LINKING GEODIVERSITY AND CULTURAL DIVERSITY IN GEOHERITAGE MANAGEMENT: PRACTICE FROM KARST OF SANGKULIRANG-MANGKALIHAT, INDONESIA

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Abstract: We aim to construct a relationship between geodiversity and cultural diversity in Karst of Sangkulirang-Mangkalihat and contextualize the relation into a geoheritage management scheme. We use the Landscape Characteristics Assessment and field survey to characterize the geodiversity and cultural diversity, aided by GIS. The materials are DEM, geological maps, and administrative maps. For the analysis, we employ the significant value approach to achieve the purpose of the study. The diversity inventory unveils many significant geomorphological and cultural features with remarkably beauty, exceptionally rare, and sustaining local communities. The linkage between geodiversity and the cultural diversity in the area has unique entities that must be addressed in the management of the area, either as a World Heritage or Geopark. Linkage between geodiversity and cultural diversity is the main key and most fundamental aspect to establish the geoheritage and develop geotourism which benefits the indigenous community and preserves the significant values and integrity of the Karst of Sangkulirang-Mangkalihat.

Key words: geodiversity, cultural diversity, significant value, geoheritage, Karst of Sangkulirang-Mangkalihat

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INTRODUCTION

The Karst area has various important values that make this landscape must be managed properly (Williams, 2008). As a geo-ecosystem, karst has multi features including lithology, hydrology, ecology that interact with each other both in the surface and sub-surface area of the cave, providing geo-ecosystem services (Gray, 2019). The interaction among karst elements occurs through the dissolution as the limestone as the karst host-rock is highly soluble. This process physically crafts the karst landscape, producing unique landforms such as doline, logva, polje, and the caves. The ecosystem services and uniqueness of the karst landscape and karst landform become a crucial element in compounding the value of the karst area, including the aesthetic of the landscape (Spate and Baker, 2018). Values in the karst landscape are then grasped together in the geoheritage notion. The geoheritage is a terminology interconnected with keywords such as geodiversity and geo-conservation. this notion was coined in 1991 and had been interpreted into several key concepts ever since; including what values the geoheritage was built upon (Mantovani et al., 2021) whether it was the economic (Brilha, 2016), tourism (Štrba et al., 2020; Paungya et al., 2020), or scientific (Çetiner et al., 2018). Therefore, in the context of the karst area, considering the values it conceives, it is reasonable to include karst as part of the geoheritage as it has a high scientifical value, has a strong relationship with a human, and it is highly potential to be developed into tourism sites (Čech et al., 2021). The values of karst and the geoheritage aspects, including the aesthetical, are brought into practice by designing karst landscape into a dedicated area that conserves the karst ecosystem while sustaining human livelihoods such as national park and nature reserve (Telbisz and Mari, 2020; Restificar et al., 2006; Ballesteros et al., 2019), or the most recent trend, The Geopark. Geopark stands above three main pillars: education, conservation, and local economic development. Those three pillars are integrated and unified into the geotourism (Ranjbaran et al., 2020). This type of

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tourism accentuates the geological-geographical features in a particular area to be a tourism attraction. Within the tourism activity, visitor education is delivered to enhance the awareness of the value of the karst area.

In Indonesia, the interest to develop geotourism within geopark areas is also increasing (Bhinekawati et al., 2020). The first area that was enacted as geopark was Batur Caldera Geopark in Bali then entailed by the Karst of Gunung Sewu, Merangin Area (Wibowo et al., 2019), Toba Caldera (Ginting et al., 2021), and Karangsambung-Karangbolong Geopark. This increasing trend is a response to the national policy which leveraged the tourism industry to be a primary sector for national GDP and the recognition of Geopark through the President Decree Number 9 Year 2019 About Geopark. This phenomenon also happens in almost notable karst areas in Indonesia where several significant areas hold remarkable geological values such as Karst of Gunung Sewu, Karst of Maros, and Karst of Sangkulirang-Mangkalihat. The last contains a very high multivalue including the cultural value of the ancient rock art (Chazine, 2008), biodiversity with endemic and endangered biota (Salas et al., 2005), and the geodiversity of morphology, hydrology, and lithology of the karst. Karst of Sangkulirang-Mangkalihat also undergoes heavy pressure from massive agroindustry of Palm Trees, extractive limestone quarrying, illegal logging, and overcapacity tourism (Pasan, 2019). All those pressures disturb the ecosystem dynamic and eventually the livelihood of the people within the karst area or those who live in the peri-karst zone. Ultimately, those pressures will also demolish the significant value of Karst Sangkulirang-Mangkalihat.

Significant values of karst, particularly in Karst of Sangkulirang-Mangkalihat is a foundation to explain why the karst is important and must be conserved to the stakeholder. In this context, the conservation is done through geo-conservation derived from geoheritage concept. In terms of karst management, the significant value could be a precious resource to formulate the exact policy and zoning of the karst. This paper is constructed on the concern of how significant value could play an imperative role in karst management, especially geoheritage as the part of geo-conservation and geotourism (Williams et al., 2020; de Sena et al., 2022) and spotlighting Karst of Sangkulirang-Mangkalihat as the example of how this notion could be implemented. The goal of the research, accordingly, is to analyze both geodiversity and cultural diversity in the Sangkulirang-Mangklihat karst within the geoheritage framework. In the future, this study is anticipated to give a novel insight into linking geoheritage with geodiversity and helps to establish the status of an area for better management.

