Study of geotourism development in Batumilmil Karst, Langkat, Sumatera Utara

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Abstract. Karst of Batumilmil comprises many unique geomorphological features such as caves, rivers, and mountainous ranges. Situated at the outskirt of the Biosphere Reserves of Leuser National Park, this area is wide open for geotourism development. This paper aims to study the potencies from Karst of Batumilmil to be developed into geotourism. Using data obtained from field surveys and visualized by Geographic Information System, we can find and design the recreational resources and formulate the development strategies toward them. Our study finds six caves as the main geotourism sites for activities like cave exploration and combined with the jungle tracking and river tubing as the secondary or supporting tourism attraction. Each cave has its characteristics that determine the geotourism activities and the carrying capacity. We also discover that each cave provides high scientific values, showing how the geological process of uplifting to form three cave levels. We conclude that Karst of Batumilmil has huge potential to be developed as geotourism destination with the strategy for this development consists of satisfying sustainability, serving educational purposes, and also balancing environmental, physical, and mental health.

1. Introduction

Indonesia has vast and numerous karst areas. With their uniqueness and breathtaking scenery, karst areas in Indonesia contain high value to be developed into a tourism destination. Several karst areas, namely Karst of Gunung Sewu, Karst of Maros, and Karst of Sangkulirang-Mangkalihat, have successfully become tourism destinations and worldly known for their unique features including caves, hills, gorge, underground river, and the beach. Tourism activities at those karst areas boost both regional and local economies [1, 2]. Another promising karst area to emerge as a tourism destination is Karst of Batumilmil, Langkat, North Sumatera. Karst of Batumilmil was legally established as Langkat Karst Landscape Area through Energy and Mineral Resources Ministry Decree Number 18 Year 2018. In the Indonesia karst management, it implies that Karst of Batumilmil is a protected area and the landform modification is prohibited. This karst area is located in the outskirt of the famous Leuser Biosphere Reserve and is one of the parts of the larger Leuser’s ecosystem which makes the biodiversity in this karst area is very rich. Because of its status as a protected area, there is a limitation for the activities within Karst of Batumilmil. Hence, tourism activities are the appropriate utilization comprises of community empowerment and
tourism object development. However, the tourism activities still have to be adjusted to enhance the sustainability of the karst area by involving the local community and prioritizing the carrying capacity. It should enable the community to collect income while at the same time, protecting the landform and the ecosystem services from the karst area which many of them are threatened by human activities [3]. Karst of Batumilmil faces several imminent threats including large palm oil plantations, impacting the biodiversity values [4]. The batumilmil limestone is also categorized as high-quality limestone for the cement industry and hence holds a very high economic value [5]. The value and quality of the limestone attract illegal quarrying from large corporations or small-scale. Therefore, it is very critical to formulate a strategic conservation plan for Karst of Batumilmil. The karstification process provides a significant scientific value of karst, particularly in Karst of Batumilmil, and also enhances the aesthetical and recreational values. By combining those values with the tourism activities, it could become another attraction for the visitors. The combination is able to be done under the geotourism framework where it constitutes from geodiversity value and educational content with a high awareness on sustainability. Karst terminology itself refers to a specific landform with many approaches [6]. Nevertheless, historically speaking, karst is related to a landform, therefore it is a geological-geographical feature. The geological aspect of karst fits with the geotourism framework because geotourism is built above the geological aspect [7]. The practice of geotourism globally had emerged from the first time it was coined [8]. With their unique value, karst landscapes share a 37% portion of the global geopark [9]. In Indonesia, geotourism can be experienced in a dedicated area such as geopark or geoheritage sites [10, 11]. An example of karst geopark in Indonesia is the UNESCO Global Geopark Gunung Sewu. Within the geotourism framework, the significant value of the karst area is expected to be preserved.

This study aims to examine the implementation of geotourism at Karst of Batumilmil and the development it requires. To fulfill that objective, the paper raises the questions of (1) how is the geotourism potency of the Karst of Batumilmil? (2) how are the development and the planning?

2. Methods
We conduct geodiversity inventory and link the geodiversity into a concept of significant value. The qualitative data were obtained using field survey and observation and then analyzed to formulate the relation of geodiversity and the significant values as the basis of geotourism development in the study area.

