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DISCOVERING THE KRAYAN HIGHLAND GEODIVERSITY AND GEOTOURISM POTENTIAL INDONESIA

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ABSTRACT

The Krayan Highland located in the west of Nunukan Regency, North Kalimantan Province, with a history of the earth dating since the Paleozoic era 570-251 million years ago. The area has a beautiful landscape of mountains and hills, home to the local indigenous people called the Dayak Lundayeh Tribe. Krayan Highland is rich in geodiversity, biodiversity and culture diversity. The area has been least developed in terms of infrastructure compared to other areas in the country. The research aims to find and map the geodiversity and geotourism potential of the Krayan Highland. The research method is qualitative method, which data collection is conducted through desk study and field survey. Descriptive, map analysis and content analysis is conducted during this research. The research discovers rich geodiversity in the area, one of them in the Kubah Garam (salt Dome). The Dayak people utilize the salt in the mountain and develop it into a geoproduct with their local indigeneous knowledge. The Krayan Highland has the potentital to be further developed into an aspiring geopark in the future.

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1. INTRODUCTION

Geodiversity and geotourism is an emerging science with clear and deep social interrelations. Geodiversity has an important role for the natural environment and human life (Kubaliková, 2013), on the other hand current geodiversity along with biodiversity is an important element of landscape appreciation, including its preservation. Geodiversity can also be used as a resource for tourism activities, especially geotourism. Geodiversity has a great influence on geotourism through research on form, process, and geological time in gaining an understanding of the complexity of the processes and the history of the formation of the earth (Dowling, 2013). Studies on geodiversity can be helpful in understanding sustainable geotourism (Thomas, 2012).

There is an increasing popularity of geosite as a natural attraction in tourism destinations, these activities are called geotourism (Newsome et.al 2012). Geotourism is a type of tourism that makes elements of process and geological forms as the main elements with the activity of tourist visits to the geosite (Newsome and Dowling, 2010), and is supported by natural (flora and fauna) and cultural tourist attractions. Sustainability development is one of the geotourism principles (Dowling, 2011). In the efforts of sustainable development of a region through geotourism, it is important to understand the characteristics of each region (Dowling and Newsome, 2017).

Geotourism has great potential in Indonesia, because the country has great geodiversity which spread across the country. The Krayan Highland is located in the west of Nunukan Regency, North Kalimantan Province, like many other regions in Indonesia, has a long history since the Paleozoic era 570-251 million years ago. The Krayan Highland region belongs to the massive Iban complex which is part of the central Kalimantan mountain range (Kuching highland). This area consists of fluvio-deltaic sedimentary rocks to the coastal lagoonal called the Paleocene Embaluh Longbawan Formation Group (Heryanto et al., 1995).

In addition, Schneeberger in Langub (2012) mentions that on these alluvial plains, there are vegetation of trees and shrubs with thick and rough leaves, which are very similar to plants from brackish coastal zones, suggesting this might be an indicator of salt water, source of salt. Between the hills and towering mountains, in the valleys there is a growing community of Dayaks. The diverse landscapes or landscapes of the Krayan Highland include almost always foggy high mountains, fields to steep rivers, plains, grasslands, agricultural fields, dense, rural jungles and tribes and the culture of Dayak people who inhabit them in particular Dayak Lundayeh Indigenous Tribe. Geodiversity supported by biodiversity and cultural diversity in the Krayan Highland is a resource that has the potential to become an attraction for geotourism.

The study aims to deepen understanding of geodiversity through exploration and inventory in the Krayan Highland. In addition, this research also identifies biodiversity and cultural diversity as geotourism resources to further develop them as geotourism potential in the area.

2. METHODOLOGY

The method used in the research is descriptive qualitative method. Descriptive research method aims to collect actual information in detail that describes the symptoms that exist, identify problems or examine the conditions and practices that apply, and make comparisons or evaluations. This method focuses on observation and natural atmosphere. The object of research determines the basic methods in research, the objects in this study are (1) uniqueness and geodiversity in the Krayan Highland are defined through landscape aspects, landforms, rock outcrops, rock groups, rock types, soils, minerals, crystals, and fossils; (2) uniqueness and biodiversity in the Krayan Highland; and (3) uniqueness and cultural diversity or traditional landscapes in the Krayan Highland.

