Geotourism Potential Study Based on Environmental Sustainability in Berambai, Samarinda City, East Kalimantan

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Abstract. The Berambai is one of the areas in Samarinda, East Kalimantan, which has a tourism potential related to geological uniqueness and landscapes. The research aims to identify geomorphological and geological diversity, to determine the distribution of geotourism potential, and to identify potential environmental damages. The method used includes literature study, field surveys, data processing, and analysis. The results show the diversity of geomorphologic conditions include anticline hill (20%), syncline hills (55%) and fault block (15%). On geological conditions, there are a variety of lithology units which include Berambai Limestone (6,6%), Puncak Samarinda Sandstones (36,2%), and Berambai sandstones (57,2%). Also, there is a fault on the eastern of the study area. The distribution of geotourism potential in the Berambai includes: Puncak Samarinda, Berambai caves, Berambai waterfalls, fishpond, Puncak Panorama, and mud volcano. The potential for environmental damages in the Berambai area includes changes in secondary forest to oil palm plantations, clearing land for cultivation or settlement, clearing land for other purposes, which are possible to be minimized or overcome by sorting out priority areas of open land/shrub lands for re-vegetation, revegetation of open land areas/shrubs with considerations of regional biodiversity, compliance and law enforcement of government regulations in spatial and area planning as well as other legal products for land clearing activities, construction of buildings and regional infrastructure. The impacts of the research are give the geological value of the area for tourism and educational purpose, and concern on environmental mitigation of the area.

Keywords: Geotourism · Potential · Distribution · Model

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1 Introduction

The Berambai area, which is partly composed of limestone, or the people know it by the name of mountain rock, has now been taken by many people to be sold as building materials. Continuous exploitation of limestone or mountain rocks can cause environmental conditions to be damaged [1]. Special attention from the government is deemed necessary, to maintain its authenticity in the Berambai area, because of the various potentials that exist, including the potential for geological diversity, biodiversity, and water catchment areas. The biodiversity of this area has been studied, especially the diversity of bird fauna, in the Berambai waterfall area [2]. In addition, this area can develop into a sustainable tourist area, which is excavated according to geology and good tourism management [3]. This study aims to study geomorphological and geological diversity, take an inventory of the distribution of geotourism potential, and assess the potential for environmental damage in the Berambai area, Samarinda City. The systematics of writing in this manuscript include Introduction, Research Methods, Results and Discussion, and closes with Conclusions.

2 Research Methods

The Berambai area is an area located in the northern part of Samarinda City with an altitude of about 25–250 m above sea level. In general, the research location is included in the Berambai, North Sempaja, Samarinda City (Fig. 1). A small part of the area belongs to the district of Kutai Kartanegara.This activity was carried out in July - December 2019. A series of materials and equipment were used during this research activity, with materials including hydrochloric acid (HCl) solution, sample bags, and equipment including GPS (global positioning system), geological hammer, topographic map, geological compass, loop, roll meter, camera, tools write.

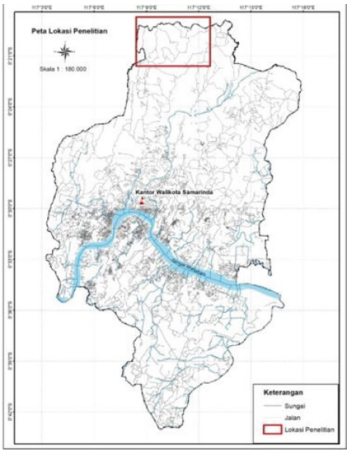

Fig. 1. Research Area

This study uses descriptive qualitative analysis, where the method used emphasizes the process of searching data or information until it is felt that it has been used enough to make an interpretation [4]. This research was conducted in several stages which include literature study/literature study, survey path planning, data collection, data processing and analysis. The literature study is prioritized for books or articles related to research as well as regional geological maps and achievement maps of the research area. Survey path planning is carried out by considering topographic distribution, geomorphologic variations, rock diversity, land use, road access, and the possibility of existing tourism potential.

The main data collected includes geomorphology (measuring slope data in the field as well as taking visual data on land conditions or utilization of existing landscapes), geology (observing rock outcrops on the trajectory, measuring rock positions, measuring geological structures, taking rock samples, plotting). Geological data from measurements on topographic maps), and geotourism potential (access to location, geographical position, scenery, uniqueness, and geological diversity). Organizing the data includes grouping the data based on the results of photo documentation and field notes. Processing and analyzing data, by dividing land form units, rock units, geological structures, distribution of geotourism potential and potential environmental damage and minimizing and overcoming potential environmental damage.

