distinct geological features contributed to lower uniqueness (2.5). Karang Daeu Beach scored 77.5, offering coastal scenery but facing erosion and tidal constraints. Kunti Island and Awang Waterfall received scores of 75, with Kunti Island recognised for its scenery and safety, while Awang Waterfall was distinguished by its scenic attractiveness despite accessibility challenges.

The Degradation Risk (DR) scores of the examined geosites vary between 33.75 and 63.75, reflecting differences in geological feature degradation, accessibility, legal protection status, proximity to human settlements, and population density (Figure 4.d). Citepus Beach has the highest DR score (63.75), followed by Palangpang Beach (55) and Sodong Waterfall (50), indicating greater vulnerability to environmental impacts. In contrast, Kunti Island and Batu Nunggul Beach have the lowest DR scores (33.75 each), suggesting a relatively well-preserved state. Karang Daeu Beach, with a DR score of 36.25, benefits from restricted access (3.75) and low population density (5.0), helping mitigate degradation risks. Other geosites with moderate DR scores include Cimarinjung Waterfall (46.25), Awang Waterfall (43.75), Cikarang Estuary (43.75), and Cikanteh Waterfall (46.25), all exhibiting mid-range vulnerability due to accessibility and human activity.

Social media data

This study analysed user-generated Instagram content spanning August 2022 to August 2023 to evaluate public engagement with ten geoheritage sites within the study area. Two key metrics were examined: the number of distinct Instagram users and uploaded photographs associated with each site. This approach was used to assess relative popularity and public visibility. Across the sites, 51 distinct Instagram users were identified, presumed to represent visitors, while 59 photographs were uploaded, resulting in averages of 5.1 users and 5.9 photos per site (Figure 5). However, these averages concealed notable disparities in engagement among individual sites.

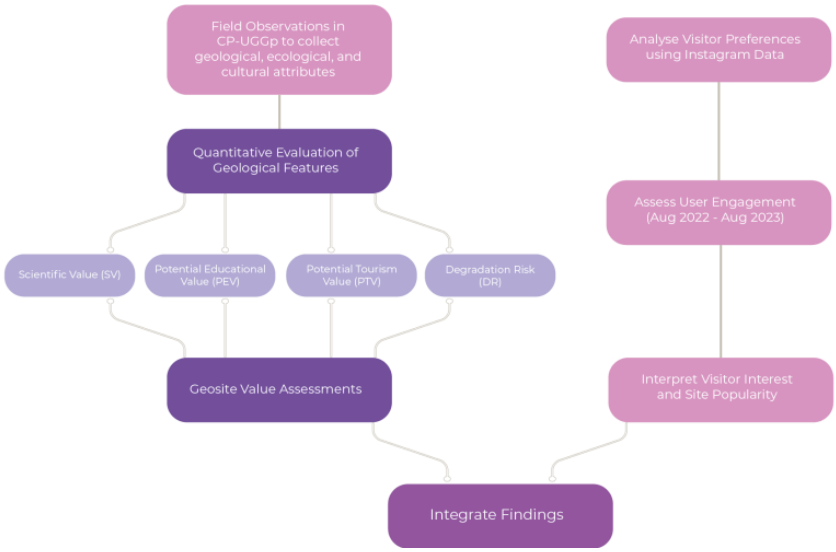

Figure 5. Workflow for integrating geosite evaluation with visitor perception analysis in the Ciletuh-Palabuhanratu UNESCO Global Geopark (CP-UGGp). This workflow combines field-based assessments with social media analytics to evaluate geosites within the CP-UGGp

Cikanteh Waterfall emerged as the most visited and documented geosite, with 15 users and 16 photographs, accounting for nearly 30% of total user engagement and 27% of all photo uploads. Its prominence may have been attributed to its accessibility, aesthetic features, and potential promotion through local tourism initiatives. Cimarinjung Waterfall ranked second, attracting six users and seven photographs, while Sodong Waterfall and Kunti Island also demonstrated relatively high activity, each receiving engagement from 5–6 users and photographs. In comparison, six of the ten geosites, including Awang Waterfall, Citepus Beach, Batu Nunggul Beach, Karang Daeu Beach, and Cikarang Estuary, showed notably lower visitor engagement, with only one or two recorded users and minimal photographic documentation at each location. These geosites collectively represented 15.7% of all Instagram users and 13.6% of uploaded photos. This pattern may have been influenced by limited accessibility, reduced aesthetic or recreational appeal, or insufficient digital visibility.

DISCUSSION

The analysis indicates a moderate level of Scientific Value (SV), while its significant Potential Educational Value (PEV) and Potential Tourism Value (PTV) present valuable opportunities for geotourism and scientific research. The significance of these sites is shaped by geological features, including rock diversity, landforms, and stratigraphic importance, as well as external factors such as accessibility, human activities, and community or institutional engagement. Furthermore, the moderate Degradation Risk (DR) observed across all assessed geosites underscores local vulnerabilities likely caused by human activities, environmental exposure, and inadequate site management (García-Ortiz et al., 2014; Selmi et al., 2022; Vandelli et al., 2024). This finding highlights the need for a conservation strategy that mitigates both site-specific and regional threats while preserving geoheritage and fostering educational and tourism initiatives (Quesada-Valverde & Quesada-Román, 2023; Zafeiropoulos et al., 2021). Geotourism enriches tourism experience by providing unique insights into the Earth's geological history, while also playing a significant role in environmental education, conservation, and community development (Malatyinszki et al., 2025). Moreover, practical preservation efforts require community involvement, regular site monitoring, and adaptive management approaches of these geosites within the geopark framework (Azman et al., 2010; Farsani et al., 2014; Suyanto et al., 2020). While none of the sites face immediate danger, proactive management remains essential to prevent future deterioration and ensure long-term sustainability.