Secondary data collection was conducted with a study literature / desk study which is an assessment and analysis of data and information. While the acquisition of primary data is done by field survey and analysis. At this stage a field visit was carried out to obtain data and information about the overall geodiversity conditions in the Krayan Highland. In this field survey stage coordination and consultation with the local government was conducted. Qualitative descriptive analysis, content analysis, and map analysis as the method used in this study.

This study uses qualitative analysis methods, map analysis, and content descriptive analysis. Data and information obtained are then carried out by the process of data input, data management (coordinate transformation, digitizing, and editing), as well as data plotting and conversion using geographic information system software (Esri ArcGIS) and graphic design software (Adobe Illustrator).

Geodiversity assessment was based on geotourism box concept (Brahmantyo, 2013). Six elements of the geotourism box are (1) process elements are geological and geomorphological activities that can be observed during volcanic activity, floods from river flows, and landslides; (2) form elements present landscapes (cliffs, volcanoes, karst landscapes, and arid environments), the face of the earth (glacial, fluvial, coastal, to alluvial fans), and rock outcrops; (3) tourism elements in the geotourism box must be well integrated, as a whole the elements of tourism contained in the geotourism box include attractions, accessibility, amenities, activities, and planning and management; (4) geobasic is the basic knowledge of earth science that has an important role in understanding the form and process of geological events conveyed through active interpretations (tour guides) and passive (guidebooks, brochures, and the internet); (5) geohistory is an explanation of the story of an event related to figures, especially geologists who record/ study a region; and (6) geo + is a supporting factor for geotourism activities such as the relationship between geology and archeology, geological phenomena which become legends and myths of local communities, flora and fauna on geotourism attractiveness, as well as the link between geotourism's attraction to the history, social and culture of local communities.

In addition, the Geotourism Box is also a reference for the formation of Geotourism Attraction (GA) and Geotourism Resources (GR). Geotourism Attraction is something that has a unique process and form of geology and geomorphology supported by elements of tourism that are the destination of geotourism visits, while geotourism resources is something that has the potential to be used as a GA with a unique process and form of geology and geomorphology.

Theoretical Framework

Geodiversity Theory

Hjort et al. (2015) explained that geological diversity is the variability of earth surface, landscape, and physical processes, such as landscapes (rocks, soil, and water) (mountains, glaciers and lakes), and processes (soil formation, coastal erosion, and sediment transport). Geological diversity is widely recognized because of the scientific value and benefits of the substantial knowledge that it provides to the community (for example, records of past climate change, evolution of Life, and understanding of how the Earth system operates) (Gray 2013; Gray, et al., 2013).

In the context of preserving nature, geodiversity provides many important services for biodiversity including providing substrate and mosaic landforms for habitat development (static aspects), as well as soil formation (biogeochemical and water cycles, and geomorphological processes; for example, water flow regimes, sediment supply, erosion, and precipitation) for habitat maintenance (dynamic aspects). These values are now embedded in the service

ecosystem concept (Millennium Ecosystem Assessment) (Board, 2005). Without the contribution of geodiversity, many of the ecosystem services that are important for life on earth will become extinct or require far more expensive technological alternatives.

Geodiversity underlies and provides most of the types of ecosystem services identified in the MA (Gray, 2011; Gordon and Barron, 2013; Gray et al., 2013). It also provides additional inseparable items (for example, minerals, aggregates and fossil fuels) which are usually considered as non-renewable capital assets (Gray et al., 2013).

The value of geodiversity is classified into five groups that can benefit human life (Gray, 2004; Melelli, 2014), namely (1) intrinsic value, independent of human evaluation, this value is also called scientific value; (2) cultural values, which have links with aspects of geomythology, historical and archeological aspects, and spiritual and religious aspects; (3) aesthetic value, refers to the visual and non-visual appeal provided by geodiversity which involves psychological effects on humans. The value of geodiversity is also very important for geotourism activities; (4) economic and functional values, which are beneficial for the use of mineral resources such as fuel, construction materials; utilization of landscapes, and geodiversity utilization, each geoheritage, for geotourism activities; and (5) research and educational value, which is associated with an understanding of the origin of life and landscape, landscape and climate evolution and palaeogeographic reconstruction.

