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RESEARCH ARTICLE

Geoheritage potential of limestone caves at Felda Chiku 7, Gua Musang, Kelantan, Malaysia

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ABSTRACT

This study aims to assess the geoheritage potential of Felda Chiku 7 in Gua Musang District, Kelantan. The study area hosts two limestone caves, which exhibit distinctive geological and geomorphological features, including karst landforms, speleothems, and speleogens. Geologically, the area is underlain by three primary lithologies — limestone, phyllite, and slate — that comprise the Gua Musang Formation. The geology of the study area is mainly composed of three lithologies: limestone, phyllite, and slate. The study integrated qualitative and quantitative assessments: the qualitative assessment was based on the author's fieldwork observations, whilst the quantitative assessment was based on the Modified Geosite Assessment Model (M-GAM) framework. The M-GAM frameworks integrate expert perceptions with visitors'/public perceptions, with the Main Values covering scientific, aesthetic, and protection values, and the Additional Values covering functional and touristic values. The qualitative assessment indicates the geodiversity of rocks (lithologies), geomorphology (speleothems and speleogens), landscape and fossil. In addition, the scopes are petrological, geomorphological and paleontological sites, and the scale is small. As for the quantitative assessment, the study shows that aesthetic values rank highest, followed by protection, scientific, functional, and tourism values. The M-GAM results indicate an intermediate overall geoheritage potential (28.4%), with exceptionally high scenic/aesthetic and protection scores, and low touristic readiness (restaurant/visitor infrastructure minimal)—consistent with local familiarity but limited public exposure. The findings demonstrate that Felda Chiku 7 holds substantial potential for future geoconservation and geotourism initiatives, provided that appropriate management strategies, interpretative programmes, and community engagement efforts are implemented to enhance accessibility and long-term protection of this natural asset.

1. INTRODUCTION

Geoheritage, or geological heritage, refers to unique, rare, or representative geological features that possess notable scientific, educational, aesthetic, or cultural importance (Prosser et al, 2011). Malaysia is recognized for its abundance of geoheritage sites and has taken active steps to conserve and promote these natural assets. As noted by Komoo (2004), the nation's initial geoheritage conservation efforts date back to the Third Malaysia Plan (1976–1980), which included provisions to preserve geological landmarks and landscapes. The formation of the Malaysia Geological Heritage initiative in 1996 marked the beginning of structured, strategic conservation efforts. Following this, numerous studies have been undertaken to document and evaluate geological sites for their protection and sustainable use.

Geoheritage includes all geologically valuable elements, whereas geotourism is a form of tourism that highlights and promotes geological features. As a niche segment within the tourism industry, geotourism is based on Earth's geological landscape and heritage (Dowling, 2013). When identifying a site of geological significance, key factors such as distinctiveness, rarity, and representative value are considered (Brocx & Semeniuk, 2007). Geological heritage can be categorized into various types, such as mineralogical, geomorphological, hydrogeological, structural, and petrological sites, among others that showcase specific geological characteristics.

The study area is in Felda Chiku 7 in the southern region of Kelantan, within the coordinates of 5º01'37.9" N to 5º03'14.6" N and 102º09'36.4" to 102º09'03.2" E (Figure 1). In the study area, the observable geomorphology comprises hills adorned with palm plantations and the Chiku River flowing through it. This study area also has a street, a school, a mosque, and a village. The study area was located in the Chiku area, part of the Central Belt of Peninsular Malaysia.

There are two cave blocks in this study area, known locally as Cave Block 1 and Cave Block 2. Both caves share similar landscapes and characteristics, and both have potential geoheritage value. Thus, the purpose of this study is to assess the geoheritage potential and its significance in determining the suitability of the areas proposed as geoheritage sites. This location possesses unique characteristics, scarcity, and exemplification of specific geological features and elements that require identification. The study area contains geoheritage resources, including minerals, rocks, fossils, landforms, and geomorphological features, that provide evidence of past geological events.

Felda Chiku 7 in the Gua Musang district, in the southern part of Kelantan, is a part of the Central Belt of Peninsular Malaysia. There are two blocks of caves in this study area, which are composed of crystalline limestone, and the surrounding area consists of phyllite and slate (Figure 1). The first limestone unit was assigned to the Gua Musang Formation (Yin, 1965), which includes lithologies of argillaceous, carbonate, volcanic and a few arenaceous rocks. The latter work by Mohamed et al (2016) proposed a new lithostratigraphic unit, which considered the association of most of the carbonate, argillite and volcanic sequences located in the northern part of Central Belt Peninsular Malaysia as the Gua Musang Group. This Gua Musang Group covered the Gua Musang Formation, Telong Formation, Aring Formation and Nilam marble as the standard lithostratigraphic units in the Gua Musang area. Based on the latter lithostratigraphic unit, this limestone body was the Gua Musang Formation, as indicated by the presence of crystalline limestone and an argillaceous component in the surrounding area. The presumed age was Permian-Triassic based on the regional Gua Musang Formation.

