

RESEARCH ARTICLE

Geosite Assessments at the Southern Part of Karangbolong Dome: New Insight to Geotourism Potential in Kebumen, Central Java, Indonesia

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Abstract

Karangbolong is a morphological dome in the Kebumen area that has a high geological diversity and has a lot of tourism potential. Still, it has not been developed optimally as a geotourism potential based on conservative and educative aspects, especially the existence of ancient volcano of Menganti, the quite interesting from a geological point of view, so in this case, an inventory of a geological diversity required. This study aims to understand the geological conditions and conduct an assessment of the feasibility of geodiversity in the ancient volcano complex of Menganti. The methodology for this research is a direct observation in the field based on the surface geological mapping, rock sampling for petrology study of rocks for supporting the quantitative assessment of geodiversity in the research area. The research area has 2 (two) landscape models, i.e., ex-volcanic landscape, in this case occupying 95% of the research area and then the karst landscape, holding 5% of the research area. Stratigraphy of the research area can be divided into five units from old to young, that is basaltic lava of Menganti, the pyroclastic flow of Menganti, which is interfingering with andesitic lava of Karangduwur, andesite-basalt intrusion unit, and limestone of Agropeni. This Menganti volcanic field has prospective value for tourism developments. This site can develop as a geological tour (geosite) that reviews the paleo-volcanism activities and cave genetic activity. Based on field investigation, the research area has 27 geosite objects that can be developed as geotourism potential, covering three geomorphological sites, seven lithology sites, nine cave karst sites, five beach sites, and two waterfall sites. Based on the results of a quantitative assessment of geosites in the research area with accessibility, state of preservation, scientific worth, and educational significance parameters, the research area has a geodiversity index from 19 until 24, in this case, the research area has good until very good grade to be developed as a geotourism potential base on educative and conservative, to improve the economic value of local communities.

Keywords: Qualitative assessment, geodiversity, geotourism, Kebumen.

1. Introduction

Indonesia is one of the big countries in terms of nature tourism in this world, especially volcano tourism because Indonesia is one of the states in the Asia-Pacific rim, which is being passed by the ring of fire. Approximately 127 active volcanoes have occurred in Indonesia until now. Generally, that condition formed by the subduction of the earth crust, and that why this country has so many volcanoes diversity. Some of them are famous as a tourism object such as Batur volcano in Bali Island, Rinjani volcano in Lombok Island, Tambora volcano in Sumbawa Island, and also volcano complex of Dieng Highlands in Central Java, and many more. Not only a recent volcano (active volcano) has a tourism value but also the ancient volcanoes and, in advance, can be developed by the geotourism approach. Indonesia is also rich in a landscape of morphological karst diversity such as Maros Karst in Sulawesi, Southern mountain Karst in Yogyakarta, and Raja Ampat Archipelago in West Papua. There are many more places that have not been exposed to and developed in Indonesia.

The geological processes produce unusual phenomena with an extraordinary uniqueness of natures in Indonesia with the high complexity of the controlling of tectonic setting. In this case, Indonesia is the meeting point of three main plates in the world, which Eurasia, Indo-Australia, and Pacific plates. And also, tropical climate influence is indirectly made Indonesia one

of the countries with a high geological diversity in the world, which made it worthy of developing it as geotourism potential at the national level or international level. Geotourism is a form of nature tourism that specifically focuses on landscape and geology to encourage tourism development that prioritizes conservation of geosite or geodiversity and biodiversity, as well as an understanding of Earth sciences through appreciation and learning. This activity achieved through independent visits to geological features, use of geo-trails and viewpoints, guided tours, geo-activities, and patronage of geosite visitor centers (Newsome and Dowling, 2010). Geotourism is an emerging trend that will endure. Sustaining the local environment or bringing in a bit of the local color can mean the difference between a discounted rate or a higher rate, which can develop increased seasonal traffic and spur local tourism (Stokes et al., 2003). Geotourism follows advanced principles; this concept is introduced openly in 2002 and reported by American Travel Industry Association and National Geographical Tourists (Tourtellot, 2010). In this aspect, tourism activities based on natural earth objects such as volcano, river, valley, beach, waterfall, lake, spring, rocks, and others. Geotourism is advanced tourism with the main focus on geological features, which promotes understanding, culture, and environmental appreciation, as well as conservation (Dowling, R. &

Newsome, 2006). The research area (Karangbolong dome) has a unique and variety of geological features, and this can be seen in the morphological character as well as some pattern, which is relatively different from the surrounding patterns. Karangbolong dome administratively belongs to Kebumen Regency, in the eastern part of south serayu mountains, which is a form of the tertiary back-arc basin due to an interaction between the Indian Ocean plate, which thrusts to the northern direction under the Asian plate (Van Bemmelen, 1949).