MATERIALS AND METHODS

Study Area

The research was conducted at Karst of Sangkulirang-Mangkalihat. This karst area is located at N 1°9'39" E 117° 9'32' situated at the Mangkalihat Peninsula, Kalimantan Island and administratively at the Berau and Kutai Timur Regency, Kalimantan Timur Province. Covering almost 362.706,11 ha, Karst of Sangkulirang-Mangkalihat consists of several blocks namely Mangkajang, Tebo-Kulat, Ambulabung, and Batu Putih block (Haryono et al., 2017; Reinhart et al., 2020). Lithological setting and geological formation variations affect the characteristic of each block, differ from one block to the others. The inner blocks of Tebo-Kulat, Tondayan, and Mangkajang exhibit peaky conical karst with thick limestone and could reach 150 meters in elevation while the outer-coastal blocks of Batu Putih have rounded and lower conical karst.



Karst of Sangkulirang Mangkalihat enters the tentative list at World Heritage Center, fulfilling criterion (iii) of remarks from vanished civilization. The remarks from the vanished civilization are the famous rock art as one of the earliest prehistoric artifacts from 100–40.000 BP and scattered in 49 archaeological sites (Sumantri et al., 2017; Aubert et al., 2018). Sangkulirang-Mangkalihat rock art represents a contact of pre-Austronesian and Austronesian migration. Karst of Sangkulirang-Mangkalihat can be seen in Figure 1.

Data Collection

To collect and obtain the geodiversity as the main source of the analysis, we use a holistic and rapid approach of Landscape Characteristic Assessment (LCA). This method is also utilized to formulate the value and interrelation of the component in the karst area, incorporating physical and cultural elements in the landscape. LCA is also compounded by spatial contents, making it easier to be translated into spatial and land use planning on the landscape scale (Jellema et al., 2009; Ding et al., 2020) and comprises 4 steps of defining purpose and scope, desk study, field study, and description from the studied landscape (Tudor, 2014; Gkoltsiou and Paraskevopoulou, 2021). The participative method involving community can also be added to one of the steps in the LCA (Koblet and Purves, 2020).

The initial step is defining the purpose and scope of the study of which determines the significant value of Karst of Sangkulirang Mangkalihat as the study area. Significant value could help prioritize areas for landscape management (Gartner et al., 2008; Mikkonen and Moilanen., 2013) for more effective geoheritage management. Afterward, we conducted the desk study to compile the secondary data and prepare for the field survey. We brought together data from the physical characters of lithology, morphology, hydrology and the cultural contents of history, demography, economy, tradition, rite, and the heritage at the study area. The spatial element of physical feature distribution, administrative boundaries, and utility and infrastructure availability were also examined supported by the base map data from Inageoportal and geological maps from the government body of Information Spatial Agency and Geology Agency.

After preparation of the data in desk study, a field survey was conducted to verify the collected data and discover information that was unavailable in the previous study (Bartlett et al., 2017). We conduct a field survey in the Karst of Sangkulirang Mangkalihat in August and October 2016. The field survey was employed to obtain multi aspects of significant values of geodiversity and cultural diversity. For the geodiversity, the characters of the landscape were observed using direct measurement and observation in the field, constituted of geology by studying the lithology, geomorphology by measuring and determining the karstic landform, and hydrology by tracing the hydrological system.

Data Analysis

1. Significant values of each block in Karst Sangkulirang-Mangkalihat

The concept of value on a landscape can be divided into use and non-use value. The latter is arguably more intricate to be measured and identified because it is non-tangible (Pereira et al., 2021) and subjective if it is addressed to the aesthetic value (Kalivoda et al., 2014; Kerebel et al., 2019; Schirpke et al., 2021). Therefore, to study the landscape character and values within it many approaches had been developed each with its advantages and disadvantages. To boldly discriminate the non-use from use-value, we derive the terms of significant value from the concept of UNESCO's Outstanding Universal Value which is commonly applied to assess the world heritage (UNESCO, 2008) and divided into ten criteria. These criteria are used to determine the significant value on each block in Karst of Sangkulirang-Mangkalihat.

The significant values are relied upon the inventory of the geodiversity and cultural diversity and seek the uniqueness of the 'no-other'ness feature as the main concern for the significant value of the geoheritage. This analysis is also an effort to construct the linkage between the geodiversities with the cultural value (Yusry et al., 2018; Ibáñez et al., 2019). The scientific values are also applied to justify the criteria of representativeness of geological and biological processes and the use-value of the karst ecosystem in terms of sustainable relation and basic livelihood of the community as the cultural landscapes in the coexistence with geodiversity (Gordon, 2018). Each block of the Karst of Sangkulirang-Mangkalihat performs as the host for the significant value due to the diversity on each block. This is implied in the main theme and targets which were surveyed. Some blocks were marked for their geodiversity while the others were highlighted for their cultural diversity. We translate diversity into significant value by simply interpreting and elaborating the reason it is important using the concept of value. To serve the translation, we use the how-why matrix wherein the 'how' lays the existing, 'as it is condition and the 'why' column, we put the justification of the significance or the importance.

2. Assessment of Geodiversity Value

The OUV of geodiversity relies on several justifications including the importance of the site and stewardship of the objects toward their surroundings (Rosengren and Petersen, 1989; Dudley, 2008), exceptional beauty, or scenery, and represents the high importance geological process. Drawing from the justifications earlier, the assessment of the value of geodiversity could be divided into four priority levels and can be seen in Table 1 below.