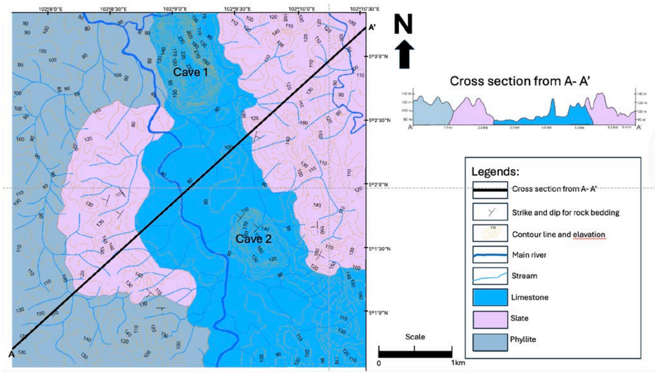

Figure 1: The geological map and cross-section of the study area.

2. MATERIALS AND METHODS

2.1. Method

In this study, a combination of qualitative and quantitative approaches was employed—the qualitative aspect involved evaluating the study area's geoheritage significance and its potential for geotourism development. A qualitative assessment in geoheritage refers to evaluating the value and significance of geological or geomorphological features — such as rocks, fossils, landforms, or geological structures — using non-numerical, descriptive criteria. Instead of merely counting or measuring features (as in quantitative methods), the qualitative approach interprets why a geosite is essential, unique, or valuable, drawing on expert judgment, observation, and contextual understanding. This evaluation primarily focused on sightseeing the site's geodiversity (Gray, 2005), geoheritage values —such as scientific (educational), aesthetic, recreational, economic, and functional—which contribute to its suitability for geotourism (Gray, 2004 & 2005) and scope (Brocx & Semeniuk, 2007, Predag & Mirela, 2010) Following this, the study area's importance was classified according to its level of significance, categorized as international, national, state, regional, or local based on its geoheritage resources (Brocx & Semeniuk, 2007). Qualitative assessment helps capture essential features that can't be easily quantified, making it helpful in supporting heritage protection, geotourism planning, or geopark development.

Conversely, the quantitative method relied on the researcher's interpretation supported by survey data. Quantitative assessment of geoheritage has become essential for the development of geotourism and geoeducation. Consequently, various inventory and assessment methodologies have been established to safeguard and promote geoheritage, as well as to document its geoeducational and geotouristic significance (e.g., Panizza, 2001; Ruban, 2015; Reynald et al., 2007; Bruschi et al., 2018; Drinia et al., 2021). These methods aim to evaluate the scientific, educational, touristic, and other values of geosites to determine which sites have the most significant potential for tourism and education. However, the methodologies differ mainly in the criteria applied, which are often influenced by individual researchers' perspectives. As a result, the quantification process is not always entirely objective, with subjectivity occasionally leading to distortions in the outcomes (Reynald et al., 2007; Fassoulas et al., 2012). Consequently, there is a risk of misinterpretation or misjudgment when assessments are not based on transparent and well-documented criteria. Conversely, specific assessment methods incorporate mathematical models to provide a more quantitative, multidisciplinary evaluation of areas of significant geoscientific interest. These approaches often integrate not only the scientific value but also the geoeducational potential of such areas (Reynald et al., 2007; Fassoulas et al., 2012; Gray, 2004; Brilha et al., 2018).

In this study, a questionnaire-based survey was conducted to gather public perception of geoheritage, complementing the findings from the site assessments (Kubalíková, 2013). This survey was structured based on the Modified Geosite Assessment Model (M-GAM), modified by Tomić & Božić, (2014) and derived initially from the Geosite Assessment Model (GAM) method introduced by Vujičić, et al. (2011). The M-GAM method was widely applied to geotourism of karst geosites (Chantharangsone et al., 2024; Resmi et al., 2023) and to other geotourism aspects (Sucahyanto et al., 2024; Cvetanović et al., 2024; Dezilia & Harnani, 2023; Reinhart et al., 2023).