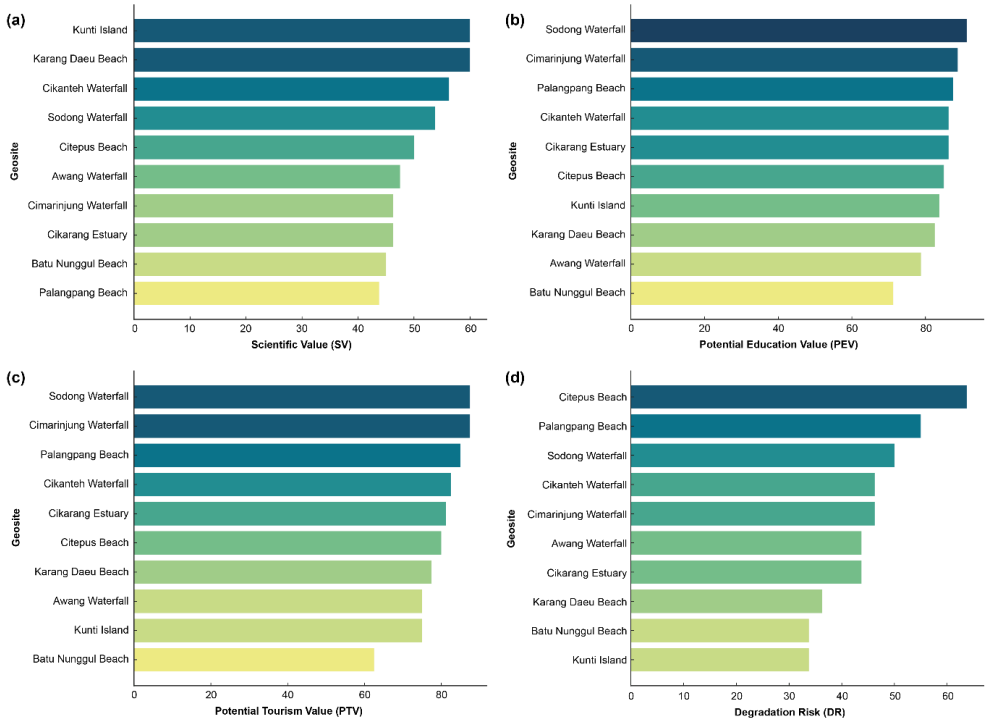

Figure 6. The figure shows a quantitative assessment of ten CP-UGGp geosites. Kunti Island and Cikanteh Waterfall score highest in scientific value, Sodong and Cimarinjung in educational and tourism potential, and Citepus and Palangpang Beaches in degradation risk

Scientific value implications

The variability in Scientific Value (SV) scores highlights differences in the research potential of geosites (Figure 6a). Kunti Island and Karang Daeu Beach exhibit outstanding geological significance due to their high representativeness and integrity, making them particularly valuable for studies in coastal geomorphology, lithostratigraphy, and paleoenvironmental reconstruction. Their well-preserved geological features affirm their importance for scientific research and long-term conservation (Ellis, 2011; Prosser et al., 2011; Wimbledon et al., 2000). In contrast, highly accessible and popular sites such as Palangpang Beach and Cimarinjung Waterfall received lower SV scores, possibly indicating a gap between public attraction and scientific significance (Baczyńska et al., 2018; Tessema et al., 2021). However, additional research may uncover previously unrecognised geological significance. Geosites such as Sodong and Cikanteh Waterfalls, which attained moderately high SV scores, are notable for their strong integrity and representativeness. Alongside Kunti Island and Karang Daeu Beach, these sites exemplify the value of well-preserved geological exposures for regional stratigraphic analysis. Conversely, Cimarinjung Waterfall and Muara Cikarang received lower scores, potentially due to limited prior documentation or insufficient uniqueness. This finding underscores a broader challenge in geosite assessments, where scientific value is often constrained by the absence of prior research (Ruban, 2024). Addressing these gaps could enhance academic recognition and facilitate integration into broader geoheritage frameworks.

The relatively narrow SV scoring range of 16.25 points suggests that geosites generally hold moderate to significant geological importance across diverse environments, including beaches, waterfalls, and estuaries. Batu Nunggul Beach, Cimarinjung Waterfall, and Cikarang Estuary each demonstrate distinct strengths and limitations. While Batu Nunggul features notable geological formations, it lacks substantial geological diversity and adequate scientific documentation.

Similarly, Cimarinjung and Cikarang Estuary exhibit geological significance but lack distinct characteristics necessary for scientific research consideration. Cikanteh and Sodong Waterfalls hold particular scientific importance, especially for educational purposes and public outreach. Cikanteh Waterfall stands out for its exceptional geological diversity and rarity, making it a crucial site for regional stratigraphic study. Sodong Waterfall, although exhibiting slightly less geological diversity, benefits from remarkable clarity and accessibility, enhancing its educational value. In contrast, Citepus Beach and Awang Waterfall show moderate geological integrity and rarity, but their lower representativeness suggests limited significance within the broader regional geological framework (Garcia et al., 2022; Shajahan et al., 2024).

Geosites with significant scientific value, such as Kunti Island and Karang Daeu Beach, should be prioritised for geoconservation and further research. Meanwhile, sites with moderate scientific value are important comparative locations, contributing to broader geological research and educational initiatives (Catana & Brilha, 2020; Németh et al., 2021). The assessment highlights the role of access restrictions in shaping scientific value, as environmental protections can limit research opportunities and dissemination of geoscientific knowledge (Brilha, 2016; Prosser et al., 2018). However, less restricted sites such as Citepus Beach and Batu Nunggul Beach offer practical research and public engagement opportunities. Despite their lower scientific value, specific sites should not be disregarded; targeted research, improved geological interpretation, and infrastructural support could uncover their hidden geoheritage significance.

Potential educational value implications

The consistently high Potential Educational Value (PEV) scores indicate the significant capacity of geosites to support geoscience education in both formal and informal settings (Figure 6.b). Most sites exhibit strong didactic potential and observational conditions, making them well-suited for interpretative activities and hands-on learning. These qualities enable students to explore fundamental geological concepts such as sedimentary processes, volcanic activity, and landform development. However, variations in accessibility and safety have affected overall PEV outcomes, highlighting the need for strategic site management and infrastructure improvements to ensure broader educational access (Azman et al., 2010; Farsani et al., 2014; Stolz & Megerle, 2022). Sodong Waterfall stands out as an exemplary site for field-based learning due to its well-developed logistical support, diverse sedimentological and geomorphological characteristics, and excellent observational conditions. These factors probably make it conducive to structured educational activities ranging from primary school excursions to university fieldwork (Setiawan et al., 2025). Similarly, other highly scored sites, including Cimarinjung Waterfall, Palangpang Beach, Cikanteh Waterfall, and Cikarang Estuary, offer substantial educational benefits owing to their stratigraphic clarity, lithological diversity, and tectonic significance. Cikanteh Waterfall is highly suitable for formal educational activities due to its well-defined geological exposures and convenient accessibility. Meanwhile, Cikarang Estuary is distinctive for its interdisciplinary value, providing opportunities to integrate geoscience with ecological and cultural studies, a growing approach in environmental education (Gordon, 2018; Henriques & Brilha, 2017).

Despite their slightly lower PEV scores, Karang Daeu Beach and Kunti Island hold substantial potential, particularly for advanced geoscientific studies. Due to logistical constraints, these sites are best suited for higher education institutions conducting complex fieldwork. Nevertheless, their strong didactic and observational qualities make them valuable for specialised training and academic research (Quesada-Valverde & Quesada-Román, 2023). Citepus Beach also offers considerable educational value. Though its uniqueness score is relatively low, its accessibility and proximity to cultural landmarks enhance its relevance for curriculum-based learning and community engagement. Its interdisciplinary nature fosters connections between scientific and humanities disciplines, supporting comprehensive educational goals (Kubalíková et al., 2025; Prosser et al., 2011). While scoring lower, Awang Waterfall and Batu Nunggul Beach still provide meaningful educational opportunities. Their well-preserved geological formations offer strong potential for guided interpretation and outdoor learning despite accessibility and uniqueness limitations.