Geodiversity is an important starting point to guarantee not only biodiversity, but also the diversity of nature as a whole. Geodiversity is a component of geology that has a function as a trace of the history of the formation of the earth.

Geotourism and Geopark Concept

Geotourism is a form of tourism in natural areas that focuses on geological and landscape aspects supported by facilities and infrastructure for tourists (Newsome et.al, 2012). Geotourism promotes geological features through tourism and encourages conservation activities, understanding earth science through appreciation and learning. The concept of geotourism is formed based on the nature and scope that refers to elements of form, process, and tourism (Dowling and Newsome, 2006). Forms and processes are part of geology which is earth science and geomorphology which studies the landscape, including landscapes, landscapes, rock outcrops, types of rocks, sediments, soil and crystals. Whereas the tourism side is a visit activity, learning, appreciation of geological sites that are supported by various tourism components such as accommodation, tourist attractions and accessibility. The concept of geotourism was expanded by adding three elements that support geotourism activities, namely geobasic, geohistory, and geo +, which is called the Geotourism Box concept (Brahmantyo, 2013).

Geotourism development can be realized through geopark. The main tool for the development of geodiversity and geotourism can be fostered through Global Geopark Network (UNESCO, 2006). Geopark is an integrated geographical area and has a significant geological landscape for the development of conservation, education and sustainable development (UNESCO, 2016). Through UNESCO and global networks, national geological sites gain recognition and benefits in exchanging knowledge, expertise, experience, and human resources with other geoparks (Dowling, 2011). There are three levels of geopark, the first is the Aspiring Geopark as an initial attempt to establish a geopark. The second stage is National Geopark and joins the network. The last stage is joining the global geopark network through the UNESCO Global Geopark (Dowling and Newsome, 2017).

3. RESULTS AND DISCUSSION

The Krayan Highland has deposits of evaporited salt deposits and not only manifesting at one or two points of spring appearance. Based on the distribution of this evidence, it is assumed that sediment covers the entire microplate of Longbawan (the Krayan Highland to the Kelabit Highland in Sarawak). It is believed that this geological resource is one of the highest salt dome in Indonesia.

Several geosites with special interest features (Table 1) include the Krayan Salt well, which have anhydrite deposits with the Krayan Salt geoproduct, culminating in Yuvai Semaring's observation, Ruab Sebiling Waterfall and Sicien Stone. Some cultural and archeological and biological sites are also available in these geoareas. Tourist information center from the Dayak Indigenous Peoples Forum and World-Wide Fund for Nature or WWF Indonesia.

Tourism facilities such as lodging/ hotels and restaurants are very limited in number. The area can be accessed through two airports, namely Yuvai Semaring airport in Longbawan and Binuang airport in South Krayan.

The geodiversity potential is analyzed based on the concept of geotourism box. The assessment of geodiversity which is likely to become a geotourism attractions can be seen in Table 2. The study results have identified eight geodiversity based on the geotourism box. There are are seven geodiversity categorized as geotourism attractions (GA) and one geotourism resources (GR). Geotourism attraction is supported by biodiversity and cultural diversity which is called a supporting geotourism attraction (SGA).

SGA identified in the Krayan Highland are: Yuvai Semaring Footprints, Yuvai Semaring Cave, Kayan-Mentarang National Park, Swamp rice planting pattern, Krayan Water (biodiversity) and Uma 'Irau, Lundayeh Indigenous Tribe, Management of Krayan Salt Dome, Rice Management Adan (cultural diversity).

All of the geodiversity found in the area have the potential to become a geotourism attraction based on the assessment of the geotourism box, one which is unique namely the Salt Dome. The area can be an attraction for geotourism and the salt produced by the local community can become a geoproduct.