This survey utilized semi-structured questions and targeted various groups, including students, lecturers, geoscience experts, eco-tourists, residents, general tourists, and the wider public. Respondents were selected using a systematic sampling method, accounting for demographic factors such as age (13–60 years), gender (male or female), educational background (high school, pre-university, undergraduate, or doctoral), and place of origin (local or non-local). The questionnaire contained 38 items covering topics such as definitions and understanding of geoheritage and geotourism, awareness, perceived importance and benefits, recognition of geological and geomorphological features, and perceived values of geoheritage.

A survey of approximately 100 participants was conducted to assess the perceived importance of various sub-indicators within the Modified Geosite Assessment Model (M-GAM). Sixty participants were experts with a geological background, while the other forty were non-geologists (non-experts/publics), including locals and tourists. Participants rated each sub-indicator on a scale from 0.00 (strongly disagree) to 1.00 (strongly agree), and the average score for each was then calculated. The questionnaire was divided into two main parts. The first section collected basic demographic information, including gender, age, education level, and geological knowledge. The remaining sections (two through six) were designed to evaluate respondents' rankings of the importance of specific indicators and sub-indicators within the M-GAM framework.

The M-GAM model consists of two main components: Main Values (MV) and Additional Values (AV). Each component includes a set of indicators, further broken down into sub-indicators, all rated on the same 0.00 to 1.00 scale. The Main Values (MV) are based on natural characteristics and include the following indicators: Scientific/Educational Value (VSE), Scenic/Aesthetic Value (VSA) and Protection Value (VPr). The Scientific/Educational Value (VSE) category includes the following characteristics: rarity, representativeness, scientific significance, and the level of interpretive information available. The Scenic/Aesthetic Value (VSA) encompasses elements such as viewpoints, surface, the surrounding landscape and nature and the site's environmental harmony—including contrasts with nature, color variation, and the distinctiveness of shapes and forms. Lastly, the Protection Value (VPr) is determined by factors such as the site's physical condition, level of protection, vulnerability to degradation, and the suitable number of visitors that the site can accommodate without a negative impact. The summary of Main Values (MV) was calculated using the equation: MV= VSE + VSA + VPr.

In contrast, the Additional Values (AV) reflect human influence and include: Functional Value (VFn), which encounted accessibility, additional natural values, additional anthropogenic values, vicinity of emissive centers, vicinity of important road network and additional functional values, whilst Touristic Value (VTr) focused on promotion, organized visit, vicinity of visitors centres, interpretative panels, number of visitors, tourism infrastructure, tour guide service, hostelry services and restaurant service. The Additional Value (AV) was calculated using the equation: AV= VFn + VTr. While the main values focus on intrinsic natural features, the additional values capture aspects shaped by human activity. These secondary values are adapted to respondents' perspectives and knowledge, contributing to a more holistic evaluation of geosite significance.

The inclusion of the importance factor (Im) enhances the objectivity and accuracy of the results. The non-expert, public opinion, or assessment was included in this survey using the equation from Tomić & Božić (2014) for the importance factor (Im). The parameter is assessed by locals, who assign numerical values of 0.00, 0.25, 0.50, 0.75, or 1.00 to the subindicators for Main and Additional Values, as experts do. This importance factor (Im) is defined in the following equation:

$$Im = \frac{\sum_{k=1}^{K} Ivk}{K}$$

Where Ivk is the assessment/score of one local for each subindicator, and K is the total number of locals who answered the questionnaire. The results of these were stated in the following form:

M-GAM = Im(GAM) = Im(MV+AV)

3. RESULT AND DISCUSSION

3.1 Qualitative assessment

The qualitative assessment of potential geoheritage sites in the study area—based on geoheritage values and levels of significance (ranking)—is summarised in Table 1. Geodiversity serves as the scientific basis for identifying geoheritage elements. The qualitative assessment interprets