Enhancing geoeducation at these sites through improved signage, designated trails, and structured educational programs would significantly increase their instructional value (Ren et al., 2013; Stolz & Megerle, 2022). A survey by Setiawan et al. (2025) in CP-UGGp underscores that geoeducation remains an underdeveloped aspect of geopark management. Despite familiarity with geotourism and geopark concepts, students often lack a more profound understanding due to insufficient integration of geoheritage in education. Addressing this issue requires enhancements in curricula, incorporation of field-based learning, comprehensive teacher training, accessibility to educational materials, and stronger collaboration between geoparks, schools, and local communities (Setiawan et al., 2025).

Potential tourism value implications

The PTV evaluation highlights the strong suitability of geosites for sustainable tourism. Sodong Waterfall, Cimarinjung Waterfall, and Palangpang Beach are top-rated sites due to their captivating landscapes, recreational opportunities, and accessibility (Figure 6.c). Their high PTV scores indicate that they function as geotourism attractions and valuable educational resources, necessitating responsible management to prevent the overuse and degradation of fragile geological features (Gordon et al., 2018). Sustainable geotourism strategies, including visitor zoning, eco-friendly infrastructure, and community-led conservation, are essential to mitigate these risks (Farsani et al., 2011; Frey, 2021).

The strong correlation between high PTV and PEV scores suggests that the assessed geosites can significantly enhance public awareness of geoheritage while fostering local economic growth through sustainable tourism practices (Dowling & Newsome, 2017; Suzuki & Takagi, 2018). Cimarinjung and Sodong Waterfalls exemplify the correlation by combining geological significance with educational accessibility, making them ideal for guided tours that integrate scenic appreciation

with geoscientific learning. Similarly, Cikanteh Waterfall and Cikarang Estuary offer multi-dimensional value by integrating geological, historical, and cultural elements, appealing to diverse tourist groups, and advancing multidisciplinary geotourism development (Gordon, 2018). Coastal sites such as Karang Daeu and Citepus Beaches feature aesthetic landscapes and urban accessibility but face environmental deterioration and geomorphological similarity challenges. Citepus Beach presents cultural tourism opportunities, while Palangpang Beach provides a balanced mix of accessibility and safety, though its uniqueness remains moderate. In contrast, Karang Daeu Beach and Kunti Island may benefit from strategic improvements, such as enhanced transportation infrastructure and better environmental risk management, to optimise their tourism potential (Stolz & Megerle, 2022). Despite notable tourism advantages, disparities persist regarding accessibility, distinctiveness, and economic infrastructure.

Sites with lower PTV scores, such as Awang Waterfall and Kunti Island, retain aesthetic and interpretative value but face logistical and economic constraints. Batu Nunggul Beach, with the lowest PTV score, highlights the challenges of isolation and inadequate infrastructure despite its geoscientific significance. Strengthening the tourism potential of these sites through targeted marketing, informative signage, and enhanced support facilities could improve their viability. Sustainable tourism in geoparks involves a delicate balance of conservation, community engagement, and economic development. The CP-UGGp represent the tourism potential, yet its success depends on effective stakeholder coordination, local community empowerment, and diversified, sustainable livelihoods to address existing challenges (Zuvara et al., 2022).

Degradation risk implications

The Degradation Risk scores unveil varying vulnerability levels among the evaluated geosites (Figure 6d). Based on Brilha's (2016) classification, all sites are classified as Moderate Degradation Risk, with scores ranging from 212.50 to 282.5, indicating no severe or irreversible degradation. Coastal sites, such as Citepus Beach and Palangpang Beach, consistently exhibit higher DR scores due to increased visitor accessibility and the dynamic nature of coastal environments. Citepus Beach, with the highest DR score is particularly vulnerable to intense tourist activity, insufficient legal protection, and coastal erosion. Global trends indicate that heavily visited coastal geosites deteriorate rapidly without effective management strategies (Dowling & Newsome, 2017; Selmi et al., 2022). Conversely, isolated geosites, such as Kunti Island and Karang Daeu Beach, demonstrate lower DR scores, with restricted accessibility serving as an unintended conservation buffer. However, despite their isolation, proactive conservation measures are necessary to secure long-term protection (Gordon, 2018; Prosser et al., 2018).

Some geosites with high SV and PEV scores, such as Sodong and Cikanteh Waterfalls, exhibit only moderate DR scores, emphasising the challenge of balancing geoheritage promotion with conservation needs (Fauzi & Misni, 2016). Sodong Waterfall's popularity and accessibility heighten its susceptibility to environmental degradation, especially without comprehensive conservation frameworks. Implementing visitor management strategies, such as zoning, monitoring, and infrastructure upgrades, could help mitigate these risks (Prosser et al., 2018; Selmi et al., 2022). The interplay between tourism and conservation highlights the necessity of integrating protective measures into geosite promotion, ensuring that educational and recreational use does not compromise geological integrity. Legal protection within CP-UGGp is crucial for geosite conservation; however, its effectiveness hinges on consistent monitoring, enforcement, and the integration of legal certainty, community participation, and sustainable development (Herlinawati et al., 2025; Siregar, 2019).

Despite regulatory protections, Palangpang Beach probably still faces moderate degradation risks, reinforcing broader conservation research findings highlighting the importance of management interventions alongside legal frameworks. Other geosites, including Cimarinjung Waterfall, Cikanteh Waterfall, Awang Waterfall, and Cikarang Estuary, typically experience intermediate accessibility and human activity, leading to degradation through trampling, littering, and informal trail formation. The proposed measures include establishing controlled access pathways, implementing interpretative signage, and conducting environmental monitoring to ensure sustainable site management and mitigate these risks (Gordon et al., 2018). Strengthening conservation policies and site-specific management strategies will be critical in sustaining the geoheritage value of these locations while supporting their educational and geotourism potential.

Comparative analysis

The comparative evaluation of geosites reveals substantial differences in scientific significance, educational and tourism potential, and vulnerability to degradation, which collectively influence their total value scores. Among the assessed geosites, Sodong Waterfall recorded the highest total value score, followed by Citepus Beach and Cikanteh Waterfall, reflecting a well-balanced opportunity for scientific research, educational use, and tourism development. In contrast, Batu Nunggul Beach had the lowest total value score due to its limited educational and tourism potential and higher degradation risk. While this comparative analysis provides valuable insights, incorporating stakeholder perspectives and visitor feedback in future research would enhance the overall findings and support more effective site conservation.