The geodiversity analysis shows that several areas have good potential for development in geotourism in the Krayan Highland and have met the basic requirement needed to obtain the National Geopark status. However, for international recognition of the geodiversity in the area, an organization must be setup to manage the geopark, develop more infrastructure and fulfill other criterias needed to become a recognized global geopar

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Table 1. List of Geodiversity and It Interpretations In The Krayan Highland

Geodiversity	Typology	ESCC (2004)	Value	Application	Description
Yuvai Semaring Peak	*area/ viewpoint / static, natural*	*Static (fossil) geomorphological (IS)*	Regional	Educational and tourism	Geological phenomena: mountainous and inland landscapes (Iban highland - Kalimantan's central mountains), panoramic views of Long Bawan village, Yuvai Semaring Cave, sandstone. Geosite type: geomorphology, sedimentary, structural, geohistory rock. Point of interest: Geomorphology. Other assets: Dayak Lundayeh culture and Kayan Mentarang National Park. Tourism, local history, biology, education and research, conservation, ecology.
Krayan – Long Bawan Salt Well	*point / dynamic, natural*	*Extensive buried interest (EB), Finite buried interest (FB)*	regional/ national	Scientific, educational, and tourism	Geological phenomena: salt in the mountains, salt water intrusion, salt dome. Geosite type: sediment / mineral, hydrology & hydrogeology, structural, paleogeography, geohistory, economics, engineering. Point of interest: salt in high mountains, minerals. Other assets: salt in the cultural journey (Dayak tribe). Local history, culture, anthropology, ecology, geography, tourism, education and research, conservation.
Long Midang Salt Well	point / dynamic, natural	Extensive buried interest (EB), Finite buried interest (FB)	regional/ national	Scientific, educational, and tourism	Geological phenomena: salt in the mountains, salt water intrusion, fine salt type, salt dome. Geosite type: sediment / mineral, hydrology & hydrogeology, structural, paleogeography, geohistory, economics, engineering. Point of interest: salt in high mountains, minerals. Other assets: salt in the cultural journey (Dayak tribe). Local history, culture, anthropology, ecology, geography, tourism, education and research, conservation.
Pakebuan Salt Well	*point / dynamic, natural*	*Extensive buried interest (EB), Finite buried interest (FB)*	regional/ national	Scientific, educational, and tourism	Geological phenomena: salt in the mountains, salt water intrusion, coarse grained salt, salt dome. Geosite type: sediment / mineral, hydrology & hydrogeology, structural, paleogeography, geohistory, economics, engineering. Point of interest: salt in high mountains, minerals. Other assets: salt in the cultural journey (Dayak tribe). Local history, culture, anthropology, ecology, geography, tourism, education and research, conservation.
Baeliku Salt Well	*point / dynamic, natural*	*Extensive buried interest (EB), Finite buried interest (FB)*	regional/ national	Scientific, educational, and tourism	Geological phenomena: salt in the mountains, salt water intrusion, salt dome. Geosite type: sediment / mineral, hydrology & hydrogeology, structural, paleogeography, geohistory, economics, engineering. Point of interest: salt in high mountains, minerals. Other assets: salt in the cultural journey (Dayak tribe). Local history, culture, anthropology, ecology, geography, tourism, education and research, conservation.
Paramayo Waterfall	*area / static-dynamic, natural*	*River and stream sections (EW)*	local	educational, and tourism	Geological phenomenon: geomorphology. Geosite types: geomorphology, hydrology, structural, sedimentary rocks. Point of interest: geomorphology. Other assets: tourism and education.
Ruab Sebiling Waterfall	*area / static-dynamic, natural*	*River and stream sections (EW)*	local	educational, and tourism	Geological phenomena: geomorphology, stocky. Geosite types: geomorphology, hydrology, structural, tectonic, igneous, sedimentary rocks, minerals, geohistories. Point of interest: geomorphology, igneous rock. Other assets: ecology, biology, tourism, education and research, conservation.
Sicien Stone	*area / static, natural*	*Inland outcrops (EO)*	local/ regional	educational, and tourism	Geological phenomena: honey stone, igneous rock, honey rock cave. Geosite type: igneous, mineral, structural. Point of interest: igneous rock, honey rock cave. Other assets: local history, ecology, archeology, tourism, biology, education and research, conservation.