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how unique or representative each feature is within the broader geological setting. In this study, the geodiversity elements observed were rocks, landscapes, geomorphology, and fossils. Even though both caves were composed of limestone, the variation of other rocks surrounding the study area (Figure 1) was exceptional, with phyllites and slates (metamorphic rocks) as the main surrounding rocks. The beautiful landscape at the entrances of both caves served as a good example of the area's aesthetic values (Figure 2). The geomorphology elements, on the other hand, cover the aspects of speleothems and speleogens (Figures 3 and 4). These elements will be discussed in the following paragraph. Within the caves, only one imprinted fossil was observed (Figure 2); however, the authors believe more microfossils can be extracted from the limestone if time permits. Both caves in Felda Chiku 7 show several other values that will be resemble in the quantitative assessment. Apart from that, the classification of elements on the geodiversity had been grouped into several scopes based on Predag & Mirela (2010). The scopes observed in the study area were petrological – for the variation in rock types, geomorphological – for the exceptional landscape and geomorphology, and paleontological – for the imprinted fossils. The scale was considered small, as it is within 100 m x 100 m or slightly larger. The geoheritage values observed in both caves included scientific, aesthetic, recreational, economic, and functional values. Even though the study area contains many geoheritage values, the level of significance is local only, as the natural history feature is important only to the local community (Brocx & Semeniuk, 2007).

The scientific value was assessed using a multi-criterion qualitative/ordinal framework adapted from Brilha (2016) and Lee et al. (2016). Each geosite was evaluated for representativeness, rarity/uniqueness, integrity/preservation, research/monitoring potential, accessibility for scientific study, and prior documentation in the scientific literature (Reynard, 2005; Xavier et al., 2023; Mariotto et al., 2023). In this study area, karst landform is formed through limestone dissolution. Calcite is soluble in dilute acid, such as carbonic acid. Hence, limestone, composed mainly of calcite ($CaCO_3$), is susceptible to carbonic acid, which can be produced through the reaction of water and carbon dioxide. Limestone is soluble in mildly acidic aqueous solutions, including carbonic acid produced by the dissolution of carbon dioxide in water. The limestone solution process yields a multitude of karstic features (speleothems and speleogens), including cavities, caves, columns, flowstones, and channels. Apart from being considered scientific values, these features also affect scenic/aesthetic value. Scenic or aesthetic value denotes the capacity of a geosite to engage through visual and sensory qualities — including form, colour, contrast, texture, and scale — that provoke emotional responses such as awe and inspiration, thereby supporting appreciation and conservation (National Park Service, 2020). Wang et al. (2022) emphasize that landscapes of outstanding natural form are particularly valued for their aesthetic dimension in geoheritage contexts. Figures 2, 3, and 4 show the karst landform and geological features, including the limestone caves at Felda Chiku 7, Gua Musang, Kelantan.

On the other hand, the recreational value of geoheritage refers to the capacity of geological sites and landscapes to provide opportunities for leisure, exploration, and nature-based experiences that enhance both physical and mental health (National Park Service, 2020). Geosites with striking landforms, accessible trails, and scenic vistas often serve as outdoor recreation spaces that foster appreciation for geological diversity and promote public engagement with nature (Gordon, 2018). Meanwhile, the functional value highlights the ecological and utilitarian roles that geological features play in sustaining natural and human systems — such as regulating hydrology, providing raw materials, stabilizing landscapes, and supporting ecosystem services (Milošević et al., 2018). This value acknowledges the practical contribution of geodiversity to environmental stability and human welfare through geosystem services.

The economic value, on the other hand, refers to the tangible and intangible benefits derived from geoheritage resources, particularly through geotourism, local employment, and regional economic growth (Nascimento et al., 2020; Yusry et al., 2018). Geosites with high aesthetic or scientific appeal often attract visitors, generating revenue for conservation and community livelihoods, thus reinforcing the link between heritage protection and sustainable economic use. Collectively, these values demonstrate that geoheritage is not only a scientific asset but also a multifunctional resource that supports recreation, ecosystem function, and economic vitality. This study area has an attractive landscape and geomorphological features that can attract tourists for recreational activities such as jungle trekking, hiking, sightseeing, and even photography. These activities can resemble recreational values and, indirectly, contribute to functional and economical values.

Table 1: The qualitative assessment of caves in Felda Chiku on the authors' assessment.

Caves (Block 1 and Block 2) Felda Chiku 7	
Geodiversity	Rocks, landscape, geomorphology, fossils
Scope	Petrological site, geomorphological site, paleontological site
Scale	Small scale
Geoheritage values	Scientific, Aesthetic, Recreational, Economic and Functional
Level of significance	Local

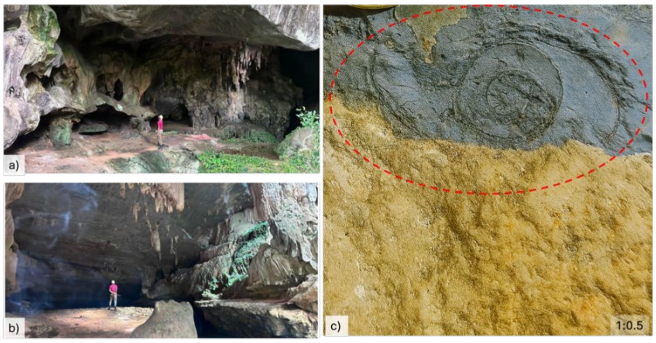

Figure 2: The beautiful landscape and aesthetic values of the cave in the study area; a) The cave entrance Block 1, b) The cave entrance Block 2, c) The imprinted fossil on the cave's wall (the red circle).