Preliminary analysis indicates that high scientific value (SV) geosites do not necessarily exhibit equally high potential educational value (PEV) or potential tourism value (PTV) scores (Figure 7a and 7b). For instance, Kunti Island and Karang Daeu Beach have the highest SV scores, yet their PEV and PTV scores are not the highest recorded. Conversely, Sodong Waterfall, despite having a moderate scientific value, attains the highest PEV and ranks among the highest in PTV, illustrating that educational and tourism values are shaped by additional factors such as accessibility, infrastructure, interpretive resources, and visual attractiveness (Dowling & Newsome, 2017; Farsani et al., 2011). Previous research suggests that geosites with high scientific value are not always the most visited, as tourists often prioritise visual attractiveness and recreational experiences over geological significance (Pál & Albert, 2021; Shajahan et al., 2024).

Educational value (PEV) represents the potential of a geosite to serve as a learning resource for diverse audiences. Data indicate that certain waterfalls and beaches achieve high PEV scores, often surpassing their SV, reinforcing that sites with dynamic geomorphological processes and visually striking features are effective for educational programs. Enhancing educational value through interpretive panels, guided tours, and educational materials helps convey geological significance to broader audiences (Stolz & Megerle, 2022). Similarly, tourism value (PTV) is influenced by visual attractiveness, accessibility, and visitor services, with Sodong and Cimarinjung Waterfalls achieving high PTV scores despite not ranking among the highest in SV. The variations observed between SV, PEV, and PTV underscore the multi-dimensional nature of geosite valuation. Sites with high SV may require targeted investment to enhance their educational and tourism infrastructure, increasing their societal impact (Dowling & Newsome, 2017; Prosser et al., 2011).

Conversely, geosites with high PEV and PTV but moderate SV should be carefully managed to prevent excessive visitation from compromising their integrity through physical deterioration or geodiversity loss (Dowling & Newsome, 2017; García-Ortiz et al., 2014). Integrated management strategies that balance scientific, educational, and tourism values are essential for ensuring geosite sustainability while promoting public engagement.

The comparative analysis highlights the need to balance tourism growth with environmental risks, as high-PTV sites such as Sodong Waterfall and Palangpang Beach face greater degradation (Figure 7.c). Coastal and waterfall geosites often experience significant pressure due to intensive recreational activities, necessitating proactive management approaches. The correlation between PTV and degradation risk (DR) underscores the importance of visitor education, infrastructure improvements, and carrying capacity assessments. Moreover, ongoing DR monitoring and the effectiveness of the management strategies will support responsible geotourism while safeguarding geodiversity.

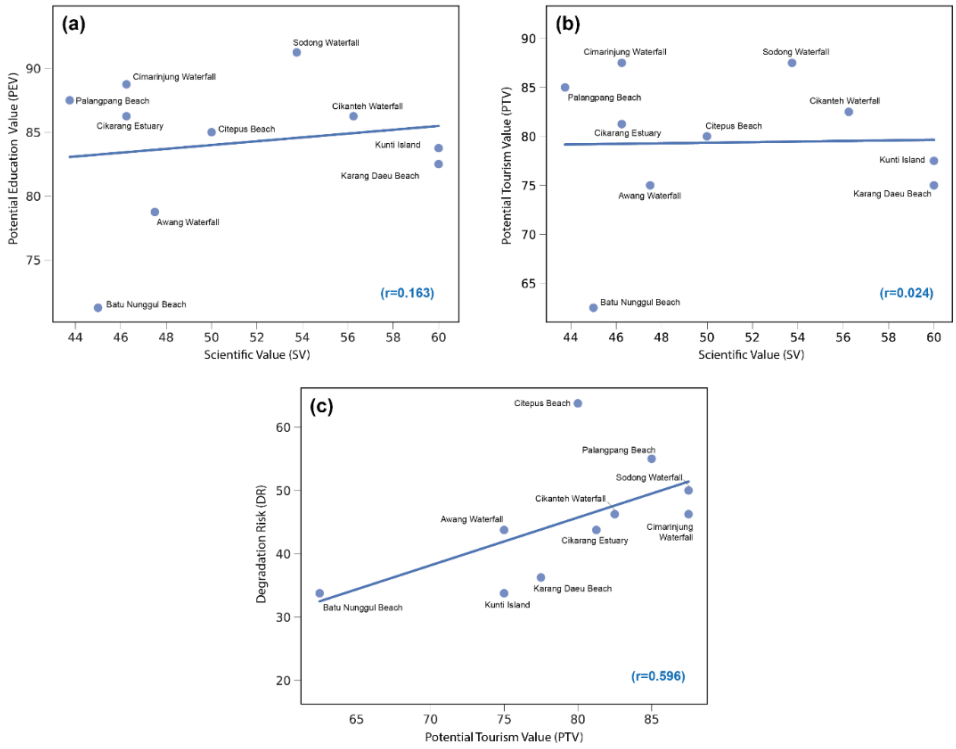

Figure 7. The figure shows that at CP-UGGp geosites, scientific and educational value are weakly linked, scientific and tourism value show little correlation, and tourism value moderately relates to degradation risk

Social media engagement of geosites

The number of inbound tourists serves as a useful indicator for assessing the competitiveness of regional tourism, with social media constituting one of the relevant data sources for such analysis (Wibowo et al., 2021). Examining user-generated Instagram content provides valuable insights into innovative approaches for communicating, promoting, and preserving geoheritage (Fox, Chamberlain, et al., 2022; Lanara et al., 2023). One notable finding is the prominence of Cikanteh Waterfall, likely influenced by its ease of access, striking visual attractiveness, and support from local tourism efforts and social media exposure (Figure 8). The engagement observed at Cimarinjung and Sodong Waterfalls further highlights the appeal of geomorphological and hydrological features within the geotourism landscape (Figure 8). The noticeable tendency for waterfalls to attract disproportionate attention aligns with broader research indicating that visually immersive environments are particularly effective for social media engagement and digital storytelling (Fox, Graham, et al., 2022).

Although the beach and estuarine sites hold significant scientific and ecological value, they receive relatively low social media engagement, representing challenges for geoheritage appreciation and geoconservation. This lack of representation could be attributed to restricted physical access, diminished recreational or striking visual attractiveness, and inadequate digital promotion (Henriques et al., 2019; Migoń & Pijet-Migoń, 2024). The findings indicate that strengthening

interpretive infrastructure, enhancing site accessibility, and utilising digital marketing strategies could help raise the visibility of these underappreciated sites (Dowling & Newsome, 2017).

A positive correlation exists between Instagram user activity and the number of uploaded photographs, supporting research suggesting social media is an indirect yet reliable indicator of site popularity and visitation intensity (Ghermandi, 2016; Richards & Friess, 2015). While these metrics do not fully capture qualitative visitor experiences or geosite significance, they provide a scalable, real-time method for monitoring public interest and engagement patterns (Hausmann et al., 2018). Furthermore, the dominance of waterfalls in user-generated content highlights the influence of landscape aesthetics and the performative nature of social media, where users prioritise capturing and sharing visually striking experiences (Munar & Jacobsen, 2014). In addition, engagement differences among the ten sites indicate the intricate interplay between physical accessibility, landscape attractiveness, and digital presence in driving geotourism trends.