2.1. Research Location
This study takes place at Karst of Batumilmil. Administratively, this karst area is located at Batujongjong Village, Bahorok District, Langkat Regency, North Sumatera. Karst of Batumilmil is mostly covered with dense low rainforest. Geologically, karst of Batumilmil is compounded by Batumilmil Formation, a Triassic limestone of crinoidal floatstone and part of the Peusangan Group [12, 13]. Limestone in Batumilmil Formation contains micrite, cement-sparite, and fossil minerals with the facies ranging from mudstone to wackestone [14]. The uplifting process caused by tectonic movement exposed the limestone and initiated the karstification process. The result of the karstification process in this area can be seen from the caves which were formed in ancient and are still going on now with the deposition of stalactite and stalagmite inside the caves [12]. In this research, we surveyed the eastern part of Batumilmil karst and gradually move north and along the trail, exploring caves and the low rainforest of Leuser Ecosystem. 6 caves were explored and studied to reveal their value and consisted of: (1) Pupukmentar Cave, (2) Belin Cave, (3) Air Cave, (4) Baturijal Cave, (5) Palonglong Cave, and (6) Bayak Cave. We also examine the geotourism potency of Berkail River.
2.2. Data Collection
To answer the research questions and objectives, we gather both primary and secondary data from various sources. The primary data were obtained using a field survey from observation and direct measurement. For the geotourism development purpose, we need the potency and the uniqueness of the study area, and these aspects were collected using purposive sampling in the particular landforms which boldly signify the karst area including caves, springs, doline, gorges, and karst hills.
To view the geodiversity value and the geotourism potency, 6 caves in this research were plotted and mapped. Cave mapping was done by using cave mapping techniques including measuring the dimension and the direction of the cave passages, documentation, and listing all of the features in the particular caves. To create a holistic condition of the cave, this study also incorporates biota as an integral part of the cave geoecosystem. Data of the biota were accused from direct observation and morphology to identify the genus or species of the certain biota. The location of the biota was also used for zoning management as part of the biodiversity conservation strategies.
The secondary data were collected from several sources such as government agencies comprised of Geological Agency for the geological formation and lithology, Geospatial Information Agency for the land use, DEM, and infrastructure, and local authority for the general characteristics of the study area. We also study several previous studies to get additional data or information on the Batumilmil karst.

Figure 1. Location of the study. The research location takes place in Langkat Regency, Sumatera Utara in the outskirt of Leuser Ecosystem
2.3. Data Analysis

We use qualitative data, taken from the direct observation and documentation to build a comprehensive description of the significant value for each site and how it could be developed into geotourism or geosites. The notion of values in this study is derived from the concept of Outstanding Universal Value (OUV) from World Heritage of UNESCO [15] and we categorized the values into geological and geomorphological, biodiversity, and cultural value depends on which of environmental elements the values hinge. to compound the justification, we challenge and contextualize the description with the concept of geotourism. we extract the core parameter of the geotourism including geological uniqueness, genesis, and how those features represent the whole Karst of Batumilmil area as the integrity. afterward, we formulate the tourism activities as the operational recommendation to implement the geotourism development.

3. Results and Discussions

3.1. Significant Values as the Basis of Geotourism

The uniqueness in each cave or karst landform in the Karst of Batumilmil is the foundation of the significant value where it contains the importance and benefits the people of the community around. The significant value on the geological and geomorphological feature according to the OUV concept must have the intactness and the integrity of the area.

3.1.1. Caves Sites

Each cave from the 6 caves we surveyed reflects the geological process that happens in the Karst of Batumilmil. Because most of the cave location is far from the settlement, they mostly remain wild and pristine; no heavy or anthropogenic destruction was encountered. the exception only prevails at Bayak Cave because its location is relatively near the village hence, many people could easily reach it, several vandalisms were found in many parts inside this cave. Belin Cave contains a multi-level passage with many solution pockets on its ceiling. the presence of the multi-level passage and the solution pocket indicate the uplifting process and the cave passage enlargement from the erosion by the underground river system. Belin Cave foretells the process that once occurred and shows the graduation of the uplifting and the water tables dropping along the time. Belin Cave also serves as a habitat for Stenasellus sp., a rare cave crustacean and is hypothesized to come from seawater but because of the uplifting process, they were carried away and then adapted with the freshwater environment inside the cave. Another cave example such as Air Cave also exhibits the integrity and the processes that are still ongoing. the growth and development of the stalactite and the stalagmite in this cave become the sign of the dissolution and deposition of calcite minerals as the process of karstification. the growths of speleothem were also found in several caves other such as the Pupukmentar Cave and Baturijal cave.