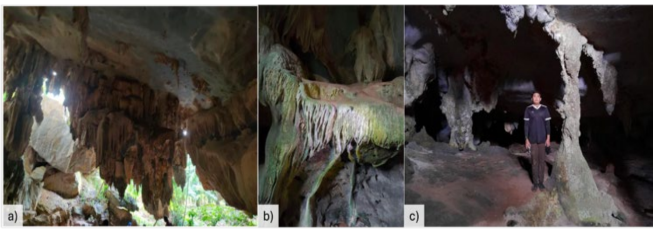

Figure 3: The speleothem aspects of both caves, a) Stalactite, b) Flowstone and c) Column.

Figure 4: The speleogen aspects of both caves, a) and b) the erosion feature which later became a small stream.

3.2 Quantitative assessment

In addition to the qualitative approach, a quantitative assessment was also conducted to assign numerical values (scores) to the geological sites, reflecting their potential for geoheritage development.

This quantitative method involved assessing each site's geoheritage features in terms of geodiversity and geoheritage value based on a schematic model, M-GAM modified by (Tomić & Božić, 2014) and later used by several researchers such as Jonić (2018), Pál & Albert (2018) and Vuković & Antić (2019). The assessment utilized a classification system comprising six value classes, ranging from 0 to 5, which represent the following categories: none (0), very poor (1), poor (2), fair (3), good (4), and very good (5), in accordance with the methodology proposed by Kubalíková (2013). The results of this quantitative evaluation are presented in Table 2.

Additionally, this assessment was supported by responses gathered through a structured questionnaire, the results of which are displayed in Table 3. All equations used in the analysis are centred and numbered on the right-hand side for consistency and reference.

3.2.1 Main values

The main values comprise three categories: scientific/educational (VSE), scenic/aesthetical (VSA), and protection values (VPr). The scientific/educational (VSE) as described above has four elements: rarity, representatives, knowledge of geoscientific issues, and level of interpretation. The evaluation of scenic/aesthetic values (VSA) involves assessing four key characteristics: viewpoints, surface, surrounding landscape and nature, and the environmental suitability of the sites. The protection values refer to the importance of conserving and managing geosites to preserve their geological integrity, scientific information, and cultural significance for future generations. It emphasizes safeguarding against threats such as urbanization, mining, erosion, and vandalism that could degrade the natural features and the heritage meanings embedded in the site (Croft et al., 2021). To assess protection values (VPr), it is necessary to examine the existing condition, protection level, vulnerability, and suitability for the number of visitors. In scientific/educational values, there are elements that need to be evaluated: rarity, representativeness, knowledge of geoscientific issues, and the level of interpretation. Each element was marked on a scale of 0 to 1.

On the other hand, the importance factor (Im) reflects the value assigned by visitors to each criterion—such as rarity, representativeness, and others—and is determined independently for each field. This factor is then multiplied by the corresponding subindicator scores, which are provided by experts. For the rarity value, the Im value was higher than the value given by the expert, 0.29 and 0.09, respectively.

For representativeness, the expert's value is around 0.85, and Im is 0.79. Next, the value given by the expert is 0.02, while Im is 0.17 for knowledge of geoscientific issues. Lastly, the level interpretation value given by experts is 0.84, whilst Im is 0.77. In general, the Im for scientific/educational is higher than the values given by the experts.

The Scenic/Aesthetic attributes encompass several sub-indicators, such as the viewpoint, the surface, the surrounding landscape and nature, and the environmental suitability of the site. The primary determinant of aesthetic value is the encompassing landscape and natural environment (Miljković et al., 2018). For the viewpoint, the expert's score is 0.77, and Im 0.70. Apart from that, for the surface, the expert-provided value is 0.70 lower than the Im, which is approximately 0.87. Experts estimate a score of 0.82 for the surrounding scenery and nature, whereas Im's value is roughly 0.79. Following that, the environmental fit of the site is rated 0.79 by experts and 0.91 by locals.