No	Level of	Table 1. Classification of Significance of Sites
	Significance	Details
1.	International	The sites or objects fully represent the landform or geological process of the global geology and can not be found
	/ Global	everywhere else
2.	Regional	The sites or objects signify the geological process within national boundaries and represent the regional geological process
3.	National	the sites or objects have similar characters with other sites within the national boundaries
4.	Local	This category includes the sites or objects that only represent the local geological or ecological phenomena

Based on that categorization, we elaborate qualitatively on how sites or objects in the Karst of Sangkulirang-Mangkalihat holds value. We also conduct the comparation among karst-type geoparks (Ruban, 2018) globally to comprehend the significant values of Karst of Sangkulirang-Mangkalihat matched with other karst areas. The research framework is shown in Figure 2.

RESULTS AND DISCUSSION Results

1. Diversity of Karst of Sangkulirang-Mangkalihat 1.1. Geodiversity of Karst of Sangkulirang-Mangkalihat

Karst of Sangkulirang-Mangkalihat is fragmented into several blocks, each undergoing a different geological/geomorphological process, yielding unique features on each block. From the lithology, there are three main limestone formations on the Karst of Sangkulirang-Mangkalihat. Lembak Formation compounds the inner

block of Tebo-Kulat, Ambulabung, Tondayan, Mangkajang, and Gergaji Block. In the coastal, the limestone that forms the karst block is the limestone of Domaring Formation. Lembak Formation is a Late Oligocene-Early Miocene limestone and consists of Napal



Figure 2. Research Framework

and limestone with the thickness reach 2000 m meanwhile the Domaring Formation is younger and formed in the late Miocene-Pliocene era and mounts the coastal block of Batu Putih (Burhan and Situmorang, 1995; Sukardi et al., 1995).Limestone or carbonate rock is highly soluble and the dissolution begins when the deposition of the reef and coral which composes the limestone are exposed to the surface. The expose is caused by the uplifting process as the result of tectonic movement. The uplifting process in the Karst of Sangkulirang-Mangkalihat can be seen by the variety of geological structures including fault, joint, crack fissures, and terraces. There are three major plates and three minor plates which interacted with each other. Generally, the structure in the Karst of Sangkulirang-Mangkalihat is mainly a strike-slip that continues to Palu, Sulawesi Island. Karst of Sangkulirang-Mangkalihat is also bounded by two major faults of the Maratua Fault in the northern part and signed by the lineament of the northern coast of Mangkalihat Peninsula. The other fault is Mangkalihat Fault that separates Mangkalihat Highland from the Kutai Basin and the presence of this fault can be seen through lineament at the Sangkulirang Bay.

The lithology of limestone, geological structure activities, and the rainfall that induces karstification craves Karst of Sangkulirang-Mangkalihat, yielding a unique landform (Reinhart et al., 2020). Karst area is fundamentally a geomorphological term and arranged by particular landforms including doline, polie, karst hills, caves, and ponor. Composition of the morphological features resulting in the varieties of the karst type in Karst of Snagkulirang Mangkalihat. Each block displays a particular type of karst. It can be viewed from the Digital Elevation Model (DEM) that Karst of Sangkulirang Mangkalihat has several types of karst including turmkarst, kegelkarst, polygonal karst, and labyrinth karst. Turmkarst and kegelkarst are the types of karst proposed by Sweeting (1972) and are commonly found in tropical areas where the limestone is thick with abundant rainfall. Turmkarst morphology can be seen at Ambolabung-Nyere-Tutunambo, Tondoyan, Gergaji, and Merabu blocks. Turmkarst is also insinuated by the presence of conical karst and could reach 240-300 meters high with narrow and steep valleys. Besides turmkarst, Karst of Sangkulirang-Mangkalihat also shows kegelkarst especially at Batuputih and Biduk-Biduk block. Kegelkarst is formed where several hills are aggregated because of high intention and all-direction erosion with little control from the geological structure. Several blocks also have polygonal karst (Haryono et al., 2017) characterized by the intersected valleys and formed because of the more intense fault and fractures. Polygonal karst could be detected in Suaran, Sekerat, and Tabalar Blocks. Karst of Sangkulirang-Mangkalihat also has hundreds of caves and could be found in most of the blocks with diverse types. Caves in the inner block have more vertical passage than caves in the coastal due to the thickness of limestone and structural control. From the cave morphology, there are several typologies of cave passages including anastomoses, spongework, angular, and curvilinear.

1.2. Cultural diversity of Karst of Sangkulirang-Mangkalihat

Humans had occupied Karst of Sangkulirang-Mangkalihat for thousands of years and their culture evolved along with the understanding and knowledge toward its environment. Through culture, humans could extract resources from the ecosystem and organize themselves into society to increase efficiency and survival. Culture could be sensed through several elements such as folklores, legends, rites, traditions, and languages (Koentjaraningrat, 1987; Moore, 2009). All of those elements together construct cultural diversity. The indigenous people of Kalimantan Island are the Dayak and consist of hundreds of tribes. Dayak is inferred to come from Yunnan, China due to the similarity in their appearances and traditions. In Karst of Sangkulirang-Mangkalihat, Dayak comprises the Kenyah, Basap, Kutai, Ga'ai and Punan and each of them has dialects and self-identification. The self-identification brings sign and context to their presence, especially when facing the newcomer of Javanese or Buginese. To apprehend their origin, some Dayak group narrates certain folklore such as the Basap Lebbo at Pannan village which perceives that their ancestors are man and woman that came from bursting Nyamur wood. That couple had 8 descendants named Tengarang, Kamahankan, Kajirun, Seput, Lulu Mangas, Kamarua, Hangkuris, and Trom. Another version tells that the Basap Lebbo's ancestor spread to the Karst