Based on the geological map of Banyumas with 1:100.000 scale (Asikin et al., 1992). Karangbolong dome mostly consists of the tertiary rocks, in this case, is the Gabon Formation (Tmog), which consists of volcanic breccia, lapilli tuff, agglomerate which is intruded by Early Miocene andesite-diorite rocks as well as andesitic lava flow on top. This formation's age is Oligocene-Miocene (Ansori, 2010). Kalipucang Formation (Tmk), consists of coral and crystallized limestone, white-yellowish in color, contain coral fossil, foraminifera, and Mollusca shell fragments. In the same place clastic pumice and in the bottom part shale bitumen is deposited, and the youngest is the Halang Formation (Tmph), lithology consists of (interlayer) sandstone, limestone, napal, and tuff, there is also a breccia insertion which is influenced by turbidity current and undersea landslide (Ansori, 2010). The various geology conditions made it significant to develop it into a real geotourism area, which is massive and integrated as well as educational and conservative-oriented. The long-term development target is development at the local or national level. In this aspect, we able to protect and keep nature sustainability as well as increase the economy of the locals.

The research area focused on the southern part of Karangbolong dome. Administratively, the research area is a part of the Ayah District, Kebumen Regency, Province of Central Java (Figure 1). The research area has quite a high geodiversity and keeps many tourism potentials. However, it has not been developed in general as potential geology and public tourism, which is based on education and conservation, especially the existence of Menganti paleo-volcano, which then geological site inventory is needed to do a good and correct assessment towards geosite in the region.

The goal of this study is to understand the geological condition as well as to give value towards the geology diversity (geodiversity) worthiness in the Menganti paleo-volcano complex to develop the target into geotourism of paleo-volcano.

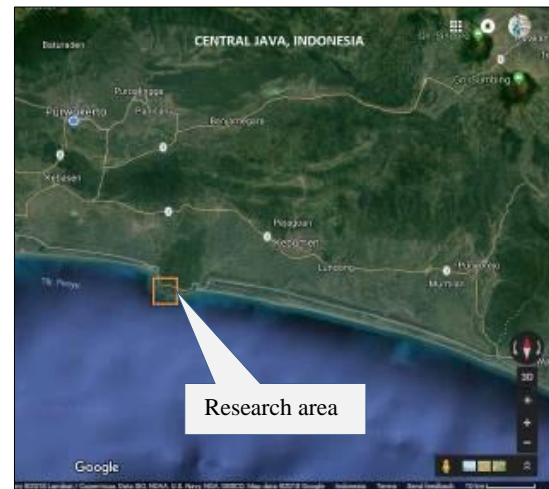


Fig 1. Location of Research area (southern part of Karangbolong Dome), source:(GoogleMap)

2. Methodology

Method of this research became a literature study of the past researcher, which is related to the object or topic research, then do observation in the field based on geological surface mapping concept with topographic base map scale 1:25.000 with the output as a geological map as well as geodiversity distribution. Field observation activity, including the random sampling of the rocks for petrographic analysis using the polarization microscope to understand the minerals composition of the rocks. Quantitative assessment towards geosite is based on (Table 1) assessment criteria for geosite inventory and geomorphological site (Solarska and Jary, 2010), which is hoped that by this quantitative assessment, it can reduce the subjectivity which is related to the evaluation of the procedures.

Table 1. Assessment criteria for geosite inventory and geomorphological sites (Solarska and Jary, 2010).

CRITERIA	TRAITS	POINTS
Accessibility	The site clearly visible, located directly on the touristic trail or nature's path	5
	The site clearly visible, located on the road or path	4
	The site barely visible, located more than 250 m away from the path or road	3
	Site difficult to access for tourist	2
State of preservation	Site unavailable for tourists	1
	A well-preserved site with no visible signs of degradation	5
	Site in slight violation of its structure	4
	Partially destroyed	3
	The site heavily modified by human	2
Scientific worth	Site destroyed-loss character of geosite	1
	Very high: one site in the region, unique to a wider scale	10
	High: very important for regional studies	8
	Average: significant for regional research	6
Educational Significance	Low: common site with average values	4
	Very low: no particularly distinctive features	2
	Very high: number of represented issues = 5 and more	10
	High :number of represented issues = 4	8
	Average :number of represented issues = 3	6
Educational Significance	Low :number of represented issues = 2	4
	Very low :number of represented issues = 1	2

3. Result and Discussion

3.1. Geology of research area

The different and unique shapes of the earth's morphology made into an attraction of its own for those who see it. Irregular

and different reliefs could identify different lithology as well (Brahmantyo and Bandon, 2006). Generally, the research area has 2 (two) geomorphology characters which are volcanic remains morphology and the karst morphology (Brahmantyo and Bandon, 2006), in this case, the volcanic remains morphology occupies 95% of the research area, consisting of

volcanic products like lava, intrusion until pyroclastic rocks. This morphology divided into four units of geomorphology, which are Volcanic Cone of Menganti, Lava Flow of Karangwudur, Pyroclastic rocks of Menganti, Lava Flow of Menganti, while the karst morphology occupies 5% of the research area. This karst morphology is divided into two geomorphology units which are karst cone hills and karst valley unit, this morphology consists of limestone. Based on surface geological mapping as well as lithological data as well as the forming characteristic of research area can be divided into five units from oldest to youngest are Menganti basaltic lava unit, Menganti pyroclastic flow unit (interfingering) with Karangduwur andesite lava flow unit, Andesite-Basalt intrusion unit and Agropeni limestone unit (Figure 2). Based on volcano stratigraphy towards the paleo-volcanism, then it is divided into one crown (Karangbolong), which consists of 2 (two) hummocks, namely Gadung Hummock and Menganti Hummock (Figure 4) with a geological alignment lineation pattern is relatively towards North-South. Based on a petrology of ancient lava basalt Menganti area, that rock sample is petrographically dark gray on parallel Nikol, has a poikilitic texture, intersertal, euhedral-subhedral crystals, with a relatively equal mineral composition of Plagioclase (bytownite An78-An71) labradorite (An68-An62)), pyroxene, hornblende, with the addition of "opaque mineral" gangue mineral, it indicates that the crystallization process takes place on a saturated aqueous environment, thus forming a hornblende mineral (Mulyaningsih et al., 2016).