In general, protection encompasses the subindicators of current condition, protection level, vulnerability, and suitable visitor numbers. According to Miljković et al. (2018), the most important aspect within the Protection subindicators, for both experts and locals, is the current condition. The value of the current condition given by experts is around 0.99, and the score with Im is 0.93. Next, the expert score for protection is 0.56, whilst Im is 0.50. For the vulnerability sub-indicator, experts have provided a value of 0.69, and Im is 0.73. Other than that, the expert gave the suitable number of visitors subindicator a score of 2.99, while Im scored 2.96.

3.2.2 Additional values

Accessibility, additional natural values, additional anthropogenic values, vicinity to emissive centers, vicinity of important road network, and additional functional values are all components of functional values. In general, functional values are more important to tourists than to experts, except for accessibility elements, which are equally important to both groups (Miljković et al., 2018). For accessibility, the values of expert are 0.31 and Im is 0.35. Next, experts provide a value of 0.50 while Im is 0.57 for additional natural values. The experts assigned a score of 0.61 to the additional anthropogenic values, compared to Im's score of 0.62. Other than that, the vicinity of emissive centers, experts give a value of 0.27, while Im is 0.25, which is lower than the experts' value. The score that was given by the 0.66 and Im is 0.67 for the vicinity of the important road network. The score given by experts and locals for the additional functional values is 0.02 and 0.06 for Im.

Meanwhile, the tourism value highlights the potential of geoheritage to attract visitors through geotourism—a sustainable form of tourism that integrates conservation, education, and local economic benefits (Gordon, 2018). Geotourism transforms geological landscapes into experiential learning environments, promoting awareness of Earth's history while generating income and employment for local communities (Strba et al., 2020). Another indicator is the touristic value, which encompasses many sub-indicators such as promotion, organized visits, proximity to visitor centres, interpretative panels, visitor count, tourism infrastructure, tour guide services, hospitality services and restaurant service. For the promotion, the experts' values are 0.15, while the Im is 0.18, which is much higher than the experts' values. For the organized visits subindicator, the score that has been given by the expert is 0.20, which is lower than the Im value of 0.30. Next, the value that has been given by experts for the vicinity of visitors' centers is 0.23, which is lower than Im, which is 0.25. The value given by the experts for the interpretative panel is lower than Im, with values of 0.03 and 0.14. For the number of visitors, experts, and Im, I gave the same score: 0.04. For tourism infrastructure, the experts do not give any value, and for Im, it is 0.04. The experts gave a value of 0.06 for tour guide service, and Im is 0.07. For the hostelry services, the expert gives a value of 0.32 while Im 0.28. Furthermore, the expert assigned higher values to restaurant service than to Im, at 1.60 and 1.42, respectively.

3.2.3 M-GAM

In this study area, the score for each subindicator was calculated using the equation described in the method section. The expert scores were multiplied by the Im, and then the total values for each subindicator were summarised (Table 2). These values were then converted to percentages to assess the ranking of geoheritage potential (Sulaiman et al., 2022).

In terms of scientific value, both the experts and the public identify representativeness as the most significant aspect. Representativeness means the study area demonstrates notable didactic and exemplary attributes stemming from its inherent qualities and overall structural configuration. The next highest sub-indicator was the level of interpretation, where the experts and public gave higher ratings. This is mainly due to the opportunities to interpret the study area in terms of its history, geomorphology, geology, and other scientific knowledge. Rarity and knowledge of geoscientific issues were low, mainly because this study area lacked publications or had nearly none, and no identical site could be matched.

Among all assessed indicators, aesthetic value received the highest ratings from both groups. They agree that Chiku 7 Caves features striking geological formations and visually captivating landscapes, as illustrated in Figure 2. From the experts' perspective, the most prominent value lies in the surrounding landscape and natural environment. This highlights the cave's impressive location and visual appeal, complemented by its ecological features, including water bodies and lush vegetation. Locals also recognize scenic and aesthetic qualities as the main attractions, emphasizing the environmental fit of the site sub-indicator within its natural surroundings. The viewpoints and surface also rated relatively high, as this study area was familiar to locals and hikers.

Table 2: The quantitative assessment based on the M-GAM structured question.