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Table 2. Geodiversity Analysis as A Geotourism Attraction in the Krayan Highland

Geodiversity	Elemen	Identification	Status
 Yuvai Semaring Peak	Process	The mountain is composed of sandstones, fresh colored sandstone, light gray, blackish gray weathered color, medium sand size, rounded grain shape, hard, open container, good permeability, and not carbonate.	GA
	Form	Mountain and inland landscape (Iban plateau - central Kalimantan mountains)	
	Tourism	Panorama of Long Bawan village, camping activity, there is a biking pole intended for nationalistic events, there are road signs, garbage facilities, the distance to the summit is around 4.5 km	
	Geobasic	Basic knowledge of ecology, geolog.	
	Geohistory	Heryanto, Supriatna and Abidin in 1995; Hidayat Amiruddin, and Satrianas in 1995; Moss, Carter, Satria in 1997; Langub in 2012	
	Geo +	Yuvai Semaring Legend, Yuvai Semaring's Footsteps Stone, Yuvai Semaring Cave, Dayak Lundayeh Culture and Kayan-Mentarang National Park.	
 Krayan Salt Well (Long Bawan, Long Midang, Pakebuan, Baeliku)	Process	The upper part of the salt well is clay-sand soil and the lower part is in the form of sandstone Long Bawan Formation.	GA
	Form	Salt in the mountains, salt water intrusion, salt dome, and coarse grained salt.	
	Tourism	Educating the process of making salt, Lundayeh Dayak culture, packaging salt geoproducts, interpreter facilities, F & B.	
	Geobasic	Basic knowledge of hydrology, hydrogeology, anthropology and ecology.	
	Geohistory	Heryanto, Supriatna and Abidin in 1995; Hidayat Amiruddin, and Satrianas in 1995; Moss, Carter, Satria in 1997; Langub in 2012	
	Geo +	The Story of Bird Budud (Hornbill)	
 Paramayo Waterfall	Process	In megaskopis these rocks look like igneous, afanitic and mesocratic textures, and enter into the Longbawan Formation in the form of feldsparan sandstones.	GA
	Form	This waterfall has a height of about 50 m. The rocks that make up this waterfall are fresh gray and black weathered colors.	
	Tourism	Accessibility to this site can be reached by car with a distance of 17 Km from Longbawan, with road conditions 9 Km paved, 4 Km land (off road), and continued by walking 4 Km to the site. In Long Bawan there are several rental / tour guide services to Paramayo Falls.	
	Geobasic	Basic knowledge about geology.	
 Ruab Sebiling Waterfal	Process	Allegedly formed through a process of tectonic activity with evidence of the large number of solids grinding on its constituent rocks.	GA
	Form	Waterfall which is on the Krayan river which is surrounded by forests and has a height of 25 m	
	Tourism	Access roads to get to this site can be reached by driving from Baeliku to forest with a distance of about 10 Km. Until the forest is continued by walking about 10 km to the Ruab Sebiling Waterfall. Fishing area and potentially used as an attraction for rapids.	
	Geobasic	Basic knowledge of geology and ecology	
	Geo +	Location Sebiling Waterfall is a sacred land that was once inhabited by the Adda tribe (ghost tribe). Upstream.	
 Sicien Stone	Process	-	GR
	Form	Honey stone, igneous rock, honey rock cave This stone is megascopically fresh in whitish gray, weathered in brownish gray, and looks like igneous rock because it contains many minerals.	
	Tourism	There is a cave where ancient human bones are stored, there is a bird's nest wallet, and a honeycomb attached to the rock. Accessibility can be reached via the Baeliku - Long Rungan line (30 Km). Long Rungan uses ketingting to the forest with a distance of about 2.5 km. Then further by foot to Batu Sicien about 4 Km	
	Geobasic	Basic knowledge of geology, archeology and biology.	