From the results of the petrographic analysis can also be interpreted that the activity of primary magma evolution from the magma basalt rich (olivine) to pyroxene-rich basalt magma with magma affinity magma tholeiitic, it can also be explained from fractionation plagioclase type bytownite to labradorite and also if petrological results are not observed the appearance of K-feldspar and quartz mineral in basalt igneous rocks samples, this indicates that these rocks have not been fractionated (Fadlin et al., 2018). Based on that samples, the texture of zoning in plagioclase minerals indicates that the process of magma mixing and assimilation causes rocks to become unstable and dissolved, marked by the presence of sieve texture (Gill, 2013) (Figure 3). Sieve texture is a texture often include combinations of intricate zoning patterns and resorption feature in plagioclase e that record changing physical conditions in the magmatic system. Based on dominant mineral composition, in this case, plagioclase and pyroxene minerals can be classified as pyroxene basalt (Travis, 1955). The columnar joint of lava basalt outcrop is one of the highest-level geodiversity sites in terms of accessibility, state of preservation, scientific worth, excellent educational significance (Table 2), in addition, this site also has a fairly high phenomenon value the shape is neatly arranged like a placemat. Geodiversity is interpreted as the center of the ancient volcanic eruption of Menganti and is considered as the center of the first (oldest) eruption in terms of relationships in volcano-stratigraphy (Pendi et al., 2018).



Fig 2. Outcrop of Menganti basaltic lava unit, showing the columnar joint structure(a). Outcrop of Menganti pyroclastic flow unit, showing the fragment interlocking relationship(b). The outcrop of the Karangduwur andesitic lava unit has been altered(c). Outcrop of Andesite-Basalt intrusion unit (d). Outcrop of Agropeni limestone unit, showing the stalactite in the rooftop of the cave(e).

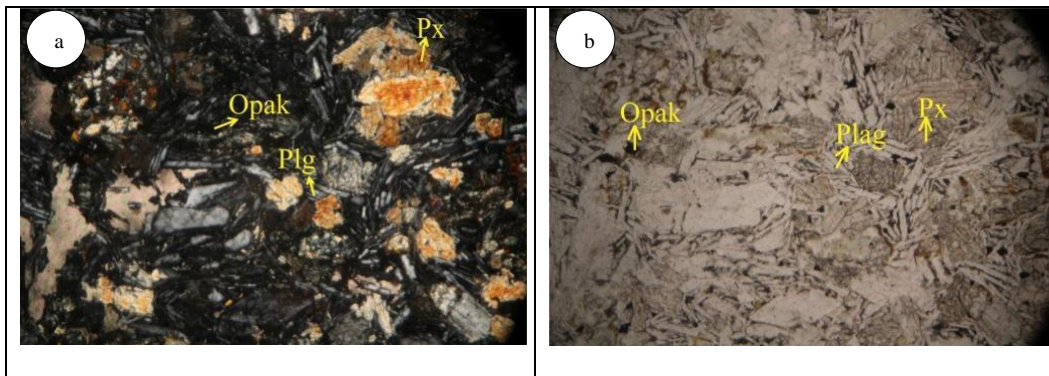


Fig 3. Photomicrograph of basaltic lava (columnar joint), showing sieve texture, consists of plagioclase (plag), which dominated by mafic plagioclase, pyroxene (Px), and opaque minerals as secondary mineral (opak=opaque). (a)parallel Nikol, (b) cross Nikol.