of Sangkulirang-Mangkalihat because of the tribe war which is commonly found in the Dayak. Dayak has a tradition of *mengayau* or head-hunting as the symbol of honor and bravery. Indigenous communities in Karst of Sangkulirang-Mangkalihat also have several rites as their way to celebrate or commemorate certain phenomenon. One of the common rites is the Erau or Nembang Taun as the tradition to be grateful to god for the crops and food resources. Kenyah Tribe in Karst of Sangkulirang-Mangkalihat also has *melalok/ngelaung* tradition and utensils such as *anjat*, a rattan-weaved bag to carry crops; *tayeng*, a sleeping mattress; and *labung*, a hat for working in the field.

2. Significant Values of Karst of Sangkulirang-Mangkalihat

The geodiversity and the cultural diversity at the Karst of Sangkulirang-Mangkalihat offers unique and valuable elements to be preserved. By deriving the geodiversity and cultural diversity, we elaborate on why they are important as follows.

2.1 Geological Values

Karst of Sangkulirang-Mangkalihat as the geological phenomenon holds an irreplaceable role as the keeper of the history of geology. At least, Karst of Sangkulirang-Mangkalihat archives three main geological geneses: 1) fragment of the Gondwana, 2) frontside of Asia/Eurasia tectonic plate, and 3) the limestone facies from Makassar Strait ex tension. Karst of Sangkulirang Mangkalihat also has a unique morphological feature of chimney-formed karst hill with numerous other kinds of karst landforms and the folding karst structure. Both lithological and geomorphological values offer a significant value of geodiversity. Borneo or Kalimantan Island holds an indication to be a Gondwana fragment (Smyth et al., 2007). Metcalfe (1996) argued Mangkalihat Peninsula was a microcontinent that originated from the northern part of Gondwana and separated in the late Jurassic, shifting to the equator by the opening of the Ceno Tethys Ocean. This microcontinent then amalgamated with Kelabit-Longbawan from the northwest. Borneo Island also encloses the tectonic interaction between Asian plates with the Pacific and Indian-Australian and could be traced from the stratigraphical column and structural patterns. The oldest rock in this region is Jurassic Ophiolite, laying in the southern part of Muaralasan as part of the Sangkulirang-Mangkalihat system. Limestone as the hostrock of Sangkulirang-Mangkalihat karst was formed when the rifting of Makssar Strait on Mid-Eocene. This rifting was then continued by tectonic inversion triggering the uplifting process which exposed the limestone to be Sangkulirang-Mangkalihat highland. The oldest limestone from the Eocene era is located in the western part and becomes younger as nearer to the coastal area.

From the geomorphological point-of-view, The Sangkulirang-Mangkalihat karst presents high diversity of karst landform as each block has a specific one such as labyrinth-cone karst on Suaran Block, Conical Karst in Tebo-Kulat and Tutunambo-Nyere; and the conical karst on Batuputih block near the coastal area. Karst of Sangkulirang-Mangkalihat also has uncommon chimney-shaped cone karst hills. This landform is distributed in the inner blocks of Tebo-Kulat, Ambulabung, and Tondayan. The genesis of this karst hill remains unknown and very little researches have ever been conducted to study this feature. Another intriguing geomorphological feature in the Karst of Sangkulirang Mangkalihat is the karst of plateau and folded setting as the indication of different geoprocesses.

2.2. Speleological Values

Caves are the exceptional features in the karst area as the main outcome of the dissolution and karstification process. The speleogenesis process or formation of the caves is heavily affected by the presence of fissures or the geological structures, the chemical composition of the limestone, and the rainfall, and the interaction among those factors could be traced back from the cave morphology, features, and deposition. This is the significant value of caves as they record the geological process. In some blocks, the speleogenetic process happens in a multi-level, archiving the uplift history of the area, with a combination of vertical passages as the result of vertical fissure and horizontal passages as the result from the paleo water level. The multi-level speleogenesis reveals the evolution of the karstification process and helps the scientist to build geochronology of it. For example, multi-level caves in Melawang Hill, Mangkajang Block consists of 4 layers of nearly horizontal passages. The lower passages have thick clastic sediment and notch indicating a paleo hydrological system of the karst area during the warmer period. Caves in Karst of Sangkulirang-Mangkalihat also accommodate swiftlets to build their nest inside the solution pockets which are commonly found in the caves as the result of the phreatic phase inside the cave passage. Food and nest materials for the swiftlet's nest are also abundant in the forest around the cave. The nest has an expensive commodity in the market and is harvested by the people for income. Its price could reach 15-25 million Rupiah for the white nest and 7 million for the black nest. The nest industry boomed and the 1990s before plummeted in 2002 due to overexploitation.

2.3. Hydrological Values

Karst is well-known for its capacity to discharge a significant amount of water. Its fissure-conduit structure functions as the aquifer and accumulates the water before discharges it to the surface through spring or caves. From the hydrological perspective, Karst of Sangkulirang-Mangkalihat has a crucial role in maintaining water resources as the basic need for the people. The surplus of water resources could be spared for future needs and reserved.