Subindicators	Value for expert	Im	Score
Main Value (MV)			
Scientific Values (VSe)			
Rarity	0.09	0.29	0.0261
Representativeness	0.85	0.79	0.6715
Knowledge of geoscientific issues	0.02	0.17	0.0034
Level of interpretation	0.84	0.77	0.6468
		TOTAL	1.3478
Aesthetic Values (VSa)			
Viewpoints	0.77	0.70	0.539
Surface	0.70	0.87	0.609
Surrounding landscape and nature	0.82	0.79	0.6478
Environmental fitting of sites	0.79	0.91	0.7189
		TOTAL	2.5147
Protection Values (VPr)			
Current condition	0.99	0.93	0.837
Protection level	0.56	0.50	0.28
Vulnerability	0.69	0.73	0.5037
Suitable number of visitors	0.75	0.80	0.6
		TOTAL	2.2207
Additional Values (AV)			
Functional Values (VFn)			
Accessibility	0.31	0.35	0.1085
Additional natural values	0.50	0.57	0.285
Additional anthropogenic values	0.61	0.62	0.3782
Vicinity of emissive centers	0.27	0.25	0.0675
Vicinity of important road network	0.66	0.67	0.4422
Additional functional values	0.02	0.06	0.0012
		TOTAL	1.2826
Tourism Values (VTr)			
Promotion	0.15	0.18	0.027
Organized visits	0.20	0.30	0.06
Vicinity of visitors centers	0.23	0.25	0.0575
Interpretative panels	0.03	0.14	0.0042
Number of visitors	0.04	0.04	0.0016
Tourism infrastructure	0.00	0.04	0
Tour guide service	0.06	0.07	0.0042
Hostelry services	0.32	0.28	0.0896
Restaurant service	0.39	0.30	0.117
		TOTAL	0.3011

Regarding site protection, both experts and locals concur that Chiku 7 Caves is currently in good condition. The vulnerability and suitable number of visitors were rated as medium ratings, despite rumors of a potential cement factory that could threaten the site. No signs of damage have been observed, despite the low ratings for the level of protection. This is mainly due to practical protection efforts from local and regional organizations, as well as enforcement by national authorities. Located within Felda Chiku 7, the site falls under the jurisdiction of the Federal Land Development Authority (FELDA), ensuring strict safeguards against encroachment.

In terms of functional value, both groups agree that the study area benefits from its proximity to major transportation routes (vicinity of important road network). Chiku 7 Caves is situated approximately 13 km from the Gua Musang–Kuala Krai Highway, making it accessible to a broad range of visitors—local, regional, national, and even international. Even though the area was situated near the main road, the inadequate access, a smaller number of additional and anthropogenic values, the absence of nearby emissive centres, and the absence of amenities contribute to the low rating for the other sub-indicators.

Regarding touristic value, experts and locals rated restaurant services as the most valuable aspect. This is due to the presence of eateries and food stalls around Felda Chiku 7. Additionally, locals noted that annual organized visits to the caves are a regular occurrence, with locals frequently participating in expeditions to explore the site. The other sub-indicators were rated low because no promotion occurred, there was no visitor center, interpretative panels, or tourism infrastructure, and there were less tour guide service and fewer number of visitors.

The scores for each sub-indicator from the experts and the importance factor (Im) were calculated in Table 2. The total score for Scientific values is 1.3478, Aesthetic values is 2.514, Protection values is 2.2207, functional values is 1.2826, and tourism values is 0.3011. These values were presented as percentages to better understand the ranking of geoheritage potential (Table 3), where the sum of the calculated main and additional values was divided into 27 subindicators and converted to percentages.

The percentage of the total score for MV and AV values is 28.4% which can be classified as intermediate for geoheritage potential (Sulaiman et. al., 2022). Even though it is intermediate, the summary of aesthetic and protection values indicates that this study area possesses high aesthetic and protection values, with total scores of 2.5147 and 2.2207, respectively, out of 4 total scores. On the other hand, the scientific and functional values are moderate, at 1.3478 and 1.2826, respectively. As for tourism, it shows a low value of 0.3011.

Table 3: The calculated MV, AV and percentage conversion of M-GAM

Study area	MV	AV	Total & Percentage
Felda Chiku 7 caves	1.3478 + 2.5147 + 2.2207 =6.0832	1.2826 + 0.3011= 1.5837	7.6669 (28.4%)

3.2.4 Discussion of the results

The combined qualitative and quantitative assessment confirms that the Felda Chiku 7 caves are locally significant geosites characterized by clear karst morphology, intact speleothems, and at least one imprinted macrofossil. These observations underpin the relatively high scenic/aesthetic (VSA = 2.5147) and protection (VPr =

2.2207) scores in the M-GAM evaluation, while the scientific/educational value (VSE = 1.3478) remains moderate because of sparse published documentation and limited targeted scientific investigations to date.