3.1.2. Berkail River Sites.

This river has been opened as one of the tourism at Batujongjong Village and has been running for years. the operator comes from the local community, and they have sufficient equipment to support the tubing activity such as buoyancy and the tube itself, the water source of this river is located far upstream and along with the river flow, many springs charge the water flow. Berkail River has a linear form in several areas and represents the geological structure in this area such as the fault. Karst of Batumilmil and Sumatera Island in general is situated in one of the most active tectonic zones of the Great Semangko Fault, stretching from the northern tip of Sumatra Island to the southern one. This tectonic movement, combined with the erosion of the water, craving the land surface into depression, including lakes and rivers.
3.1.3. **Karst Springs.**

There are at least 20 springs in Karst of Batumilmil with various types and sources of water. These springs provide a very critical water source for the community in the study area. The usage of the water from the springs is optimized by the locals by constructing supporting infrastructure such as the pipe, dam, and artificial reservoir. Karst springs formed from the water infiltration into the aquifer system and charge the conduit network beneath the karst underground. The water then comes out where the ground level is lower than the water table. The springs reflect how the unique conduit aquifer and hydrological setting in the karst work.

3.1.4. **Lowland Rainforest.**

Forest in this area is the result of the interaction between the soil that comes from the weathering of the bedrock and the seeds that grow into trees, full filling the area to become a dense rainforest. Rainforest in this area is part of the bigger Leuser Ecosystem, a respected rainforest ecosystem and one of the global natural reserves. Leuser Ecosystem is home to high biodiversity and supported by the geological setting of the Karst Batumilil. The limestone of Batumilil Formation provides a critical calcium mineral to support the tree growth and the water from the retention in the limestone becomes the source to the large animals. Many endangered species such as Sumatran Tiger (*Panthera tigris*) and the *Amorphophallus titanum* seek refuge from poaching and illegal trading.

**Table 1. Geodiversity Feature and Significant Value**

| Feature       | Sub-Feature | Intactness                  | Integrity                                                                                                                                  | Values                                      |
|---------------|-------------|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Caves         | Belin Cave  | Mostly intact               | The multi-level cave passages; indicating uplifting and water-table dropping                                                               | Geological value, scientific value          |
| Air Cave      |             | Mostly intact               | Form of the cave passages showing the geological structure and the water flow-induced landform                                             | Geological and geomorphological value, aesthetic values |
| Bayak Cave    |             | Disturbed by vandalism and partially destructed due to human visit | Three-level passages indicating bedding plane and the geological structure                                                                 | Geological and geomorphological values      |
| Baturijal Cave|             | Mostly intact               | Serves as habitat to *Stenasellus sp.*                                                                                                    | Biodiversity value                          |
| River Berkail |             |                             | Signifying the geological structure as the result of tectonic activities                                                                     | Hydrological value                          |
| Karst Springs |             |                             | Shows the conduit network character of the karst hydrological setting                                                                      | Hydrological value                          |
| Lowland Rainforest |       | Natural reserve for rare and endangered | Encapsulating how the geological settings of                                                                                              | Biodiversity value                          |
Feature | Sub-Feature | Intactness | Integrity | Values
---|---|---|---|---
species such as Sumatran Tiger and Giant Flower. | Karst of Batumilmil support the forest and ecosystem |  

| (a) | (b) | (c) | (d) |

**Figure 2.** (a). Entrance of Belin Cave with the underground river as the attraction, (b). Tracking in the jungle before reaching the cave entrances., (c). *Scutigera sp.*, a cavernicole lives in the cave, (d) Solution pocket, a speleogen feature that signifies the saturated zone in the passage.

### 3.2. Implementing the Geotourism Concept

Geotourism encompasses the element geological with the spirit of preserving and conservation [7]. As the implementation, this type of tourism consists of education, economic, and conservation aspects [16]. The geotourism in Karst of Batumilmil is embodied for each aspect within the tourism activity. The educational aspect is fulfilled by providing the geoinformation from the interpretation of the guide and the information board. The geotourism aspects and activities should be focused on the selected geosites [17, 18]. Geosites are the “geological ambassador” which represents the geological uniqueness of the area. Regarding the human resource, the role of the guide and interpreter in the tourism process and activities are fundamental hence the human resource in this aspect must be ensured. Moreover, the guide also must act as the guardian for the tourist because of the risk and the danger from the tourism activity. The educational aspect in Karst of Batumilmil is supported by the richness of the features available hence, it is important to make sure the tourism activity covers most of the geological and geographical story in this area [19, 20]. Economic and conservation aspects could be paired along within the geotourism. The economic aspect of the community is nurtured by the tourism industry, enhancing
income for the local community. As tourism becomes the source of income, the community will conserve the natural resource.