3 Result and Discussion

3.1 Geological Setting

The area refers consist of 3 land forms, as anticline hills, syncline hills and fault blocks. Anticline hill landform units are characterized by very tight contours with a height of 60–220 m, with the presence of joints and anticlines caused by endogenous forces. The fault block landform unit has a rather dense contour with a height of 100–200 m. The land has steep slopes, frequent erosion and soil movement at a slow speed. The structure in this area is a horizontal fault and an ascending fault caused by endogenous and exogenous forces. The syncline hill landform unit occupies 55% of the entire research location with a rather dense contour with a height of 50–130 m. The land has a sloping slope, frequent erosion and soil movement at a slow speed. The active structure in this area is a folded wing, then the surface shape is caused by endogenous and exogenous forces. The river flow patterns that developed in this study area are trellis flow patterns and subdendritic flow patterns. Trellis flow patterns are influenced by geological structures and subdendritic flow patterns are found these rivers flow in all directions from a single point.

Berambai area is part of the Kutai Basin, as a result of the transgression and marine regression cycle on northeast-southwest (NE-SW) orientation, resulted Samarinda Anticlinorium in the east-southeast part of the basin, characterized by strongly folded, asymmetrical anticlines and is bounded by synclines filled with Miocene siliciclastic sediments. The structural patterns caused by the influence of the sliding process due to gravity (gravity sliding) on the bedrock which has high plasticity due to the uplift of the Kuching Heights during the Tertiary Period [5–8]. In the stratigraphic order of the Berambai area, it is divided into three rock units from old to young, namely Berambai

limestone, Samarinda Peak sandstone, and Berambai sandstone. The Berambai limestone unit consists of limestone and sandstone. The Samarinda Peak sandstone unit consists of greywacke sandstone, as well as mudstone and sandstone. The Berambai sandstone unit has the characteristics of alternating between sandstone and mudstone, with other rocks such as siltstone, coal, shaly coal and coal shale. The geological structures that develop in the study area are folds, joints, and faults.

3.2 Potential Geosites

Several potential geosites occurred in the area, as Samarinda Peak, Berambai Cave, Berambai Waterfall, Fishing Pond, Panorama Peak, Mud Volcano.

Samarinda Peak
Geology and tourism science are related and can be proven in many aspects. Landscapes including peaks are generated by geological processes and are controlled by a variety of geological factors. Complicated geological factors led to the diversification of the shape of the natural landscape. In particular, the structural features produced by tectonic activity as well as their properties, characteristics, and scale all directly control the formation and development of natural landscapes [10]. Samarinda Peak is the location of the highest elevation point in Samarinda City. This peak location is located in the anticline hills which are part of the Samarinda Anticlinorium. At an altitude of more than 200 m above sea level, this location is interesting to see how the distribution and orientation of the anticline and syncline hills are part of the Samarinda Anticlinorium (Fig. 2a). The geomorphologic condition of the Puncak Samarinda area is included in the form of structural origin, with an anticline hilly landform.

Berambai Cave
In the Berambai area, there is a cave known to the public as the Berambai Cave. In Berambai Cave we can observe and study how the geological and geomorphologic conditions played a role in the process of its formation. The geomorphologic condition of the Berambai cave belongs to the structural origin, with an anticline hilly landform. From the geomorphological aspect, in Berambai Cave we can see how the exogenous process of karstification plays a role in the formation of the cave. In addition, we can also study the characteristics of rocks and sedimentation forming Berambai Cave in the form of dominance by reef limestones and massive limestones and greywacke sandstones which are included in Pulau Balang Formation. In addition, people might learn and enjoy the beauty of the cave ornaments, mainly consisting of stalactite pillars on the roof of the cave and stalagmite pillars on the cave floor (Fig. 2b).

The definition of cave ornamentation (speleothem) is the result of the deposition or crystallization of CaCO3 minerals in several rocks and mostly occurs in limestone [13]. Many limestone boulders are scattered on the floor of the cave, which may come from past activities in the form of beating against stalactites or stalagmites or cave walls. The height of the mouth of the cave is about 2.5 m with a height of about 3–4 m inside the cave. Berambai Cave classified into landscape tourism from exogenous geological processes [10]. Natural vegetation in Berambai cave and its surroundings is included in secondary forest which shows the dominance of tall trees alternating with lower trees,

(a) (b)

Fig. 2. Samarinda Peak and Berambai Cave Situation (a) Bright View ff Samarinda Peak, (b) Cave Mouth

(a) (b) (c)

Fig. 3. Berambai Waterfalls And Fishing Pond (a) Berambai 1 Waterfall, (b) Berambai 2 Waterfall, (c) Ponds with Geological Study, Various Mudstones with Coal and Quartz Sandstone Intercalation.

following a hilly topography pattern. The conditions in the cave are fairly humid, there is a flow of water, and inhabited by several living creatures such as bats (Chiroptera), spiders (Araneae).