This pattern — strong visual/aesthetic appeal but modest documented scientific value — is frequently reported in recent karst geoheritage assessments, where aesthetic metrics often dominate visitor perceptions, while rigorous scientific datasets (chronology, micropaleontology, geochemistry) are lacking (Wang et al., 2022; Mariotto et al., 2023). The inclusion of the Importance (Im) factor in our M-GAM survey aligns with Tomić & Božić's (2014) argument that non-expert input meaningfully modifies geosite scores and yields assessment outputs that are more relevant to geotourism planning.

Visitor-inclusive assessment improves management relevance. Studies applying M-GAM and similar hybrid models demonstrate that integrating visitor perceptions reveals conservation priorities and tourism opportunities that are not evident in expert-only scoring (Pál, 2025; Brđanin et al., 2024). Our dataset — with Im often higher than expert scores for aesthetic and interpretative indicators — supports this finding and suggests that community engagement should be institutionalized for repeat assessments.

Degradation risk and cumulative impacts require explicit incorporation. Work on geoheritage degradation risk (Vandelli et al., 2024) and recent karst assessments emphasize that proximity to industrial developments (e.g., a proposed cement factory) and access pressures necessitate routine risk screening. Although current field observations indicate good site condition, the medium vulnerability rating underscores the need for a formal degradation risk assessment to quantify exposure to dust, blasting, hydrological changes, and visitor impacts.

Multiple recent reviews recommend coupling baseline scientific studies (microfossil sampling, petrography, speleothem dating, stable isotopes) with interpretative products (panels, guided trails) to convert latent scientific value into demonstrable educational and tourism goods (Mariotto et al., 2023; Xavier et al., 2023). For Felda Chiku 7, targeted analytical work would both improve the VSE score and support stronger, evidence-based interpretive content.

4. CONCLUSION

The geoheritage value assessment of the limestone caves in Felda Chiku 7, Gua Musang, Kelantan, was conducted using qualitative and quantitative assessement methods. The qualitative assessments were based on the author's interpretation and observation. The qualitative assessment was conducted using a survey based on the Modified Geosite Assessment Model (M-GAM). Survey participants were categorized into two groups: those with geological expertise (experts) and those without such a background, which were later calculated as Importance factors (Im). The qualitative results show that these caves possess various geodiversity, including rocks, landscape processes, geomorphology, and fossils. These contributed to the geosite scope by reflecting geomorphological, paleontological, and petrological sites. The scope is small, as the area covered is limited, and the level of significance is local.

As for the quantitative assessment, results revealed that the highest geoheritage value identified in the study area was its scenic and aesthetic appeal. Both limestone caves—Cave Block 1 and Cave Block 2—were found to possess stunning landscapes formed through unique geomorphological processes. These caves represent a significant natural discovery and have strong potential to become a tourist destination due to their distinctive features. Upon entering, visitors are often captivated by the caves' enchanting and unusual formations.

Despite these impressive natural features, the touristic value of the site received the lowest scores from experts and locals. This is primarily because the area remains undeveloped and relatively unknown to the public. There are currently no visitor facilities near the caves, and most visitors are residents who are already familiar with the site. Limited accessibility may be a contributing factor, as reaching the caves requires a 4-wheel drive vehicle to travel approximately 3 km on an unpaved road from the Felda Chiku 7 settlement.

Furthermore, rumors of a potential cement factory development in the cave area are not currently considered a significant threat. The situation remains under control, provided relevant authorities continue to play an active role in safeguarding the site from harmful developments.

The overall result from the M-GAM survey was expressed as a percentage to better understand the geoheritage potential of the study area. The study area was ranked as having intermediate geoheritage potential, even though it was noted to possess a relatively pleasing aesthetic value. However, due to a lack of information, both caves appear underdeveloped and have been left behind in geotourism. It is suggested to highlight more fully the splendid geoheritage values of these caves and to promote geotourism or ecotourism in both caves.

Limitations of the study include a small sample size (≈100 respondents) and the absence of laboratory analyses (micropaleontology, geochemistry, and absolute dating) that would strengthen scientific claims. Future research should prioritize systematic micropaleontological and geochemical sampling to validate the paleontological and petrological scope; high-resolution mapping of karst microfeatures to better quantify representativeness; and integrative socio-economic studies to assess community willingness and capacity for geotourism enterprise.

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