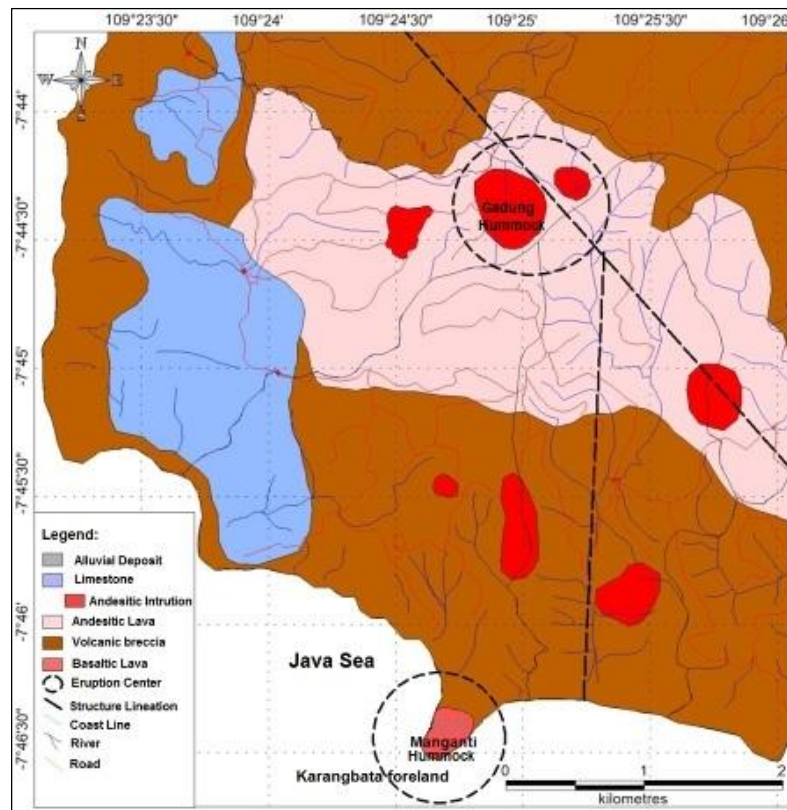


Fig 4. Geology map of the research area

3.2. Geodiversity site inventory

Geodiversity is a description of the diversity of geological components found in an area, including its existence, distribution, and condition so that it can represent the geological evolutionary process of the area (Kementrian ESDM, 2020). Geodiversity also has another meaning is an image of diverse geological components that exist in an area, including occupation, distribution, and condition so that it could represent the geological evolution of the area such as rocks, minerals, fossils, soil, and landforms is an integral part of nature (Gray, 2004). Geodiversity assessment argued to be a potentially effective tool for supporting decision-making processes with regards to management and conservation of natural areas or regions at different scales, be these local or regional. Further, geodiversity is seen to be a complementary resource to natural heritage and as such can be an asset of environmental, scientific, educational, cultural or economic interest in need of effective management (Serrano and Ruiz-Flaño, 2007), so that

is very important to do a quantitative assessment about geodiversity in the research area for supporting the geotourism development. The research area has those diversity aspects which are geomorphology diversity which consists of 3 geosites (structural valley, karangbata cape and karangduwur peak), lithology diversity consists of 7 geosites (pyroclastic fall deposit, pyroclastic flow deposit, primary hyaloclastic breccia, secondary hyaloclastic breccia, columnar joint of basaltic lava, sheet joint of basaltic lava and pillow texture of basaltic lava), karst cave diversity consists of 9 geosites (Sawangan, Siwowo, Campur, Sarangburung, Payung, Surupan, Upas, Celeng, and Sikidang), beach diversity consists of 6 geosites (Karangagung, Sawangan, Menganti, Lampon, Pecaron, and Pasir) as well as waterfall diversity consists of 2 geosites (Sawangan rainbow waterfall and Ketep Widodari waterfall) (Table 2). There are 27 geosites which are spread throughout the south-west region of the research area (Figure 4), which can develop as a geotourism potential.

Table 2. Geodiversity site based on incentivization result (distribution on map)

Site Geodiversity		
Geomorphology:	Karst cave:	Beach:
1. Structural Valley	11. Sawangan	20. Karangagung
2. Karangbata foreland	12. Siwowo	21. Sawangan
3. Karangduwur peak	13. Campur	22. Menganti
Lithology:	14. Sarangburung	23. Lampon
4. Pyroclastic fall deposit	15. Payung	24. Pecaron
5. Pyroclastic flow deposit	16. Surupan	25. Pasir
6. Primary hyaloclastic breccia	17. Upas	Waterfall:
7. Secondary hyaloclastic breccia	18. Celeng	26. PelangiSawangan
8. Basaltic lava columnar joint	19. Sikidang	27. KetepBidadari
9. Basaltic lava Sheetet joint		
10. Basaltic lava pillow texture		