This area also holds a very essential part as the main watersheds of the rivers flowing downstream from Mangkalihat Peninsula. Springs in the karst area is the upper river course of the main rivers in the region (Fathoni et al., 2020; Widyastuti et al., 2018) not less than 6 main rivers of Tabalar River, Lesan River, Suaran Bengalon, Manubar Rover, and Karangan River heavily depends on Karst of Sangkulirang-Mangkalihat springs. Watershed and rivers in Mangkalihat Peninsula Region are the regulator of the ecosystem and sustaining community livelihood for generations. The rivers have been used for the domestic uses, food resources, and transportation for the people.

2.4. Cultural Values

Rock art has a significant value and shows human intelligence as well as their view toward the world (Nurdini et al., 2020). By learning how they perceived the world pictured on the painting, we could reveal the adaptation and, livelihood or even the environment around their dwelling cave (Aubert et al., 2019; Berrocal and Garcia, 2007).

As the contact spot of pre-Austronesian and Austronesian migration, rock arts at Karst of Sangkulirang Mangkalihat were painted by the hunter-gatherer communities and dated from 40 ky ago. The Austronesian migration which is indicated by the rock art at Karst of Sangkulirang-Mangkalihat shows how the cultural diversity in South East Asia (Bellwood, 1984; Tan, 2016; Tan, 2014) originally stems and also reveals how the Indonesian archipelago was once a bulk mass of land, enabling the Austronesian to migrate. Rock art is also discovered at South Sulawesi (Aubert, et al., 2019) and Misool (Leihitu and Permana, 2019), strengthening the theory of the Austronesian migration. Another cultural value that could be found in the Karst of Sangkulirang Mangkalihat is the *lungun* or the ancient burial sites. People in Karst of Sangkulirang-Mangkalihat created *lungun* in the cave for their relative's dead body and instead of burying them underground, the dead bodies were placed inside a cave or in *lungun*. This practice of *lungun* was constructed above a belief in which if the dead bodies were buried underground then the living would get bad luck or *memahing* in the local terms. *Lunguns* are scattered in many caves on Karst of Sangkulirang Mangkalihat. All of those significant values could be seen in Figure 3 and Table 2 to show the linkage between geodiversity and cultural diversity to the significant values.



Figure 3. Values of Karst Sangkulirang-Mangkalihat: (a) Tebo-Kulat karst block, one of Conical Karst in the Sangkuirang Mangkalihat (Geomorphological Value), (b) Chimney-Like Karst Hill in the Merabu Block (Geomorphological Values), (c) One of the cave in Tutunambo-Nyere Block (Speleological Values), (d) One of Rock art at Bloyot Cave, Merabu Village (e) Lake in the Polje of Tebo (Hydrological Value) (f) Cave burial (Lunguns) in the Long Lanuk Village (Cultural Value). All the photographs are courtesy of Karst Research Group, Faculty of Geography)

Aspects	Elements	Diversity (How's it?)	Significant Values (Why's it?)
	Geological	Limestone with the oldest formation is the ophiolite	Contains the fragment of Gondwana
	Geomorpho	Constitutes various karst morphology tipology:	Chimney-shaped as the unique feature and different
	-logical	- Polygonal karst; - Turmkarst; - Kegelkarst	from common karst hills
Geodiversity	Hydrological	al Spring, abundant water resource Water is a vital resource for humans and Kar Sangkulirang-Mangkalihat bestows a significant amou water. Karst springs in the Karst of Sangkul Mangkalihat function as the upstream for the main rive	
	Speleological	Hundreds of caves with various typologies including spongework, anastomosis, ramification, and various speleogenetic processes.	Rock-shelter cave is the location of the rock art as the main attraction in the Karst of Sangkulirang- Mangkalihat
Cultural	Rock Art 29 caves with rock art picturing hand painting		Sign of Austronesian migration One of the oldest signs of civilization & Palaeolithic cave art in Borneo
diversity	Traditions	Dances, rites, lunguns	 Signifies the relation between humans and the karst area <i>Lungun</i> shows the burial practice in the cave.

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2.5. Tourism Value

Visitors tend to be influenced by their perceptions in the choice of a specific destination site. Destination imagery is a multidimensional concept formed by cognitive and emotional assessments of a place (Martin and del Bosque, 2008). Such assessments can be made through direct experience of nature as revealed in numerous studies on environmental education. These, in turn, will have a significant impact on attitude and behaviour toward the location. The image and attitude towards a place are therefore highly critical because such dimensions will shape the motivation of people to visit a particular site. With the rise of the current trend from mass tourism to the concept of quality tourism, geological diversity attractions offer great potential for leisure as well as tours of special interest. Sangkulirang-Mangkalihat Karst is a place of interest, that can be developed into a tourist destination site, since the place attracts people due to its special features.