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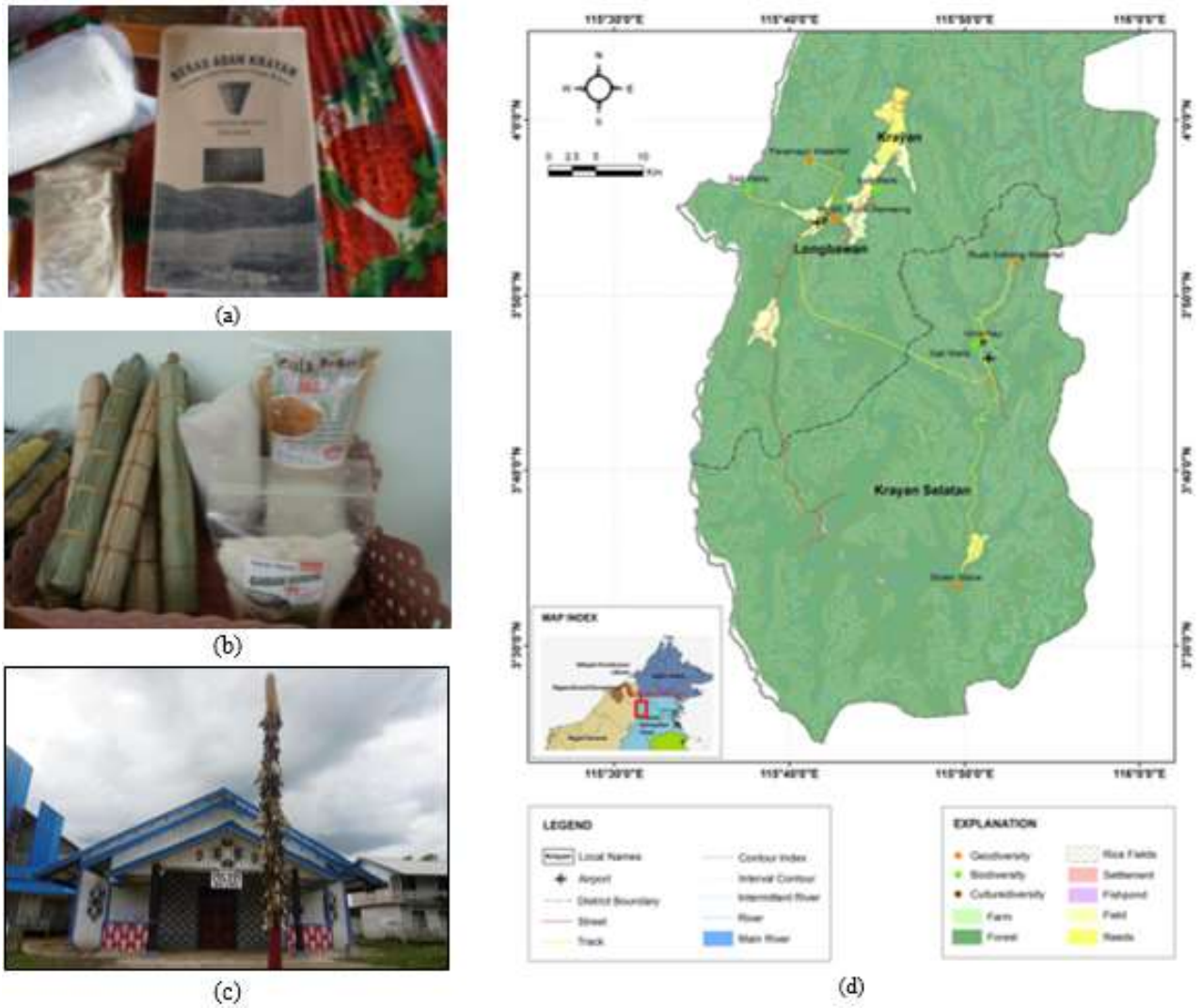

Figure 1. The Krayan Highland typical product packaging: (a) Adan Rice, (b) Mountain Salt, and Sugar Cane; (c) Uma'Irau is a function hall for local community of the Ba 'Liku Village; (c) geodiversity distribution in the Krayan Highland

4. CONCLUSION

Geodiversity has an important role as a resource for geotourism potential. The Krayan Highland has great geodiversity supported by its cultural and biodiversity, which makes it attractive for geotourism activities. There are a total of eight geodiversity in the Krayan Highland Region Geotourism attractions in the Krayan Highland is supported by biodiversity and cultural diversity, which can be the source of competitiveness in the tourism destination. The Krayan Highland can be marketed as the new geotourism destination and become the geotourism brand identity of Nunukan Regency and North Kalimantan Province. The implication of this research is the result can be used as a baseline study for future research and geotourism planning in the area.

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