Berambai Waterfall

Waterfalls existence is one of criteria for young rank rivers as (a) the shape of a waterfall that has gone through river erosion and shows that the river has not been able to show a terraced concave, (b) the forms that occur are caused by interference or external power in the process of forming the river. The waterfall might perform in different appearance, as the factor of different type and shapes [14, 15]. Berambai waterfall, located on Jalan Batu Besaung, Sempaja Utura, North Samarinda District, East Kalimantan province is an interesting geotourism object to visit. There are two commonly visited waterfall locations, which can be referred to as Berambai 1 waterfall and Berambai 2 waterfall (Fig. 3a, b).

The waterfall was formed by a fault that cuts the anticline hills in the area around Berambai Cave. This interpretation is based on the existence of a lineament zone that extends with an orientation perpendicular to the longitudinal direction of the anticline hills and the presence of a destruction zone along the waterfall. This waterfall is located in a fault block geomorphologic unit, with a slope of 14–20% (moderate steep), erosion and soil movement occur at a slow speed. The constituent rocks in this waterfall area are greywacke sandstone with mudstone and sandstone intercalation. This destination shows that the geological process that develops in the form of the appearance of the geological structure, lithology and morphology of the constituents greatly influences

the formation of Berambai Waterfall. Berambai waterfall are classified into a waterfall tourism landscape [10, 15].

Fishing Pond

Old mining locations, such as former coal mines, tin mines and so on can provide a choice of tourism objects related to issues surrounding the importance of geology in human life as well as aspects of the impact of environmental damage. In addition, the mining landscape is an interesting one that serves as an excellent link of past and present relationships and the mining area that maintains traces of its heritage both artificial and natural can also tell stories of industrial memory [16, 17]. In Indonesia, ex-mining areas have been developed which are then converted into geotourism objects such as those in Sawah Lunto and Pongkor. In East Kalimantan itself, also has this potential. Several ex-mining areas that have geotourism potential include the Berambai area in the form of a former coal mining area by PT. Mahakam Sumber Jaya (PT. MSJ). The geomorphologic setting of the former mining ponds in the coal mining area of PT. MSJ is anticline hilly landform. The original rocks that exist are mainly mudstone with intercalation of sandstone (sandstone), coal (coal) and carbonaceous mudstone. Since 2011 the pit has been abandoned, and being reclamated until it eventually becomes a pond. This pond was then managed as an eel pond by the Berambai Farmer Group and produced the first harvest of 1.4 tons of eel. The pond walls can be used to study rock diversity in the ancient Mahakam delta ecosystem (Fig. 3c). The natural vegetation in the pond and its surroundings includes secondary forest as a result of reclamation including weeds, some of which have been replaced by the community into oil palm plantations.

Peak Panorama

Panorama Peak is part of the Samarinda anticlinorium. From this peak, visual undulating morphology occurred as part of structural landform. The name Puncak Panorama was given because from this location you can see a panoramic view of the north side of the city of Samarinda (Fig. 4a). The lithology in this area is mainly sandstone with mudstone inserts. Sandstone has a gray-white color (brown weathered color), fine-coarse sand grain size, massive structure, wavy and cross-linked laminate, open packing, well-rounded, quartz mineral composition, and silica cement. Mudstone is gray in color, with a massive structure, and the composition is clay minerals. The natural vegetation at the top of the panorama and its surroundings includes weeds with occasional overgrown trees. The landscape of Puncak Samarinda was formed due to tectonic processes as indicated by the formation of anticline hills which are also influenced by geomorphic processes and might classify as Samarinda Peak into erosive tectonic landscape tourism [10].