From a managerial perspective, these findings significantly affect geotourism planning, conservation strategies, and community engagement. Social media data can help identify frequently visited sites that face overuse risks and underappreciated locations that may benefit from improved interpretation and targeted promotional efforts (Lanara et al., 2023; Zeng & Gerritsen, 2014). This approach aligns with participatory, data-driven heritage management, where digital footprints guide adaptive planning and inclusive management (Farsani et al., 2014). However, relying exclusively on social media data presents limitations, as platform biases may exclude certain demographic groups or types of engagement (Hausmann et al., 2018; Heikinheimo et al., 2017). Future research should integrate digital insights with conventional survey methods to develop a more comprehensive understanding of public interaction with geoheritage landscapes.

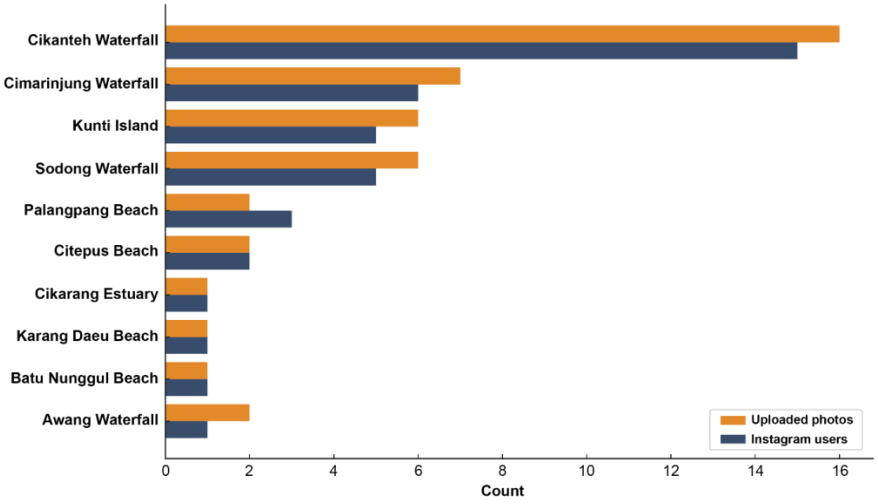

Figure 8. The chart shows Instagram activity at CP-UGGp geosites (Aug 2022–Aug 2023).
Cikanteh Waterfall is most popular, while Batu Nunggul Beach and Cikarang Estuary have the least engagement

CONCLUSION

The geosites within the Ciletuh-Palabuhanratu UNESCO Global Geopark (CP-UGGp) exhibit substantial potential for scientific research, geoeducation, and sustainable geotourism. While their scientific value varies, their consistently strong educational and tourism appeal highlights opportunities for integrated development benefiting local communities and geoheritage conservation. Further research is particularly pressing for sites with underexplored geological significance, while enhancements in accessibility, safety, and interpretive infrastructure are essential to maximizing their educational impact.

The tourism potential of the CP-UGGp is particularly robust at visually striking and accessible sites, such as waterfalls and beaches, though this also correlates with increased risks of degradation. The moderate degradation risk observed across all sites underscores the urgency of site-specific management strategies that balance visitor engagement with conservation. Legal protection, regular monitoring, and community participation are critical to safeguarding these geosites and ensuring their long-term sustainability. Social media analytics have provided valuable insights into public engagement and site popularity, revealing opportunities and challenges in digital geoheritage promotion. While visually prominent sites attract significant attention, less accessible or understated locations remain underrepresented, necessitating targeted outreach and improved digital visibility. Overall, a holistic approach to geosite management that integrates scientific, educational, and tourism objectives supported by stakeholder collaboration, enhanced interpretive resources, and adaptive management practices will ensure CP-UGGp serves as a model for sustainable geoheritage preservation.

Despite its comprehensive scope, this assessment has several limitations. lessaluation of scientific, educational, and tourism values was constrained by the availability of geological documentation, potentially underestimating the significance of lesser studied geosites. In addition, degradation risk assessments, based on observable indicators rather than long-term monitoring, may lack precision. Social media analytics, though useful, favour visually appealing and accessible sites, overlooking scientifically valuable but less-visited locations. The reliance on short-term social media data further limits a holistic understanding of visitor preferences. Future research should address these gaps through detailed geological surveys, continuous monitoring, and mixed methods approaches to enhance documentation, conservation strategies, and engagement.

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REFERENCES

Ardiansyah, N., Nugraha, K. S. A., & Ikhram, R. (2019). Geodiversity of Ciletuh-Palabuhanratu UNESCO Global Geopark, Sukabumi, West Java. *Berita Sedimentologi*, *44*(1). https://journal.iagi.or.id/index.php/FOSI/article/view/66

Azman, N., Halim, S. A., Liu, O. P., Saidin, S., & Komoo, I. (2010). Public Education in Heritage Conservation for Geopark Community. *Procedia - Social and Behavioral Sciences*, *7*, 504-511. https://doi.org/10.1016/j.sbspro.2010.10.068

Baczyńska, E., Lorenc, M. W., & Kaźmierczak, U. (2018). The Landscape Attractiveness of Abandoned Quarries. *Geoheritage*, *10*(2), 271-285. https://doi.org/10.1007/s12371-017-0231-6

Brilha, J. (2016). Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a Review. *Geoheritage*, *8*(2), 119-134. https://doi.org/10.1007/s12371-014-0139-3

Brilha, J., Gray, M., Pereira, D. I., & Pereira, P. (2018). Geodiversity: An integrative review as a contribution to the sustainable management of the whole of nature. *Environmental Science & Policy*, *86*, 19-28. https://doi.org/10.1016/j.envsci.2018.05.001

Brocx, M., & Semeniuk, V. (2007). Geoheritage and geoconservation - History, definition, scope and scale. *Journal of the Royal Society of Western Australia*, *90*(2), 53-87.

Catana, M. M., & Brilha, J. B. (2020). The Role of UNESCO Global Geoparks in Promoting Geosciences Education for Sustainability. *Geoheritage*, *12*(1), 1. https://doi.org/10.1007/s12371-020-00440-z

Clements, B., & Hall, R. (2007). Cretaceous to Late Miocene stratigraphic and tectonic evolution of West Java. Indonesian Petroleum Association 31st Annual Convention and Exhibition 2014,

CP-UGGp, M. B. O. (2024). *One page Summary Ciletuh-Palabuhanratu UNESCO Global Geopark*. Ciletuh-Palabuhanratu UNESCO Global Geopark.