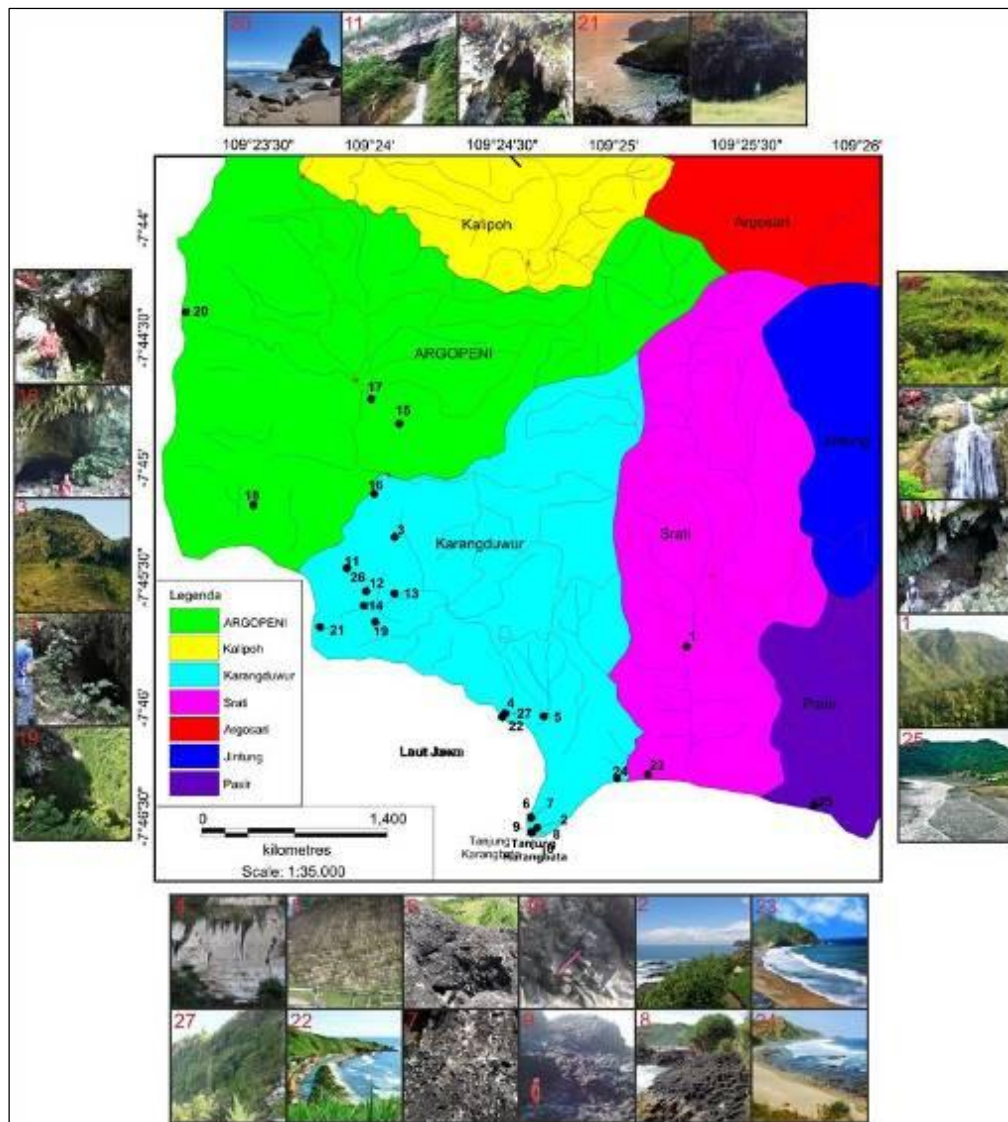


Fig 5. Distribution map of geodiversity site based on inventory result

3.3. Quantitative assessment of geosite

The assessment of geosite, which occurs in the research area, is hoped to be able to reduce objectivity towards the geology diversity evaluation process that occurs in the research area. The result from the assessment value evaluation towards the geosite shows a diverse geodiversity index with a total grade index from the four variables are around 19-24 for each geosite

(Table 3). Qualitatively the research area has a geodiversity index in a varying level, starting from the highest score (very good) until the middle score (good), in this case, the highest grade is in the south-western part of the research area, the middle score (good) is in the central part of the research area while the lowest score (satisfactory) is in the north-eastern part of the research area wherein that part there are not many geosite occurrences which is potential to be developed (Figure6).

Table 3. Identification and assessment quantitatively of geosite occurrence in the research area based on (Solarska and Jary, 2010), modified by the researcher in this paper.

No	Geosite	Description	Score	Index level
A Geomorphology				
1.	Structural valley	<p>This morphology is formed by tectonic activity, generally in the form of fracture, with a triangular facet appearance; this valley is generally composed of volcanic breccia lithology, with land use as forest and plantation by Perhutani.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: the site is well groom, signs of degradation have not yet been seen (5)</p> <p>c. Scientific worth: Average, scientific worth (6)</p> <p>d. Educational significance: Average, the number of problems represented = 3 (6)</p> <p>This Potential can be used as a geotracking location, for tracking tours or walking along the valley with length \pm 4 km, or for special interest tours, as a place of study of earth sciences such as geological structure and geomorphology.</p>	21	Good
2.	Karangbata Foreland	<p>This morphology is formed by the volcanic activity of ancient volcanoes that occur in the region Menganti, in this case, composed of the lithology of basalt lava.</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road (3)</p> <p>b. State of preservation: The site is well groom, signs of degradation have not yet been seen (5)</p> <p>c. Scientific worth: High, very important for regional study (8)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>This Potential can be used as a camping site for the pleasure of enjoying the expanse of the sea and sunset just spoil the eyes, as a place of study of earth science such as understanding the morphology, the process of erosion and abrasion.</p>	24	Very Good
3.	Karangduwur peak	<p>This morphology is a height built by reef limestone units that have sufficiently intense karstification. The limestone units are riding in an uncomfortable manner with volcanic rocks of lava.</p> <p>a. Accessibility: the site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: the site is well preserved, the degradation mark has not yet been seen (5)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>This Potential can be used as a camping site, tourism substation view, spot climbing, and also very good to enjoy the sunset, and as a place of study of earth science such as understanding the geomorphology, erosion, abrasion and karstification process.</p>	23	Very Good
B Lithology				
1.	Pyroclastic fall deposit	<p>This falling pyroclastic was an eruption product of the ancient volcanic, composed of pyroclastic breccia, with andesite fragment composition, a tuffaan sand matrix, with a vertical thickness of \pm 50 meters, with a relatively steep morphological slope (90°) generated from its collapse wall near the eruption center.</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road (3)</p> <p>b. State of preservation: site slightly changed (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: average, the number of problems represented = 3 (6)</p> <p>This Potential can be used as a climbing location, or cable train, or flying fox, as well as a place of study of earth science such as understanding the product rock as a volcanism activity of the ancient.</p>	19	Good
2.	Pyroclastic Flow deposit	<p>This pyroclastic flow deposit is a product of ancient volcanic eruption, transported by river and composed of an epiclastic breccia with andesite fragment composition, a tuffaan sand matrix, with a vertical thickness of \pm 20 meters, with a relatively steep slope of morphology (80 °) resulting from tectonic activity.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: site slightly changed (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: average, the number of problems represented = 3 (6)</p>	20	Good
3.	Primary Hyaloclastic Breccia)	<p>It can be developed as a place or stopsite for learning of earth science, such as understanding the product rock as an ancient volcanism activity.</p> <p>This hyaloclastic breccia was formed by past volcanic activity under the sea.</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p>	21	Good