Table 2 above indicates the various wealth of knowledge that a visitor would attain once they visit Sangkulirang-Mangkalihat Karst. Areas rich in geo-cultural diversity, are currently in growing demand in Indonesia as nature-based tourism destinations as elicited in the Indonesia Presidential Regulation number 9 of 2019 on Geopark Development, thus have the potential to maximize the benefits of nature-based tourism for conservation. Furthermore, cultural attractions are statistically one of the strong points of Indonesian tourism (Sunkar et al., 2013). According to Sunkar et al., (2016), Community involvement is often motivated by local culture, which is at the root of the values, attitudes and lifestyles that contribute to the preservation of a the community's heritage. In this spirit, the conservation of the geological site should focus on the conservation of the geoheritage, knowledge and geotourism, which form the three objectives of a Geopark: conservation, education and geotourism (Sunkar and Brahmantyo, 2013). The geological diversity as shown in Figure 3 and Table 2 will form the basis for geoeducation for the visitors on the history of the Earth, geology in general and the actions needed to protect the environment and maintain diversity. Learning should be fun, not forced, so an informal form of education through recreational activities such as visiting a geosite could become educated. Reconnecting with nature psychologically will affect someone's reflective response through their sensory impressions and emotional affinity that will determine the behaviour response. Geodiversity obviously is more than just scientific and aesthetic values. Furthermore, the presence of visitors could boost the local economy of the adjacent communities. The Sangkurilang-Mangkalihat Karst Tourism is divided into several tourist objects, including Bloyot Cave located in Merabu Village (Figure 3d) and Tewet-Karim Cave located in Tepian Langsat Village. Developing a tourist attraction definitely requires a positive participation and perception of the surrounding community to achieve sustainable management.

Discussions

1. Linkage of Geodiversity and Cultural Diversity in Geoheritage Management

The linkage or relation between human and their environment had fascinated and attracted the attention of scientists across disciplines since the school of materialism emerged. Many theories had tried to unveil the complex relationship between those two. Along with the development of the school of thought, the relationship also expands and is incorporated into a wider concept including the recent one: geoheritage. The concept of geoheritage stands on the concept

of value. We discover this value is another form to accommodate the relationship between human (cultural diversity) and the environment (geodiversity) since the birth of the theory. In the Karst of Sangkulirang-Mangkalihat, we identify the relation is constructed upon three values of use-value, aesthetical value, and scientific value. each of those values is embodied differently for each diversity and through practices. The conceptual framework of the linkage can be seen in Figure 4 below.





The significant values that facilitate the Geodiversity and the Cultural Diversity of Karst of Sangkulirang then become the basis to regulate the utilization of the resource in this area and providing integrity as the objective of the management. Integrity is one of the foundations to apply the geoconservation practices and is mostly recognized through the framework of World Heritage and Geopark (Gordon, 2019; Crofts et al., 2020). Geoconservation thrives to maintain the integrity of the geoheritage area or geoheritage sites as the representation of the area. It is compounded by several steps (Burek and Prosser, 2008) and should be done by actively involving the indigenous community in the area (Tavares, 2015).

2. Karst of Sangkulirang-Mangkalihat as World Heritage

The frameworks that incorporate the significant values, besides integrity, especially the geodiversity and cultural values are the world heritage and geopark. These statuses provide guidelines in managing the Karst of Sangkulirang-Mangkalihat. Based on the cultural values of Karst of Sangkulirang-Mangkalihat, especially the presence of rock art as the significant artifact from the pre-historic era, this area was proposed to be World Heritage in 2015 within the criterion number {iii): "to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared". Elaboration of novel significant values in the Karst of Sangkulirang-Mangkalihat such as the geodiversity and cultural values could enrich the OUV of Karst of Sangkulirang-Mangkalihat. Landscape and the uniqueness of landform in this area can be considered to fulfill the criterion number (vii) of "contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance".

Condition of integrity demands interaction among ecosystem components, simultaneously forming uniform metabolism and process. Complete inventory of diversity and significant value constitutes of the physical and biological component at Karst of Sangkulirang-Mangkalihat supposed to help build comprehensive interaction and the interaction to meet the condition of integrity. The obligation entails this plan is to secure the condition of integrity from disturbance such as extraction and exploitation. In the Karst of Sangkulirang-Mangkalihat, geoconservation implementation could be sensed through the geotourism industry in several sites. Merabu Villages, with the Nyadeng Lake and Bloyot Cave as the attraction, operates tourism to enhance incomes and providing jobs as a tour guide or homestay. Through the geotourism, the community in Merabu Village successfully conserves their forest and obtains economical advantages from it (Rochmayanto et al., 2019). The same practice is also found in the Biduk-Biduk area where the community runs geotourism principle to preserve the Labuan Cermin spring as the tourism site and obtain profits from the tourism activities. Moreover, the geoconservation through geotourism is considered as a strategy to deal with the threat such as palm oil plantation and limestone quarrying that would potentially devastate the integrity of the Karst of Sangkulirang-Mangkalihat.

3. Aspiring Geopark of Karst of Sangkulirang-Mangkalihat

Among other frameworks, Geopark area is the latest yet fastest growing area because of its close relationship with the tourism sector, a priority sector causing visitor numbers and branding to be the main attention in fixing the geopark status in Indonesia. Indonesia acknowledges the geopark concept through President Decree Number 9 Year 2019. This decree states the geopark to be placed on three pillars of conservation, education, and local economic development. The local economic development is the one that is often interpreted to be the justification of tourism development. Especially, geopark is packed along with the sustainability concept; making tourism to become the main objective. Geopark of Batur Volcano became the first geopark in Indonesia that joined the Global Geopark Network, followed by the Geopark Gunung Sewu which is a karst area. Across the globe, 37% of the geopark is karst area and could be divided into fully karst area or partially karst area (Ruban, 2018). Geopark consists of geosite as the representative of the geological process in a certain area. Therefore, selecting the right geosite is the key to ensure geopark operates seamlessly by attracting visitors while also educating and raising their awareness. In the Karst of Sangkulirang-Mangkalihat, several sites have high potencies to be developed into geosite for their specific character as the representative of the Karst of Sangkulirang Mangkalihat. The proposed geosites can be seen in Table 3 and Figure 5 below. Many karst areas have been admitted as geopark and can be divided into three types as Ruban (2018) mentions fully karst, partial karst, occasional karst. From this division, Karst of Sangkulirang-Mangkalihat is categorized as the full karst where all of the features, values, and diversities are present within the karst area and have a direct linkage to the karstification process. Amongst the karst-based geopark, Karst of Sangkulirang-Mangkalihat also renders firm relation of geological, geomorphological, and cultural value. The comparison of Karst Sangkulirang with the three karst UNESCO Global Geopark site is summarized in Table 4.