Dowling, R. K., & Newsome, D. (2017). Geotourism Destinations – Visitor Impacts and Site Management Considerations. *Czech Journal of Tourism*, *6*(2), 111-129. https://doi.org/10.1515/cjot-2017-0006

Ellis, N. (2011). The Geological Conservation Review (GCR) in Great Britain—Rationale and methods. *Proceedings of the Geologists' Association*, *122*(3), 353-362. https://doi.org/10.1016/j.pgeola.2011.03.008

Farsani, N. T., Coelho, C., Costa, C., & de Carvalho, C. N. (2011). *Geoparks and geotourism: New approaches to sustainability for the 21st century*. BrownWalker Press.

Farsani, N. T., Coelho, C. O. A., Costa, C. M. M., & Amrikazemi, A. (2014). Geo-knowledge Management and Geoconservation via Geoparks and Geotourism. *Geoheritage*, *6*(3), 185-192. https://doi.org/10.1007/s12371-014-0099-7

Fauzi, N. S. M., & Misni, A. (2016). Geoheritage Conservation: Indicators Affecting the Condition and Sustainability of Geopark – A Conceptual Review. *Procedia - Social and Behavioral Sciences*, *222*, 676-684. https://doi.org/10.1016/j.sbspro.2016.05.224

Fox, N., Chamberlain, B., Lindquist, M., & Van Berkel, D. (2022). Understanding Landscape Aesthetics Using a Novel Viewshed Assessment of Social Media Locations Within the Troodos UNESCO Global Geopark, Cyprus [Original Research]. *Frontiers in Environmental Science*, *10 - 2022*. https://doi.org/10.3389/fenvs.2022.884115

Fox, N., Graham, L. J., Eigenbrod, F., Bullock, J. M., & Parks, K. E. (2022). Geodiversity Supports Cultural Ecosystem Services: an Assessment Using Social Media. *Geoheritage*, *14*(1), 27. https://doi.org/10.1007/s12371-022-00665-0

Frey, M. L. (2021). Geotourism—Examining Tools for Sustainable Development. *Geosciences*, *11*(1), 30. https://www.mdpi.com/2076-3263/11/1/30

Gao, L., Wang, Y., Li, D., Shao, J., & Song, J. (2017). Real-time social media retrieval with spatial, temporal and social constraints. *Neurocomputing*, *253*, 77-88. https://doi.org/10.1016/j.neucom.2016.11.078

García-Ortiz, E., Fuertes-Gutiérrez, I., & Fernández-Martínez, E. (2014). Concepts and terminology for the risk of degradation of geological heritage sites: fragility and natural vulnerability, a case study. *Proceedings of the Geologists' Association*, *125*(4), 463-479. https://doi.org/10.1016/j.pgeola.2014.06.003

Garcia, M. D. G., Nascimento, M. A. L. D., Mansur, K. L., & Pereira, R. G. F. D. A. (2022). Geoconservation strategies framework in Brazil: Current status from the analysis of representative case studies. *Environmental Science & Policy*, *128*, 194-207. https://doi.org/10.1016/j.envsci.2021.11.006

Ghermandi, A. (2016). Analysis of intensity and spatial patterns of public use in natural treatment systems using geotagged photos from social media. *Water Research*, *105*, 297-304. https://doi.org/10.1016/j.watres.2016.09.009

Gordon, J. E. (2018). Geoheritage, Geotourism and the Cultural Landscape: Enhancing the Visitor Experience and Promoting Geoconservation. *Geosciences*, *8*(4), 136. https://www.mdpi.com/2076-3263/8/4/136

Gordon, J. E., Crofts, R., & Díaz-Martínez, E. (2018). Geoheritage Conservation and Environmental Policies: Retrospect and Prospect. In E. Reynard & J. Brilha (Eds.), *Geoheritage* 213-235. Elsevier. https://doi.org/10.1016/B978-0-12-809531-7.00012-5

Gray, M. (2008). Geodiversity: developing the paradigm. *Proceedings of the Geologists' Association*, *119*(3), 287-298. https://doi.org/10.1016/S0016-7878(08)80307-0

Greenberg, B. S., S., E. M., Paul, S., Len, C., Mark, L., & Lachlan, K. (2005). Comparing Survey and Diary Measures of Internet and Traditional Media Use. *Communication Reports*, *18*(1-2), 1-8. https://doi.org/10.1080/08934210500084164

Hall, R. (2002). Cenozoic geological and plate tectonic evolution of SE Asia and the SW Pacific: computer-based reconstructions, model and animations. *Journal of Asian earth sciences*, *20*(4), 353-431. https://doi.org/10.1016/S1367-9120(01)00069-4

Hall, R. (2012). Late Jurassic–Cenozoic reconstructions of the Indonesian region and the Indian Ocean. *Tectonophysics*, *570-571*, 1-41. https://doi.org/10.1016/j.tecto.2012.04.021

Hall, R., Clements, B., Smyth, H. R., & Cottam, M. A. (2007). A new interpretation of Java's structure. Indonesian Petroleum Association 31st Annual Convention and Exhibition,

Hall, R., & Morley, C. K. (2004). Sundaland Basins. In *Continent-Ocean Interactions Within East Asian Marginal Seas* 55-85. https://doi.org/10.1029/149GM04

Hamilton, W. B. (1979). *Tectonics of the Indonesian region* [Report](1078). (Professional Paper, Issue. U. S. G. P. Off. https://pubs.usgs.gov/publication/pp107

Haryanto, I., Hutabarat, J., Sudrajat, A., Ilmi, N. N., & Sunardi, E. (2017). Tektonik Sesar Cimandiri, Provinsi Jawa Barat. *Bulletin of Scientific Contribution: Geology*.

Hausmann, A., Toivonen, T., Slotow, R., Tenkanen, H., Moilanen, A., Heikinheimo, V., & Di Minin, E. (2018). Social Media Data Can Be Used to Understand Tourists' Preferences for Nature-Based Experiences in Protected Areas. *Conservation Letters*, *11*(1), e12343. https://doi.org/10.1111/conl.12343

Heikinheimo, V., Minin, E. D., Tenkanen, H., Hausmann, A., Erkkonen, J., & Toivonen, T. (2017). User-Generated Geographic Information for Visitor Monitoring in a National Park: A Comparison of Social Media Data and Visitor Survey. *ISPRS International Journal of Geo-Information*, *6*(3), 85. https://www.mdpi.com/2220-9964/6/3/85

Henriques, M. H., & Brilha, J. (2017). UNESCO Global Geoparks: A strategy towards global understanding and sustainability. *Episodes Journal of International Geoscience*, *40*(4), 349-355.