No	Geosite	Description	Score	Index level
4.	Secondary hyaloclastic Breccia	<p>b. State of preservation: the site has changed little (4) c. Scientific worth: average, Scientific worth (6) d. Educational significance: average, the number of problems represented = 4 (8)</p> <p>It can be developed as a place or stopsite for learning of earth science, such as understanding the product rock as the activity of the past / ancient volcanism, due to having phenomenal value that can be patented as geoheritage.</p>	20	Good
5.	Basaltic lava columnar joint	<p>This hyaloclastic breccia was formed by past volcanic activity under the sea but as a secondary product, with the presence of a carbonate clay matrix.</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road (3) b. State of preservation: the site is well-preserved, has not seen the appearance of degradation (5) c. Scientific worth: average, Scientific worth (6) d. Educational significance: average, the number of problems represented = 3 (6)</p> <p>This location can be developed as marine tourism to enjoy the beach or sunset or dusk, also very worthy as a place or stopsite for learning of earth science such as understanding the product rock as the activity of the past / ancient volcanism, due to have phenomenal value can be patented as geoheritage.</p> <p>These igneous rocks are produced from the cooling of magma on the activity of underwater volcanoes in the past with a unique structure resembling a brick or otherwise known as a columnar joint.</p> <p>a. Accessibility: the site is clearly visible, located on the tourist track (5) b. State of preservation: the site is well-preserved, yet visible signs of degradation (5) c. Scientific worth: average, Scientific worth (6) d. Educational significance: high, the number of problems represented = 3 (6)</p>	22	Very Good
4.	Basaltic lava (Sheeted joint)	<p>This location can be developed as marine tourism to enjoy the beach or sunset or dusk, also very worthy as a place or stopsite for learning of earth science such as understanding the product rock as the activity of the past / ancient volcanism, due to have phenomenal value can be patented as geoheritage.</p> <p>These igneous rocks were produced from the magma cooling process of past underwater volcanic activity with a unique structure resembling a brick head or known as a sheeted joint structure.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4) b. State of preservation: site slightly changed (4) c. Scientific worth: average, Scientific worth (6) d. Educational significance: high, the number of problems represented = 4 (8)</p>	22	Very Good
5.	Basaltic lava (pillow texture)	<p>This location can be developed as marine tourism to enjoy the beach or sunset or dusk, also very worthy as a place or stopsite for learning of earth science such as understanding the product rock as the activity of the past / ancient volcanism, due to have phenomenal value can be patented as geoheritage.</p> <p>These igneous rocks are produced from the cooling of magma on the underwater volcanic activity of the past with a unique structure resembling a brick or otherwise known as a pillow joint.</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road (3) b. State of preservation: the site is well-preserved, yet visible signs of degradation (5) c. Scientific worth: average, Scientific worth (6) d. Educational significance: average, the number of problems represented = 3 (6)</p> <p>This location can be developed as marine tourism to enjoy the beach or sunset or dusk, also very worthy as a place or stopsite for learning of earth science such as understanding the product rock as the activity of the past / ancient volcanism, due to have phenomenal value can be patented as geoheritage</p>	20	Good
<hr/>				
C	Karst Cave			
1.	Sawangancave	<p>Sawangancave is one of the karst cave in the research area, formed by the activity of limestone solubility (karstification), the flow of water below the surface directly flow to the beach, and this cave has its own uniqueness, there are igneous rocks of volcanic lava at the basement of the river.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4) b. State of preservation: little sites have changed (4) c. Scientific worth: average, Scientific worth (6) d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>That potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. This location also offers a waterfall tour exactly at the mouth of the cave. In addition to these two things in geosite, it is very feasible as a place or stopsite for the study of earth science to understand the carbonate rock and karstification process that works.</p>	22	Very Good