Mud Volcano

The mud volcano found in the Berambai area is located in the anticline hills and is still related to the mud volcano found around Batu Putih, result as overburden loading of rapid thick sediments. The fluid (water and gas) and solid fractions are ejected from different geological formations rather than from unique sources and classified as Chikistylar type [18, 19]. The geomorphologic condition of mud volcano is an anticline hilly landform. Mud volcano or so-called mud volcano (Fig. 4b, c) is interpreted to have formed in the prodelta environment to the outer shelf. The phenomenon of mud volcano at this

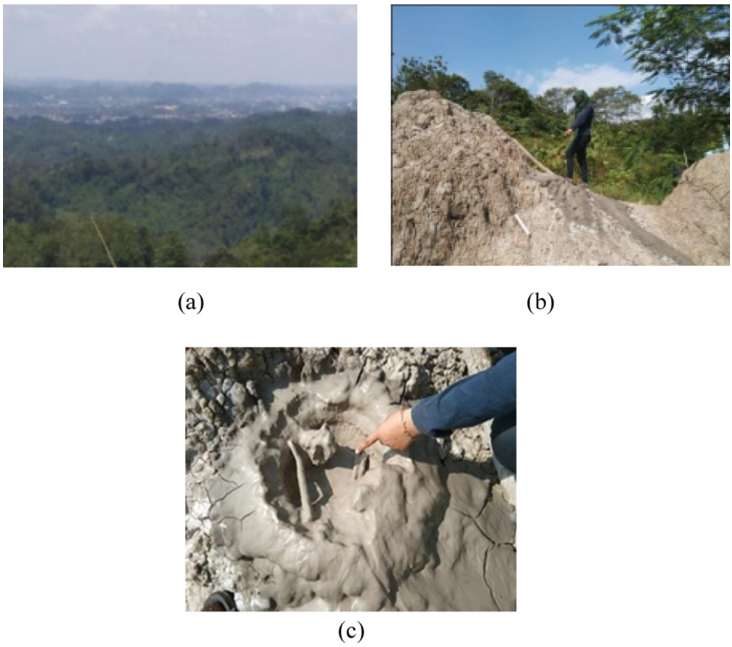

Fig. 4. Peak Panorama and Mud Volcano (a) Peak Panorama view to Samarinda City, (b) Mud Volcano Geometry, (c) Closer Look to Mud Volcano 'Crater'

location is interpreted to occur due to the presence of mud mixed with gas (methane) which experiences excess pressure below the earth's surface and then exits through the fault plane in the Samarinda anticlinorium path. The geometry of the mud volcano that can be interpreted is composed of 3 rock layers which indicate a layer of mud volcano with the maximum depth that can be reached is 38 m below the earth's surface [20]. The geological phenomenon in the form of a mud volcano at this geosite shows that geological processes have a major role in the occurrence of mud volcanoes at this location including the rapid sedimentation process, the presence of geological structures, lithological characteristics, and morphological constituents. The natural vegetation of the mud vulcano and its surroundings is included in secondary forest which shows the dominance of large trunked trees alternating with lower trees following a hilly topography pattern and shrubs.

4 Analysis

A SWOT (Strengths, Weakness, Opportunities, Threats) analysis was carried out on the assessment of this area for geotourism potential, which was then described according to the respective strengths, weaknesses, opportunities, and threats. Strengths that exist in the Berambai area include (1) the diversity of tourism potential in one area including panoramic tourism, waterfalls, caves, and ponds (Fig. 5a, b), (2) the potential for biodiversity in the Berambai area, at least has been identified at the Berambai waterfall, (3)

there is access to the Aji Pangeran Tumenggung Pranoto airport and good regional road infrastructure, (4) there is a local tourism actor by the name of Puncak Samarinda who opens panoramic tourism services, lodging and regional tour guides (managed by Catur Febri Hananto), (5) availability of related university study programs for enrichment of area assessment (at least Geological Engineering, Environmental Engineering, Forestry Science, Master of Environmental Science study programs). Weaknesses in the Berambai area include (1) the condition of the main road access that is not yet fully good; there are still dirt roads and road subsidence, (2) access to several potential tourist spots in the form of dirt trails that are risky to pass during the arainy season, (3) there have been several excavation activities in the past that left traces of open land with minimal tree vegetation, (4) pond ponds have been abandoned, having previously been used as eel breeding. Opportunities (Opportunities) that exist in the Berambai area include (1) the area, in general, is still minimally occupied and covered by vegetation, both from shrubs to secondary forest, (2) a place for studying earth material for students and students to get to know geological objects and the process of their formation, (3) there is still potential for tourism diversity in the form of caves that have not been identified properly due to terrain, pandemics, and research time constraints. Threats that exist in the Berambai area include (1) the reclamation area of a coal mining company, some of which are converted to oil palm plantations, (2) there are efforts by a group of people who encroach on the waterfall area under the pretext of maturation of land for preparing tourist facilities, (3) the community is more dominant in mining or making houses rather than being used as nature tourism or planting productive plants.