Henriques, M. H., Canales, M. L., García-Frank, A., & Gomez-Heras, M. (2019). Accessible Geoparks in Iberia: a Challenge to Promote Geotourism and Education for Sustainable Development. *Geoheritage*, *11*(2), 471-484. https://doi.org/10.1007/s12371-018-0300-5

Herlinawati, Setiawan, I. F., Rohaendi, N., & Wahyudi. (2025). Safety Assessment for Geotourism in Ciletuh-Palabuhanratu UNESCO Global Geopark, West Java. *IOP Conference Series: Earth and Environmental Science*, *1451*(1), 012045. https://doi.org/10.1088/1755-1315/1451/1/012045

Ikhram, R., Hoshide, T., Ohba, T., Rosana, M. F., & Hardiyono, A. (2025). Origin and evolution of serpentinized peridotite from the Ciletuh Mélange in Sunda Arc, Indonesia: Evidence from petrography, mineralogy, and geochemistry. *Journal of Asian Earth Sciences: X*, *13*, 100188. https://doi.org/10.1016/j.jaesx.2024.100188

Ikhram, R., Rosana, M., Agusta, R., & Andriani, S. (2018). Study of Significance of Geodiversity in Ciletuh-Palabuhanratu National Geopark, West Java, Indonesia. *11*, 139-145. https://doi.org/10.21276/ijee.2018.11.0207

Illingworth, S., Stewart, I., Tennant, J., & von Elverfeldt, K. (2018). Editorial: Geoscience Communication – Building bridges, not walls. *Geosci. Commun.*, *1*(1), 1-7. https://doi.org/10.5194/gc-1-1-2018

Katili, J. A. (1973). Geochronology of West Indonesia and its implication on plate tectonics. *Tectonophysics*, *19*(3), 195-212. https://doi.org/10.1016/0040-1951(73)90019-X

Kubalíková, L. (2013). Geomorphosite assessment for geotourism purposes. *Czech Journal of Tourism*, *2*(2), 80-104. https://doi.org/10.2478/cjot-2013-0005

Kubalíková, L., Vandelli, V., & Pál, M. (2025). New horizons in geodiversity and geoheritage research: Bridging science, conservation, and development. *Moravian Geographical Reports*, *33*(1), 2-6. https://doi.org/10.2478/mgr-2025-0001

Lanara, T., Xanthopoulou-Tsitsoni, V., Kostopoulou, S., & Tsitsoni, T. K. (2023). Geoparks and Sustainable Tourism Development. The Role of Internet and Social Media. In S. Kostopoulou, G. Herrera-Franco, J. Wood, & K. Al-Kodmany, *Cities' Vocabularies and the Sustainable Development of the Silkroads* Cham.

Malatyinszki, S., Kálmán, B. G., & Dávid, L. D. (2025). The role of geoparks in sustainable tourism development: a case study approach. *Geojournal of Tourism and Geosites*, 59(2), 572-586. https://doi.org/ 10.30892/gtg.59206-1438

Mandradewi, W., & Herdianita, N. R. (2010). Characteristics of Surface Manifestation, Cisolok, Sukabumi , West Java: With Relation to Cisolok Geothermal System Proceedings World Geothermal Congress 2010, Bali, Indonesia.

Migoń, P., & Pijet-Migoń, E. (2024). Non-Uniform Distribution of Geoheritage Resources in Geoparks—Problems, Challenges and Opportunities. *Resources*, *13*(2), 23. https://www.mdpi.com/2079-9276/13/2/23

Munar, A. M., & Jacobsen, J. K. S. (2014). Motivations for sharing tourism experiences through social media. *Tourism Management*, *43*, 46-54. https://doi.org/10.1016/j.tourman.2014.01.012

Németh, B., Németh, K., Procter, J. N., & Farrelly, T. (2021). Geoheritage Conservation: Systematic Mapping Study for Conceptual Synthesis. *Geoheritage*, *13*(2), 45. https://doi.org/10.1007/s12371-021-00561-z

Newsome, D., & Dowling, R. (2018). Geoheritage and Geotourism. In E. Reynard & J. Brilha (Eds.), *Geoheritage* 305-321. Elsevier. https://doi.org/10.1016/B978-0-12-809531-7.00017-4

Owuor, I., & Hochmair, H. H. (2020). An Overview of Social Media Apps and their Potential Role in Geospatial Research. *ISPRS International Journal of Geo-Information*, *9*(9), 526. https://www.mdpi.com/2220-9964/9/9/526

Pál, M., & Albert, G. (2021). Examining the Spatial Variability of Geosite Assessment and Its Relevance in Geosite Management. *Geoheritage*, *13*(1), 8. https://doi.org/10.1007/s12371-020-00528-6

Prosser, C. D., Bridgland, D. R., Brown, E. J., & Larwood, J. G. (2011). Geoconservation for science and society: challenges and opportunities. *Proceedings of the Geologists' Association*, *122*(3), 337-342. https://doi.org/10.1016/j.pgeola.2011.01.007

Prosser, C. D., Díaz-Martínez, E., & Larwood, J. G. (2018). The Conservation of Geosites: Principles and Practice. In E. Reynard & J. Brilha (Eds.), *Geoheritage* 193-212. Elsevier. https://doi.org/10.1016/B978-0-12-809531-7.00011-3

Quesada-Valverde, M. E., & Quesada-Román, A. (2023). Worldwide Trends in Methods and Resources Promoting Geoconservation, Geotourism, and Geoheritage. *Geosciences*, *13*(2), 39. https://www.mdpi.com/2076-3263/13/2/39

Ren, F., Simonson, L., & Pan, Z. (2013). Interpretation of Geoheritage for Geotourism – a Comparison of Chinese geoparks and National Parks in the United States. *Czech Journal of Tourism*, *2*(2), 105-125. https://doi.org/10.2478/cjot-2013-0006

Reveilhac, M., Steinmetz, S., & Morselli, D. (2022). A systematic literature review of how and whether social media data can complement traditional survey data to study public opinion. *Multimedia Tools and Applications*, *81*(7), 10107-10142. https://doi.org/10.1007/s11042-022-12101-0

Reynard, E., & Brilha, J. (2018). Geoheritage: A Multidisciplinary and Applied Research Topic. In E. Reynard & J. Brilha (Eds.), *Geoheritage* 3-9. Elsevier. https://doi.org/10.1016/B978-0-12-809531-7.00030-7

Richards, D. R., & Friess, D. A. (2015). A rapid indicator of cultural ecosystem service usage at a fine spatial scale: Content analysis of social media photographs. *Ecological Indicators*, *53*, 187-195. https://doi.org/10.1016/j.ecolind.2015.01.034

Rosalia, S., Widiyantoro, S., Cummins, P. R., Yudistira, T., Nugraha, A. D., Zulfakriza, Z., & Setiawan, A. (2022). Upper crustal shear-wave velocity structure Beneath Western Java, Indonesia from seismic ambient noise tomography. *Geoscience Letters*, *9*(1), 1. https://doi.org/10.1186/s40562-021-00208-5

Ruban, D. A. (2024). Questionable suitability of pure geological publications to distant inventory of world-class palaeogeographical geosites. *Discover Geoscience*, *2*(1), 25. https://doi.org/10.1007/s44288-024-00027-z

Satyana, A. H. (2014). New consideration on the cretaceous subduction zone of Ciletuh-Luk Ulo-Bayat-Meratus: Implications for Southeast Sundaland petroleum geology. Indonesian Petroleum Association 38th Annual Convention and Exhibition.