Another crucial aspect to be taken into account is the education aspect of the geopark. The most complete story or information about a geological site is meaningless if tourists cannot associate with the site (Sunkar and Brahmantyo, 2013). Consequently, geotourism is closely connected with education. Interpretative media should be able to improve the relationship between the site and the experience of tourists by increasing their passion for the site. Successful geosite interpretation depends on the precise scientific information on the site and well-informed interpreting guides who can tell the story behind the geological formation of the site. Geotourism is the birth of a sustainable form of tourism that focuses on geological diversity. Therefore, it is important that geodiversity has its place as the principal resource of tourism activity.

Sangkulirang-Mangkalihat Karst area is a natural educative playground for those wanting to have a deep understanding of how Earth's geology is related to human culture. Sangkulirang-Mangkalihat Karst provides a natural laboratory for the studies and understanding of the relationships between geology, past culture, and local livelihoods and how they are intertwined. The presence of the unique landscape formation and rock arts will allow the visitors to travel back through time. Visitors will enhance their knowledge of how people have survived in the area. Much geological-based tourism, such as karst and cave tourism in Indonesia, still relies heavily only on the resources, not knowledge (Sunkar and Brahmantyo,

2013). It is necessary to support geotourists with scientific information to generate more in-depth knowledge about geology. Geology is a science and geotourism cannot be promoted if there is no in-depth knowledge of the geology of the area being promoted. Science is essential to the collection of information necessary for site management, the understanding of geological processes and their effects, and the understanding of geology and ecology.

Category	Proposed Geosite	Level of Significance	Justification
	Paragenetic Cave of Melawang,	International: 1. Beloyot Cave,	Caves in Karst of Sangkulirang Mangkalihat such as
	Selung Air Cave,	2. Tewet Rock-shelter,	Bloyot, Merdua, Mengkuris contain the rock art as
	Beloyot Cave, Tewet Rock-	3. Ambulabung Cave Complex	the cultural significance and the oldest cave painting
Cava	shelter, Tebo Cave,	Regional: 1. Paragenetic Cave of Melawang,	in the world. Some caves such as Melawang Cave
Cave	Ambulabung Cave Complex,	2. Mengkuris Cave; 3. Semerep Cave	and Kambing Cave show the geological process
	Semerep Cave, Kambing Cave,	National: 1. Kambing Cave; 2. Tebo Cave	with multi-level shapes. Others like Ambulabung
	Ampanas Cave and Hotspring,	Local: 1. Selung Air Cave	Cave Complex is irreplaceable habitat for endemic
	Mengkuris Cave	2. Ampanas Cave and Hotspring	species like Sarax sangkulirangensis
	Biru Lake, Kuranji & Jumangut	International: Danau Labuan Cermin	Karst of Sangkulirang-Mangkalihat has a huge
	Spring, Hulu Binatang Spring,	Regional: 1. Mataair Kuranji & Jumangut	hydrological potency in various features including
Karst	Pemapak Hotspring, Telaga	1) Mataair Hulu Bintang; 3. Mataair Panas	karst lake, spring, hot spring, and waterfall. Labuan
Hydro-	Biru, Labuan Cermin,	Pemapak; 4. Danau Nyadeng; 5. Danau Tebo	Cermin is a spring in the coastal area and has been
logical	Sigending Lake, Bidadari	National: 1. Danau Biru; 2. Danau Sigending	developed into a tourism site. For the regional level
Features	Waterfall, Langga Duae,	1) Mataair Panas Batu Lepoq	of significance, several springs supply the main river
	Waterfall, Nyadeng Lake, Tebo	Local: 1. Telaga Biru; 2. Air Terjun Langga	in Berau and Kutai Timur Regency like Hulu
	Lake, Batu Lepoq Hotspring	Duae; 3. Air Terjun Bidadari	Binatang and Kurandji Spring.
		International: chimney-like karst hills	The most significant morphological feature in Karst
	Karst hill Domaring Formation, chimney-like karst hills, Polje of Batu Onyen, Batu Onyen	Regional: 1. Polje of Batu Onyen,	of Sangkulirang-Mangkalihat is the chimney-like
Morpho-		2. Batu Onyen conical karst.	karst hills as this feature has never been studied
logy		National:	anywhere else beforehand. On the regional scale, the
	conical karst	Karst hill Domaring Formation	polje and conical karst of Batu Onyen represent the
			tropical land morphology.
	T T 1 T/11		Long Lanuk Village maintains a close interrelation
Cultural	Long Lanuk Villages	National	with the karst area with their tradition. This village is
			home to Lungun, a burial practice at the caves.
		International:	Sinondok Cape contains ophiolite as the oldest rock
	Mangkajang Ophiolite Outcrop,	Sinondok Cape	formation and signifies the tectonic subduction and
Outcrop	Suaran Quarter Volcano, Sinondok Cape	Regional:	ragment of Gondwana. The quarter volcano
		Mangkajang Ophiolite Outcrop, Suaran	represents the regional geological of Kalimantan
		Quarter Volcano	Island.