No	Geosite	Description	Score	Index level
2.	Siwowocave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: little sites have changed (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>That potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. This location also offers a waterfall tour exactly at the mouth of the cave. In addition to these two things in geosite, it is very feasible as a place or stopsite for the study of earth science to understand the carbonate rock and karstification process that works.</p>	21	Good
3.	Campur cave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: little sites have changed (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>That potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. This location also offers a waterfall tour exactly at the mouth of the cave. In addition to these two things in geosite, it is very feasible as a place or stopsite for the study of earth science to understand the carbonate rock and karstification process that works.</p>	21	Good
4.	Sarangburing cave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: little sites have changed (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>That potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. Geosite is also very feasible as a place or stops site for the study of earth science to understand the carbonate rock and karstificationprocess that works.</p>	21	Good
5.	Payung cave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: little sites have changed (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>That potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. Geosite is also very feasible as a place or stops site for the study of earth science to understand the carbonate rock and karstificationprocess that works.</p>	21	Good
6.	Surupan cave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: little sites have changed (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>That potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. Geosite is also very feasible as a place or stops site for the study of earth science to understand the carbonate rock and karstificationprocess that works.</p>	21	Good
7.	Upas cave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: the site has changed little (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>That potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. Geosite is also very feasible as a place or stops site for the study of earth science to understand the carbonate rock and karstificationprocess that works.</p>	22	Very Good

No	Geosite	Description	Score	Index level
8.	Celeng cave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: the site has changed little (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>The potential that can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave while enjoying the ornaments in the cave. Geosite is also very feasible as a place or stops site for the study of earth science to understand the carbonate rock and karstificationprocess that works.</p>	21	Good
9.	Sikidang cave	<p>This cave is a karst cave that is formed from limestone dilution activities (karstification).</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: the site has changed little (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>The potential can be developed in geosite location is, of course, the most interesting is the caving tour or down the cave, while enjoying the ornaments in the cave. Geosite is also very feasible as a place or stops site for the study of earth science to understand the carbonate rock and karstificationprocess that works.</p>	21	Good
<hr/>				
D	Beach			
1.	Karangagung beach	<p>This beach is a coast with a relatively steeply coastal line, which is formed as a result of the abrasion process.</p> <p>a. Accessibility: be on the tourist path or the path(5)</p> <p>b. State of preservation: site has been changed slightly (4)</p> <p>c. Scientific worth: high, very important for regional studies(8)</p> <p>d. Educational significance: average, the number of problems represented = 3 (6)</p> <p>This potential can be Developed for beach tourism potential to enjoy the natural scenery while enjoying the sunset or sunset. This geosite is also very feasible as a place or stopsite for learning geography to understand the process of coastal formation associated with abrasion and erosion.</p>	23	Very Good
2.	Sawangan beach	<p>This beach is a coast with a relatively steeply coastal line, which is formed as a result of the abrasion process.</p> <p>a. Accessibility: be on the tourist path or the path(4)</p> <p>b. State of preservation: site has been changed slightly (4)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>This potential can be Developed for beach tourism potential to enjoy the natural scenery while enjoying the sunset or sunset. This geosite is also very feasible as a place or stopsite for learning geography to understand the process of coastal formation associated with abrasion and erosion.</p>	22	Very Good
3.	Menganti beach	<p>This beach is a coast with a relatively flat coastal line, with white sand, which formed due to the abrasion process.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: site has been changed slightly (4)</p> <p>c. Scientific worth: high, very important for regional studies(8)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>This potential can be Developed for beach tourism potential to enjoy the natural scenery while enjoying the sunset or sunset. This geosite is also very feasible as a place or stopsite for learning geography to understand the process of coastal formation associated with abrasion and erosion.</p>	22	Very Good
4.	Lampon	<p>This beach is a coast with a relatively steeply coastal line, which is formed as a result of the abrasion process.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: site has been changed slightly (4)</p> <p>c. Scientific worth: high, very important for regional studies(8)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p> <p>This potential can be Developed for beach tourism potentialto enjoy the natural scenery while enjoying the sunset or sunset while understanding the process of coastal formation associated with abrasion and erosion, as well as volcanic rocks in the location.</p>	24	Very Good
5.	Pecaron	<p>This beach is a coast with a relatively flat coastal line, with white sand, which formed due to the abrasion process.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: site has been changed slightly (4)</p> <p>c. Scientific worth: high, very important for regional studies(8)</p> <p>d. Educational significance: high, the number of problems represented = 4 (8)</p>	24	Very Good