Satyana, A. H., Prasetyo, A., & Rosana, M. F. (2021). Ciletuh Subduction, West Java - New Findings, New Problems: Regional Implications to Cretaceous-Paleogene Convergence of Sundaland Margin and Its Petroleum Geology. Indonesian Petroleum Association 45th Annual Convention and Exhibition 2014.

Satyana, A. H., & Purwaningsih, M. E. M. (2011). Collision of micro-continents with eastern Sulawesi: records from uplifted reef terraces and proven-potential petroleum plays. Indonesian Petroleum Association 35th Annual Convention and Exhibition.

Selmi, L., Canesin, T. S., Gauci, R., Pereira, P., & Coratza, P. (2022). Degradation Risk Assessment: Understanding the Impacts of Climate Change on Geoheritage. *Sustainability*, *14*(7), 4262. https://www.mdpi.com/2071-1050/14/7/4262

Setiawan, I. F., Herlinawati, Rohaendi, N., & Harmoko, A. A. (2025). Assessment of Geoeducational Value of Geosites in UNESCO Global Geopark Ciletuh-Palabuhanratu Based on School Students. *IOP Conference Series: Earth and Environmental Science*, *1451*(1), 012013. https://doi.org/10.1088/1755-1315/1451/1/012013

Setijadji, L. D., Kajino, S., Imai, A., & Watanabe, K. (2006). Cenozoic Island Arc Magmatism in Java Island (Sunda Arc, Indonesia): Clues on Relationships between Geodynamics of Volcanic Centers and Ore Mineralization. *Resource Geology*, *56*(3), 267-292. https://doi.org/10.1111/j.1751-3928.2006.tb00284.x

Shajahan, R., van Wyk de Vries, B., Zanella, E., & Harris, A. (2024). Creating a sense of intangible science: Making it understandable to a broad public via geoheritage. *International Journal of Geoheritage and Parks*, *12*(3), 396-415. https://doi.org/10.1016/j.ijgeop.2024.07.007

Siregar, H. (2019). Analisis Perlindungan Hukum Terhadap Geopark Nasional Ciletuh Sebagai Kawasan Geowisata di Kabupaten Sukabumi Provinsi Jawa Barat. *Jurnal Surya Kencana Satu : Dinamika Masalah Hukum dan Keadilan*, *10*, 15. https://doi.org/10.32493/jdmhkdmhk.v10i1.3173

Stolz, J., & Megerle, H. E. (2022). Geotrails as a Medium for Education and Geotourism: Recommendations for Quality Improvement Based on the Results of a Research Project in the Swabian Alb UNESCO Global Geopark. *Land*, *11*(9), 1422. https://www.mdpi.com/2073-445X/11/9/1422

Sudjatmiko. (1972). *Geological Map of Cianjur Quadrangle, West Java, Scale 1:100.000*. Bandung, Geological Research and Development Centre.

Sukamto, R. (1975). *Geological Map of Jampang dan Balekambang Quadrangle, West Java, Scale 1:100.000*. Bandung, Geological Research and Development Centre.

Suyanto, A., Haryono, E., & Baiquni, M. (2020). The community-based conservation management in gunung sewu unesco global geopark cased study of Nglanggeran Geoheritage. *IOP Conference Series: Earth and Environmental Science*, *451*(1), 012049. https://doi.org/10.1088/1755-1315/451/1/012049

Suzuki, D. A., & Takagi, H. (2018). Evaluation of Geosite for Sustainable Planning and Management in Geotourism. *Geoheritage*, *10*(1), 123-135. https://doi.org/10.1007/s12371-017-0225-4

Tessema, G. A., Poesen, J., Verstraeten, G., Van Rompaey, A., & van der Borg, J. (2021). The Scenic Beauty of Geosites and Its Relation to Their Scientific Value and Geoscience Knowledge of Tourists: A Case Study from Southeastern Spain. *Land*, *10*(5), 460. https://www.mdpi.com/2073-445X/10/5/460

Thayyib, S. E., Said, E. L., Siswoyo, & Prijomarsono, S. (1977). The status of the melange complex in Ciletuh area, South-West Java. Indonesian Petroleum Association 6th Annual Convention and Exhibition.

Trunfio, M., & Rossi, S. (2021). Conceptualising and measuring social media engagement: A systematic literature review. *Italian Journal of Marketing*, *2021*(3), 267-292. https://doi.org/10.1007/s43039-021-00035-8

UNESCO. (2015). Statutes of The International Geoscience and Geoparks Programme. In *Operational Guidelines for UNESCO Global Geoparks* 16.

Van Bemmelen, R. W. (1949). General Geology of Indonesia and Adjacent Archipelagoes. In *The geology of Indonesia*. The Haque Martinus Nijhoff.

Vandelli, V., Selmi, L., Faccini, F., Ferrando, A., & Coratza, P. (2024). Geoheritage Degradation Risk Assessment: Methodologies and Insights. *Sustainability*, *16*(23), 10336. https://www.mdpi.com/2071-1050/16/23/10336

Wibowo, T. W., Santosa, S. H. M. B., Susilo, B., & Purwanto, T. H. (2021). Revealing tourist hotspots in yogyakarta city based on social media data clustering. *Geojournal of Tourism and Geosites*, 34(1), 218-225. https://doi.org/10.30892/gtg.34129-640

Wimbledon, W. A. P., Ishchenko, A. A., Gerasimenko, N., Karis, L. O., Suominen, V., Johansson, C. E., & Freden, C. (2000). Geosites-an IUGS initiative: science supported by conservation. *Geological Heritage: Its Conservation and Management*, 69-94.

Yuniarti, M., Syamsuddin, M. L., Efendi, H. M. F., Wulandari, A., & Suhanda, D. (2022). Implementation of tourism development policy in Geopark Ciletuh-Pelabuhanratu, West Java, Indonesia. *The Institute of Biopaleogeography named under Charles R. Darwin*, *11*, 63

Zafeiropoulos, G., Drinia, H., Antonarakou, A., & Zouros, N. (2021). From Geoheritage to Geoeducation, Geoethics and Geotourism: A Critical Evaluation of the Greek Region. *Geosciences*, *11*(9), 381. https://www.mdpi.com/2076-3263/11/9/381

Zeng, B., & Gerritsen, R. (2014). What do we know about social media in tourism? A review. *Tourism Management Perspectives*, *10*, 27-36. https://doi.org/10.1016/j.tmp.2014.01.001

Zuvara, R. A., Herdiansyah, H., & Asteria, D. (2022). Environmental Conservation in Ciletuh Geopark, West Java. *IOP Conference Series: Earth and Environmental Science*, *1041*(1), 012043. https://doi.org/10.1088/1755-1315/1041/1/012043

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