Geology and Geoheritage Assessment of Lata Keding, Jeli, Kelantan, Malaysia

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Abstract. Lata Keding boasts numerous unique geological features encompassing diverse geological structures. The area is in the Jeli District of Kelantan and straddles the border of Kelantan and Perak. The topography ranges from a height of 480 meters to a low of 40 meters. This research was focused on the geoheritage value of Lata Keding and explored its potential for geotourism. The study area comprises five distinct rock units: hornfels, gneiss, schist, meta-alkali feldspar granite, and meta quartz-rich granitoid. Lata Keding's geoheritage value assessment revealed high aesthetic and recreational significance based on the qualitative and quantitative evaluation. The primary attraction of that area is its beautiful cascades and unique rock structures. Activities such as swimming, picnicking, and photography have gained popularity among visitors. Thus, it is important to protect and preserve Lata Keding to maintain its natural integrity, particularly in the face of potential rapid development.

1 Introduction

Lata Keding is one of the newly developing recreational areas in Jeli. It is located in Bukit Kudung Jeli, Kelantan (Figure 1), near Kampung Gemang, Gemang subdistrict, and bordered by the East-West Highway in the north-western corner of Kelantan. It holds various natural and historical treasures. The stunning waterfall, the new recreational area and the resort make Lata Keding famous not only for people around but for tourists. Other than that, Bukit Kudung used to be a stronghold and hiding place for the communists in the past, many still unknown. Behind the beauty of Bukit Kudung, which is 480 meters high, there is also a border stone known as Batu 73, which borders Thailand for 2.3 kilometres. The field and petrographic study show that this area comprises five distinct rock units: hornfels, gneiss, schist, meta-alkali feldspar granite, and meta quartz-rich granitoid.

Geological heritage, or geoheritage, is a part of in situ and ex situ geodiversity elements which have a high scientific value [1]. The geological site or geosite is the area or locality which has a specific geological interest. The main aim for the geoheritage assessment is usually for geoconservation. [2] also emphasized the significance of geosites as geoheritage resources that should be carefully maintained to encourage their long-term conservation and

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to ensure their continuous usefulness for both scientific research and general public enjoyment. Nowadays, the increasing numbers of natural processes events such as erosion, earthquake and flooding had contributed to the geosite deteriorate. Human activities also play a part in this situation. Thus, it is important to assess the geoheritage potential of certain area for the sake of geoconservation.

2 Method and materials

The geological mapping was conducted with the aim of observing the study area's rocks and geological features. The field study, including traversing and data collection, was the first stage to evaluate the presence of rock distribution and other geological features. The second stage was the geoheritage assessment. Three approaches were taken when assessing the geoheritage resources in a study area: the qualitative and the quantitative methods and geoheritage values validation by questionnaire distribution. The first involved examining the various values and significance of the resources. This includes considering their geodiversity [3], geoheritage values, scope [4][5] and scale [4]. In addition, the qualitative approach also involved assigning significance levels to the resources, such as global, national, regional, and local significance [4].

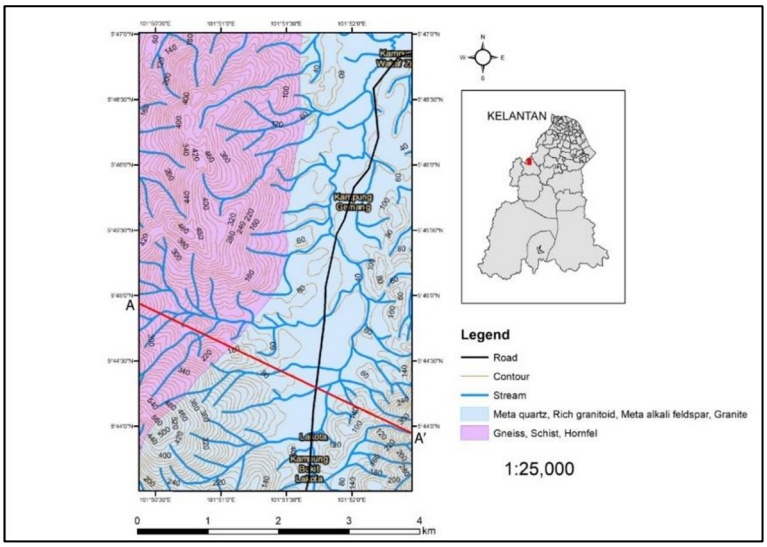

Figure 1: The geological map of Bukit Kudung and the surrounding area.