The potential for environmental damage in the Berambai area includes internal and external potential. Internal potential includes the potential for landslides on steep slopes and subsidence in mud volcano areas. External potential is in the form of coal and limestone excavations in the past that have changed the original landscape, efforts to clear land around Berambai waterfall for tourism development reasons, change secondary forest to oil palm plantations, clear land for cultivation or settlements, land clearing for other purposes. Things that can be done to minimize and overcome potential environmental damage, include (1) Priority segregation of open/bush land areas for revegetation. Areas of open land/bush spread in many places. The priority location for revegetation is mainly on critical or open land without vegetation, followed by bushland with minimal tree stands, next is land with more tree stands, (2) Revegetation of open/bush land areas with consideration of regional biodiversity. Revegetation of the area is carried out by taking into account the distribution of existing vegetation in areas that have tree stands. The plants selected were non-invasive plants. Consideration of the diversity of herbivorous fauna that exist in the area, is also a consideration for planting plants that feed these fauna, (3) Obedience and law enforcement against government regulations in spatial and regional management as well as other legal products for land clearing activities, construction of buildings and regional infrastructure, The government has regulated various regulations related to spatial and regional planning for various community interests and also environmental conservation. The Samarinda City Government, through the Public Works and Spatial Planning Office, has carried out the work on the North Samarinda Detailed Spatial Plan 2019–2039 (Fig. 5c). In the Berambai area as a research area, most of the area is planned as a water catchment area and horticultural agriculture [21]. The

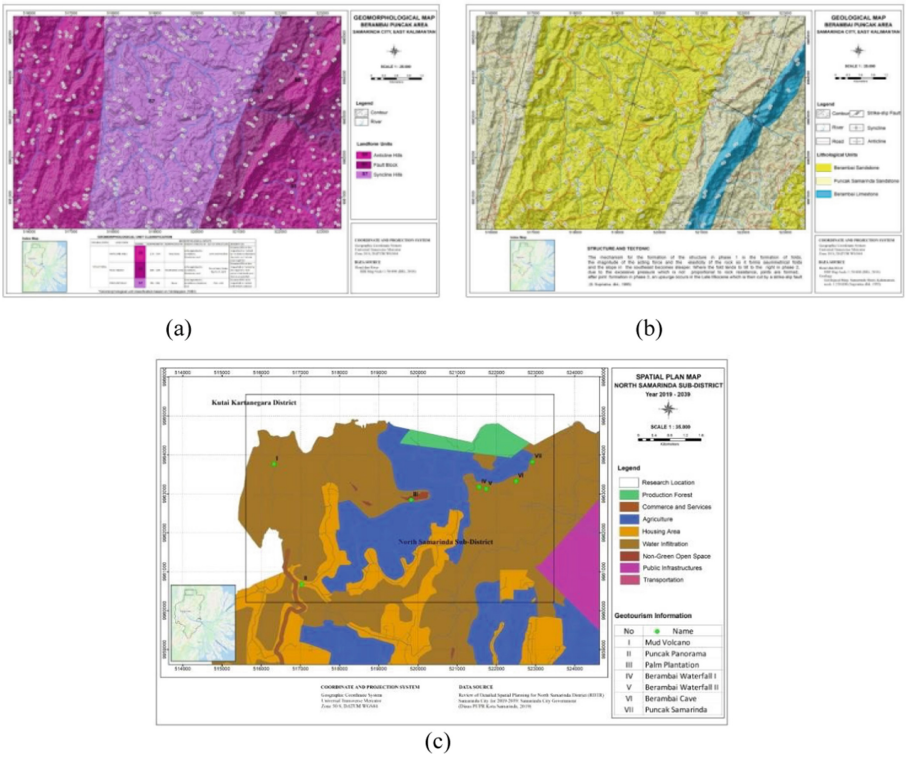

Fig. 5. Distribution of Geotourism Map (a) on the Geomorphological Map, (b) on The Geological Map, (C) Against the North Samarinda Spatial Plan Map 2019–2039

Samarinda City Government has also taken action in the form of an order to stop activities for those who clear land in the Berambai waterfall area as part of the government's supervisory function for compliance with applicable regulations.

5 Conclusion

In the study area in Berambai and its surroundings, there is geomorphological diversity in the form of fault block units, anticline hill units, syncline hill units, as well as geological diversity including: Berambai sandstone units, Samarinda Peak sandstone units, Berambai limestone units. The distribution of geotourism potential in the Berambai area includes: Samarinda Peak, Berambai Cave, Berambai Waterfall, Fishing Pond, Panorama Peak, and Mud Volcano. The potential for environmental damage in the Berambai area occurred mostly on tight elevation area (very steep to moderately steep) conversion of secondary forest to oil palm plantations, land clearing for cultivation or settlement, land clearing for other purposes. Higher risk on erotion and landslides will occur.

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