No	Geosite	Description	Score	Index level
6.	Pasir	<p>This potential can be Developed for beach tourism potentialto enjoy the natural scenery while enjoying the sunset or sunset while understanding the process of coastal formation associated with abrasion and erosion, as well as volcanic rocks in the location.</p> <p>This beach is a coast with a relatively flat coastal line, with white sand, which formed due to the abrasion process.</p> <p>a. Accessibility: accessible on foot, approximately 250 meters from the main road(3)</p> <p>b. State of preservation: site has been changed slightly (4)</p> <p>c. Scientific worth: high, very important for regional studies(8)</p> <p>d. Educational significance: high, the number of problems represented = 4</p> <p>This potential can be Developed for beach tourism potential to enjoy the natural scenery while enjoying the sunset or sunset while understanding the process of coastal formation associated with abrasion and erosion, as well as volcanic rocks in the location.</p>	19	Good
E Waterfall				
1.	Pelangi Sawangan Waterfall	<p>This waterfall is formed due to morphological cuts in the flow of the underground river that flows down to the beach. This waterfall will also have a considerable water discharge in the rainy season.</p> <p>a. Accessibility : Site looks clear, there is a way to the site (5)</p> <p>b. State of preservation: site is well-maintained, no degradation has been seen (5)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: average, the number of problems represented = 4 (8)</p> <p>The potential can be developed for waterfall tourism while studying carbonate and volcanic rocks, as well as the process of submarine rafting.</p>	24	Very Good
2.	Ketep Bidadari Waterfall	<p>This waterfall is formed due to fault slide down on the steep morphology in the Menganti area, has a large enough water discharge in the rainy season.</p> <p>a. Accessibility: Site looks clear, there is a way to the site (4)</p> <p>b. State of preservation: terawatt good site, has not seen any degradation (5)</p> <p>c. Scientific worth: average, Scientific worth (6)</p> <p>d. Educational significance: average, the number of problems represented = 4 (8)</p> <p>The Potential can be developedfora waterfall tour while studying volcanic rocks.</p>	23	Very Good

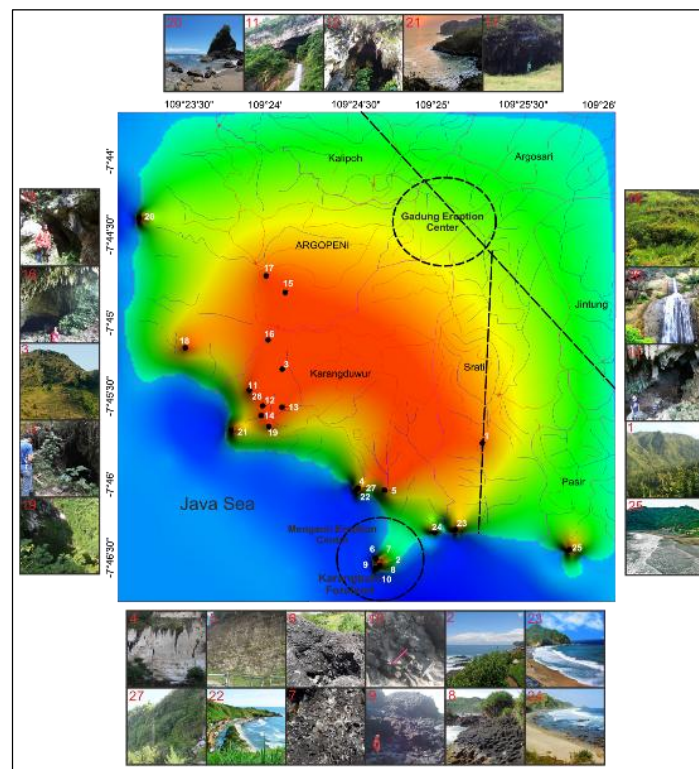


Fig 6. Geodiversity anomaly map index of the research area, which shows high to low score diversity index (red: high index/very good, green: middle index/good and blue: low index/satisfactory). 1. Structural Valley; 2. Karangbata foreland; 3. Karangduwur peak; 4. Pyroclastic fall deposit; 5. Pyroclastic flow deposit; 6. Primary hyaloclastic breccia; 7. Secondary hyaloclastic breccia; 8. Basaltic lava columnar joint; 9. Basaltic lava Sheetet joint; 10. Basaltic lava pillow texture; 11. Sawangan cave; 12. Siwowo cave; 13. Campur cave; 14. Sarang burung cave; 15. Payung cave; 16. Surupan cave; 17. Upas cave; 18. Celeng cave; 19. Sikidang cave; 20. Karangagung beach; 21. Sawangan beach; 22. Menganti beach; 23. Lampon beach; 24. Pecaron beach; 25. Pasir beach; 26. PelangiSawangan waterfall; 27. KetepBidadari waterfall.

4. Conclusion

The research area has two landform models, which are volcanic mountain landform; in this case, it occupies 95% of the research area and karst hills landform, which occupies 5% of the research area. Stratigraphy of the research area can be divided into 5 units from oldest to youngest are Menganti basalt lava flow unit, Menganti pyroclastic flow unit, which (intercorrelated) with Karangduwur lava flow unit, Andesite-Basalt intrusion unit and Agropeni limestone unit.

Menganti Volcanic Filed has prospective value for tourism developments. This site can develop as a geological tour (geosite) that reviews the paleo-volcanism activities and cave genetic activity. Based on field observation, the research area has 27 geosite objects, which could be developed as geotourism potential, including three geomorphology sites, seven lithology sites, nine karst cave sites, five beach sites, and two waterfall sites.

The research area has various geodiversity index. Therefore this geosite can develop into good geodiversity. From total scoring from every single site has an average score of about 19-24. In this case, it has a good index level. Therefore it needs development so that it is possible to develop into geotourism potential, which based on educative and conservative in the hopes of increasing the welfare of the local economy.

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