Table 3. List of	Geosites in	The Karst o	f Sangkulirang	-Mangkalihat
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Table 4. Comparison of Karst of Sangkulirang-Mangkalihat with Others Karst-Type Geopark Source: Informations of Gunungsewu, Sillin, and Causses du Quercy were taken from UNESCO, 2021a; UNESCO, 2021b; UNESCO, 2021c

	-			
Aspects of Geoheritage	Karst of Sangkulirang- Mangkalihat	Karst of Gunung Sewu	Karst of Shilin	Causses du Quercy
Geological	 Fragment of Gondwana. Limestone indicates the Makassar Strait expansion. 	 Represents the subduction of the Australian Plate to Eurasian. The lithology shows the contact of volcanic activity of Mount Merapi and Mount Lawu. 	The limestone host rock records information of geological processes in late Paleozoic.	The limestone was deposited during the Jurassic when the Atlantic Ocean began to open.
Geomorphological	 Hosts "chimney-like" karst hills, a feature which has never been identified before. The geomorphology includes kegelkarst, or conical karst. 	Exhibits "typical tropical karst" with conical hills its conical hills and had been scientifically recognized since the early 19th century.	Filled with the most various karst morphological features including "the tall pillar-like limestone", "sword-shaped limestone", "mushroom- shaped limestone" and "tower-like limestone"	Karstification activities yield unique karst features such as resurgence, doline, cavity, and chasms.
Cultural	 Oldest cave art and signifies the Austronesian Migration. Cultural products embodied in artifacts, folklore, rites, traditions 	Various archaeological sites with famous Pacitanian stone culture. Recently, the community sustains their livelihood using dry-land agriculture as an adaptation to the water scarcity.	Related with the livelihood of Sani People of Yi for almost 2000 years	for the Cadurques Gallic people it serves as Quercy territory. Adaptation of these people forming "the caussenard identity"

Geoeducation should be part of nature conservation education and, ultimately, sustainable development. The manager of the Sangkulirang-Mangkalihat Karst has to ensure that every geosite has sufficient education material to support the geotourism and geoconservation as the backbone of the geopark. Conservation education would improve the conduct of sustainable tourism (Sunkar et al., 2013). An educational strategy is required to be set up in partnership with schools, universities, and local organizations, in order to develop geotourism training and courses for local teaching staff and students and to organize events for public awareness for natural and cultural heritage associated with geology.

CONCLUSION

By analyzing the landscape through the Landscape Characteristic Assessment, it is known that the Karst of Sangkulirang-Mangkalihat has inextricably geodiversity and cultural diversity. The geodiversity of this area comprises elements of geology, geomorphology, hydrology, and speleology while the cultural diversity is constituted by Prehistoric rock art painting and tradition. Through the occupation, human refines and entangles both geodiversity and cultural diversity of Karst of Sangkulirang-Mangkalihat as its significant values.

Stemmed directly from the diversity, Karst of Sangkulirang-Mangkalihat possesses geological, geomorphological, hydrological, and speleological values that belong to the geodiversity and the cultural values within the cultural diversity. While the diversity contains an exposition and description of particular karstic phenomena, the values held the importance of those. Both geodiversity and cultural diversity have an outstanding value of locally, regionally, and internationally significant, urgently need to be conserved as the Karst of Sangkulirang-Mangkalihat is enduring threat from limestone mining and large-scale palm oil plantation. Those two diversities are then linked and woven with each other through the utilization of use-value, interpretation of scientific value, and appreciation of aesthetical value. Use-value is related to the direct and materialistic usage of the natural resource from Karst of Sangkulirang Mangkalihat like the water, limestone, and the landscape. Scientific values are extracted for the novel understanding and knowledge while the aesthetical value, as it is appreciated, is used for recreation and tourism. The linkage between the geodiversity and cultural diversity signifies the geoheritage notion to be implemented in Karst of Sangkulirang-Mangkalihat and becomes the considerations for the establishment of World Heritage or Geopark. It also becomes a conservation effort for the geodiversity and cultural diversity and cultural diversity, ensuring the intactness and integrity of Sangkulirang-Mangkalihat as a whole landscape.

To be World Heritage, Karst of Sangkulirang-Mangkalihat satisfies criterion numbers (iii (*"to bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared"*)) and (vi(*"contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance"*)) because of its rock art artifact and exceptional landscape beauty. The rock art painting and archaeological remainings represent a civilization, picturing the livelihood and culture of the pre-historic human while the landscape exhibit the beauty that roots to the uniqueness of the karstic landform. Karst of Sangkulirang-Mangkalihat is also aspired to be a Geopark, joining and fulfilling the requirement of Global Geopark Network. 29 sites have been listed as representative of the geological process and have multi significance levels from local to international. Those sites, based on the geodiversity and the cultural diversity-geological, geomorphological, hydrological, and speleological values and cultural geosites from the cultural diversity-cultural and tourism values. Compared to the other karst-type geoparks like Karst of Gunung Sewu, Karst of Shilin, and Causses du Quercy, Karst of Sangkulirang Mangkalihat has satisfied the geoheritage aspects of geological, geomorphological, and cultural. For further development, Karst of Sangkulirang Mangkalihat needs to strengthen the three Geopark pillars of conservation, education, and sustainable local economy embodied in the geoducation, geotourism, and provision of partnership among stakeholders.

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