On the other hand, the quantitative method involved a more statistical approach to evaluate and rank the geological features based on their geoheritage values [6]. This approach involved the use of a rating system based on criteria presented in Table 1, which was modified from [7][8] by [9]. The summary of the geoheritage potential had been calculated based on the below equation by [9] for the small scale/ area geosite:

$$GP=((0.45\ Sv+0.15\ Av+0.2\ Rv+0.10\ Cv+0.10\ Ev)/19)\times 100$$

where, GP = Geoheritage Potential
Sv = Scientific Value
Av = Aesthetic Value
Rv = Recreational Value

Cv = Cultural Value
Ev = Ecological Value

The percentage of the Geoheritage Potential then had been ranked based on low rank (<25%), intermediate rank (25%- 74%) and high rank (>75%). All these values and calculations will be solely on the assessor's knowledge and influence by subjectivity.

Questionnaires were sent out to a wide range of people, including local and non-local inhabitants of the Jeli region and people from various educational levels, to ensure the data was representative of the population. 102 people participated in the survey. The survey focused on five systematic studies and the geoheritage values present in the area. In addition to these topics, the survey also included questions about the types of activities that can be enjoyed at these sites and the main attractions that draw people to visit. This information is valuable for understanding the potential of the region's geoheritage values and assessing the level of awareness among residents about the importance of conserving these sites.

The survey results may also help shift attitudes towards preserving these geosites and encourage a greater appreciation for nature. The score numbering of geoheritage values representing 0 is none; 1 is very bad; 2 is bad; 3 is fair; 4 is good; and 5 is very good [10][11] had been ranked based on respondents. This will lead to the quality of geotourism sites based on [12] where the sum of 0-7 is much too low, 8-14 is a little too low, 15-21 is about right, 22-28 is a little too high and 29-35 is much too high.

Table 1. The modification of scoring parameters/ criteria from [7] and [8], which focus on small scale/ area [9].

SCORE FOR ALL CRITERIA			
SCORE	**1**	**2.5**	**5**
SCIENTIFIC VALUE			
Geodiversity (Sv1)	<25%	26 – 74%	>75%
Scientific report (Sv2)	<2 general report	2/3 general report	>3 general report
Geological history (Sv3)	Single types of history	Combination of moderate history	Local story
Representativeness (Sv4)	Low	Moderate	High
Integrity (Sv5)	Almost destroyed	Strong deteriorated	Intact
AESTHETIC VALUE			
Panoramic (Av1)	No/ Low	Moderate	High
Landscape Different (Av2)	No/ Low	Moderate	High
Rarity (Av3)	No/ Low	Moderate	High
RECREATIONAL VALUE			
Attraction (Rv1)	No low attraction	Moderate attraction, 2/3 attractions	High attraction >3
Accessibility (Rv2)	No access	Can be access using pathway	Easily access from main road
Scenery (Rv3)	No/Low scenery	Moderate scenic	High scenic
CULTURAL VALUE			
Religion (Cv1)	No/ Low	Moderate	High
Belief (Cv2)	No/ Low	Moderate	High
Legends/ Myths (Cv3)	No/ Low	Moderate	High
ECOLOGICAL VALUE			
Ecological Impact (Ev1)	No/ Low	Moderate	High
Protection Status (Ev2)	No/ Low	In spots	In large parts

3 Results

3.1 Geology

Five lithologies were observed in the study: meta-quartz-rich granitoid, Meta alkali feldspar granite, schist, hornfels and gneiss. The meta-quartz rich granitoid has medium to coarse grain size and is composed mainly of quartz, feldspar, and mica minerals. The first lithology is meta-quartz-rich granitoid rocks, a subtype of granitoids with a particularly high quartz content, with some other minerals such as feldspars, micas, and amphiboles. This rock is light in colour and has a granular or crystalline texture. The second lithology is meta-alkali feldspar granite contains a high proportion of meta-alkali feldspar, a mineral-rich in sodium and potassium. The texture is phaneritic - weak foliation, and the size of the minerals is coarse - medium.

On the other hand, schist is characterized by its distinct foliation and ability to be split into thin sheets or flakes. It is composed of mica minerals such as biotite, muscovite, chlorite, quartz, and feldspar. Hornfels is the fourth lithology found in the study area. It is fine-grained and has a smooth, even texture due to the intense heat and pressure. It is also composed of various minerals, including quartz, feldspar, mica, and hornblende, and is often used as building materials due to their durability and resistance to weathering. The last lithology is gneiss, characterized by a banded or layered appearance.

3.2 Qualitative assessment

The cascading waterfall in Lata Keding makes this study area unique and beautiful. The variation of rocks in this study area, such as quartz vein, granite, and granitoid, and landform and landscape process, were evaluated as geodiversity in qualitative assessment [3]. The other parameters and assessment for the qualitative evaluation of Bukit Keding are shown in Table 2.

Table 2. The qualitative assessment of Bukit Kudung based on geodiversity [3], geoheritage values, scope [4][5], scale [4] and level of significance [4].