3.3. **Geotourism Activity Planning**

In tourism planning, especially geotourism, it is essential to arrange tourism activities to offer the guests a glimpse experience of the attractive sites and the knowledge as part of education in geotourism [21]. Education aspect can also help achieve sustainable development as studied at Pangandaran and Germany, as examples [22, 23]. From the managerial aspect, the arrangement will also make it easier for the manager to design tourism content, satisfy tourist demands, and estimate the costs required for these activities as shown by Ginting and Febriandy [24]. It also supports the concept of eco-edu-tourism which will conclude the information of sustainable objects so that the visitors can obtain a set of holistic knowledge about the site. From an ecotourism or geotourism perspective, tour packages could also localize tourism activities, so that the residents near tourist sites are becoming more aware of their ecological importance and environmental issues around their locality.

The Batumilmil karst area has several potential geotourism attractions that are mutually supportive and related to each other. Berkail River, which runs from the Leuser Mountain Range and passes through limestone rocks, functions as the main tourist attraction. Its significance supports the ecosystem and biodiversity around the region. Thus, it provides potential tourist attractions that can be used as the elements inside a tour package. The element goes as follows: water tourism; cave exploration; and biodiversity jungle tracking.

3.3.1. **The Jungle Tracking.**

The jungle track highlights the forest exploration activity in Batu Jongjong Village. The trail starts from the Tourist Information Center and ends in Belin cave entrance. Along the routes, tourists are invited to relish the tranquility of the pristine forest of North Sumatra. The whole activity will be accompanied by a guide as an explainer, and a porter whose job is to carry the provisions. The main objective of the trip is to acquaint visitors with the biodiversity in North Sumatra, namely in Leuser landscape. The guides will bring the narratives of the regional ecosystem as a whole, along with the significance of the existing flora and fauna along the trail. *Amorphophallus titanium,* for example, is one of the exotic plants that can be found along this trail. It is an endemic flowering plant from Sumatra with the largest unbranched inflorescence in the world.

3.3.2. **Show Cave.**

Batumilmil karst area has three caves that are considered interesting to be displayed to the general audience, a tourist who wants to visit caves merely for entertainment purposes without bearing the high risk of an adventure. The main cave attraction is Gua Belin which endows the natural feature of underwater passage and chambers decorated with limestone ornaments. Once the tourists finish exploring the Belin Cave, they are allowed to choose one cave as the destination for the next tour. Two available options are Gua Air; and Gua Pupuk Mentar. The main distinction between these two is their physical characteristic. Gua Air is a subterranean river that is still actively undergoing a solutional process, whereas Gua Pupuk Mentar is a dry cave with a little occurrence of an intermittent river inside.

3.3.3. **Adventure Caves.**

Tourists will have the chance to explore all the existing caves. The trip starts with jungle tracking to Belin Cave. On the first day, tourists will be directed to visit Belin Cave and Pupuk Mentar Cave. After that, they will return to the shelter owned by *Yayasan Ekosistem Leuser* to stay overnight. The trip continues on the next day for a full-day exploration of the Gua Air. Starting from its outlet, tourists will continue moving upstream along the subterranean river until it exits at the inlet of the Gua Air cave. At the end of the cave exploration, tourists will have a long break for lunch and jungle tracking preparation. Tourists will take the western jungle route to return to the village. Otherwise, tourists can take the motorbike option through the logging trail.
Figure 3. Maps of geotrail in the Karst of Batumilmil. Geotrail ensures visitors reach all of the geosites as the representation of the geological characteristics hence, it is designed to connect all the caves through the river as the geological feature.

4. Conclusion
Karst Batumilmil has fascinating geological features with limestone host-rock, crafting karst geomorphology either in the surface or in the subsurface such as karst hills, karst springs, and the caves. All of those features record a geological process for million years and contain much significant value including geological value, hydrological value, and ecological value. These values are the basis for the landscape utilization and conservation framework. A more detailed assessment of the values of the Karst of Batumilmil could be done using the integrity and the intactness which show how most of the sites and the objects are still intact. The most appropriate utilization for this case is tourism especially the geotourism one.

Nevertheless, the implementation and the development of the geotourism are still needed to be improved. To do so, a geotourism activities are designed by choosing the activities at each site such as jungle tracking, spelunking, and river tubing. These activities are expected to raise awareness and knowledge as part of the educational aspect and run the tourism industry, sustaining the local’s economy.
and preserving the landscape. All of the geotourism activities are integrated using a geotrail that integrates all of the geosites in the area.

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