Geological site	Geodiversity [3]	Scope [4][5]	Scale [4]	Geoheritage Values [6]	Level of significance [4]
Bukit Kudung	Rock (Quartz veins intrusive and granite, granitoid, hornfels, schist and gneiss), landform/landscape process.	Petrological site, geomorphological site, recreational site	Medium scale	Scientific/ Education, Aesthetic, Recreational, Economic	State

3.3 Quantitative assessment

The geoheritage potential values were calculated based on the formula mentioned in the method section. These values are based on the parameter in Table 1, which indicates the scientific, aesthetic, recreational, cultural and ecological values. The scientific value was reflected by the geodiversity (Sv1), scientific report (Sv2), geological history (Sv3), representativeness (Sv4) and integrity (Sv5). The geodiversity (Sv1) is the variation of geological features in the study area, scientific report (Sv2) is the formal report by any study,

geological history (Sv3) is the process of the geological feature development, representativeness (Sv4) is the representation of the geological features, and integrity (Sv5) is the condition of all the geological features. The aesthetic value was reflected by panoramic (Av1), landscape difference (Av2) and rarity (Av3). The panoramic (Av1) is the scenery view of the study area, landscape different (Av2) is the representation of differences in landscape and rarity (Av3) is the uniqueness of geological features or views in the study area. The recreational value was reflected by the attraction (Rv1), accessibility (Rv2) and scenery (Rv3). The attraction (Rv1) is the quality to attract tourists into this study area, the accessibility (Rv2) is the ability of the study area to be accessed by road or other option for the tourist to come, and the scenery (Rv3) is the beautifulness of the study area that can attract tourist. All these recreational values will contribute to the enjoyment and pleasure of the tourists to increase the tourism element in the study area. The cultural value was reflected by religion (Cv1), belief (Cv2) and legend (Cv3). These three qualities refer to historical events of the local community, and the last value is the ecological value which resembles the ecological impact (Ev1) or protection status (Ev2) of the study area [5][7][9] (Table 1). The scoring values for all five parameters are shown in Table 3 below:

Table 3. Scoring values for geoheritage values

Parameters	**SCORE**
Scientific	
Geodiversity (Sv1)	5
Scientific report (Sv2)	1
Geological history (Sv3)	2.5
Representativeness (Sv4)	5
Integrity (Sv5)	5
TOTAL	**18.5**
Aesthetic	
Panorama (Av1)	5
Landscape (Av2)	5
Rarity (Av3)	2.5
TOTAL	**12.5**
Recreational	
Attraction (Rv1)	5
Accessibility (Rv2)	5
Scenery (Rv3)	5
TOTAL	**15**
Cultural	
Religion (Cv1)	1
Belief (Cv2)	2.5
Legend (Cv3)	1
TOTAL	**4.5**
Ecological	
Ecological impact (Ev1)	2.5
Protection status (Ev2)	1
TOTAL	**3.5**

Thus, the value of geoheritage potential using the equation in the method section is obtained as below:

$$(GP) = ((0.45x18.5) + (0.15x12.5) + (0.20x15) + (0.10x4.5) + (0.10x3.5)/19) \times 100$$
$$= 73.7\% \sim 74\%$$

3.4 Questionnaire survey

Based on the survey conducted to assess the geoheritage value of Lata Keding, it can be classified as possessing many different geoheritage values, including scientific and educational value, aesthetic value, recreational value, and economic value (Figure 2). According to the survey results, most respondents demonstrated an average level of knowledge related to the scientific value of Lata Keding, with a percentage ranging from 30% to 40%. Some respondents possessed good and very good knowledge about the scientific value of Lata Keding, as indicated by ratings of 4 and 5 (Table 4), with a percentage ranging from 10% to 30%. Similarly, some respondents had poor and very poor knowledge about the scientific value of Lata Keding, as indicated by ratings of 1 and 2, with a percentage ranging from 10% to 30% (Table 4).

Based on questions of aesthetic value, most of the respondents demonstrated very good knowledge related to aesthetic value, as evidenced by a score of 5 on a scale of 5, with a percentage of 40.2%. Additionally, on a scale of 4, representing good knowledge about aesthetic value, the percentage of respondents was the second highest, amounting to 36.3%. Notably, one respondent scored 2 on this question, indicating poor knowledge related to aesthetic value. Additionally, no respondents rated 1, which represents very poor knowledge. This data suggests that most respondents have some level of understanding and knowledge of aesthetic value and may have likely visited Lata Keding and observed the features considered to possess aesthetic value.

Regarding the recreational value question, the highest percentage of respondents scored 4 on a scale of 5, indicating good knowledge about recreational value, with a percentage of 45.1%. The second highest rating was on scale 5, which had a percentage of 31.4%. There were also respondents who gave a rating of 2, which represents poor knowledge about recreational value, with a percentage of 1%. These results suggest that most respondents possess the knowledge and can comprehend recreational value.

Lastly, regarding economic value, the highest percentage of respondents scored 4 on a scale of 5, representing good knowledge about economic value, with a percentage of 41.2%. This was followed by the second-highest rating of 5, which had a percentage of 38.2%. This data demonstrates that respondents possess good and very good knowledge and awareness about economic value in Lata Keding. However, it should be noted that there were also respondents who gave a rating of 2, indicating poor knowledge about economic value, with a percentage of 1% (Table 4).

Table 4. Quantitative assessment of the study area based on the questionnaire

Geoheritage values	Respondents
Scientific/ Educational value	3
Aesthetic value	5
Recreational value	4
Economic value	4
TOTAL	**16**

4 Discussion and conclusion

Lata Keding possessed a beautiful and unique cascading waterfall (Figure 3). This place had been widely known as a recreational area by the public. The qualitative assessment shows that Lata Keding has a variety of geodiversity, scopes and geoheritage values. The scale can be considered medium, and the significance level is stated. Regarding quantitative assessment, the highest geoheritage value is scientific, followed by recreational, aesthetic, cultural and ecological. However, this arrangement might be biased, as all the parameters are

not the same quantity. Therefore, the highest geoheritage values are recreational values, as all parameters scored by 5, followed by aesthetic, scientific, ecological and cultural. Based on the calculation, this study area exhibits 74% for geoheritage potential (GP) with a sum of 16 for all geoheritage values based on the survey. The GP value of 74% shows the intermediate rank for the study area [9], whilst the sum of 16 shows that it is about right for geotourism potential [12].

The study of Lata Keding's geoheritage value found a high aesthetic and recreational significance using qualitative and quantitative approaches. The stunning cascades and distinctive rock formations make this area attractive for geotourism. Tourists may enjoy activities like swimming, picnicking, photography, camping, and hiking in this location. Lata Keding must be conserved so that its natural state is not further compromised by human activity.

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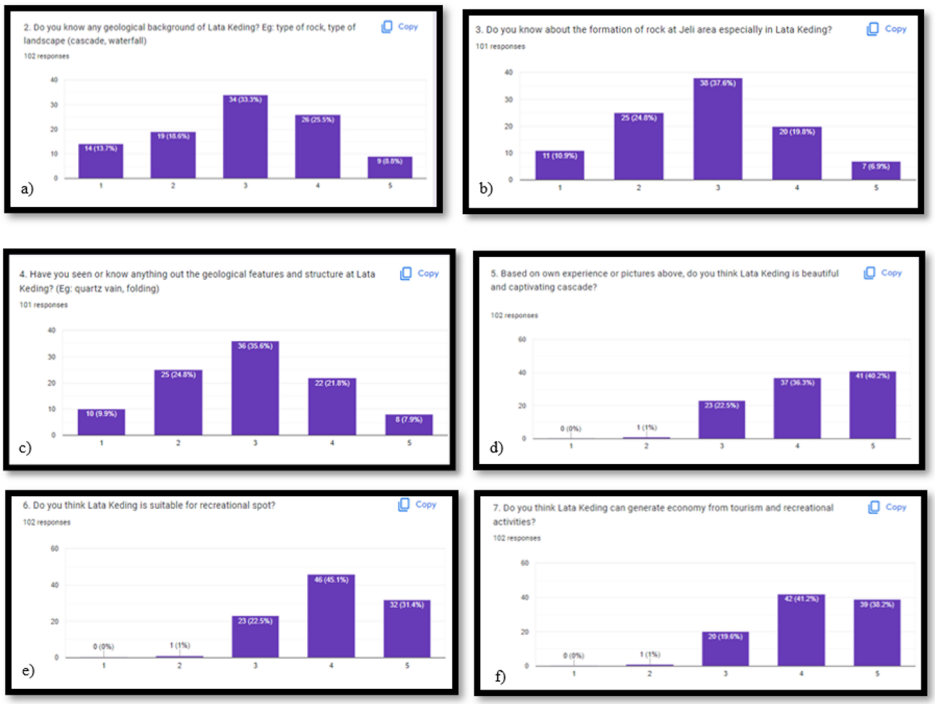

Figure 2: The question for the survey distributed to participants; a-c) question about scientific value, d) question about aesthetic value, e) question about recreational value and f) question about economic value.

Figure 3: Few views of Lata Keding from geological and geoheritage perspectives; a-b) the intrusion of the quartz vein in hornfels outcrop question about scientific value and c-d) the stunning cascade waterfall of Lata Keding.