Inventory of geoheritage of the Muria Peninsula to develop geotourism

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Abstract. The three main pillars of geoheritage are education, conservation, and sustainable development of local peoples. Mount Muria is a complex of quarternary volcanoes that form a large peninsula in the northern part of Java. The composition of K series magma (the Old Muria) and high-K alkali (the Young Muria) is very different from the composition of volcanoes in the main land which are Calc-alkali.Detailed field observations of the targets indicate on Mount Muria many phenomena that can be used as geoheritage candidates, such as: dry maar Bambang and wet maar Gunung Rawa; pillow lava Banyumanis; volcano parasite Puso, and twin volcanoes Ragas and Bako; litoral fossiliferous sedimen at Gajah River; various lithology at North Gelis River and South Gelis River; Tiga rasa and lima rasa water spring with different flavors.However misuse in land use has resulted in disasters, especially landslides and flash floods in South Muria.

Keywords: Muria Volcano, geoheritages, geotourism

1. Introduction

The diversity and uniqueness of geology gives its own potential value to be geological heritage. The potential is very strategic to support the program of geological resources conservation and its development in the geology-based tourism sector through the concept of geopark. So if the geological potential can be well managed, it is expected to form a sustainable geological appeal and its benefits directly for society and nation.[1]. Important interrelated elements in the protection of geological heritage, environmental conservation and earth science distribution are geodiversity, biodiversity and culture diversity.

Geodiversity or geological diversity is a description of the diversity of geological components present in an area, including its existence, dispersion and circumstances so as to represent the process of geological evolution of the area[4]. The components in question are minerals, rocks, fossils, geological structures, and landscapes. Limited geodeversity studies applied to geological and geomorphological elements, not used for other elements such as climate and land use, so geodiversity becomes an intrinsic property possessed by a locality[5].

Geological heritage is interpreted as a geodiversity that has more value or uniqueness as an heritage because it becomes a recording of an event on earth that has ever been or is happening.[4]. Therefore geological heritage is important for research and earth science. Geodiversity that has tourism potential or its close presence with history and culture is also understood as a geological heritage. Whereas

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geological conservation is described as an attempt to protect and preserve more meaningful geological components [1].

According to Dowling in Kubalikova (2013) [3], geology-based tourism is defined as a form of nature tourism that specifically focuses on landscapes and geology. It can also be interpreted as the introduction of tourism potential from a place with unique geological appearance, the introduction of geodiversity conservation and understanding of earth science through tourism[2].

The Muria Peninsula is one of the areas with potential as a geopark candidate. It has a unique position that is not parallel to other quaternary volcanoes as well as the unique rock composition compared to the quaternary volcano products on the same island. The geology of the research area is composed of volcanic eruption rocks of lava tepritic, phonolitic and foidite, pyroclastic (breccias, lapili and tuff) rocks and also exposed older clastic carbonate sedimentary rocks and locally present limestones (National Technical Team, 2000). Eight geosites were selected.

2. Methods

The research was conducted by detailed surface mapping method and detail field observation which includes identification of geodiversity data and its relation with tourism potential. Identification is based on important geological and geomorphological appearance on geosite. All geosite have been identified by the author and additional information is obtained from local residents and related agencies to obtain new geotarget reference.

3. Result and Discussion

3.1. Fossil Volcano Maar Bambang

The availability of maar volcano is the characteristic of Mount Muria. One of the maar volcano fossil remaining is Maar Bambang Volcano which is well exposed on the slopes of the northern Muria Peninsula exactly 13 km to the northeast of the peak of Mount Muria. The name Bambang is taken from the location type namely DusunBambang, Plaosan Village, Cluwak District, Pati Regency (Coordinate X = 493498; Y = 9276615). The appearance of circular basin that opens to the northeast and a diameter of ± 1 km, Maar Bambang is a dry maar volcano type.

The appearance of Bambang maar volcano landscape is shown by the morphology of circular height in the form of typical volcano maar crater(Figure 1a), which composed by eruption products ignimbrite breccias or breccias of various materials with bomb fragments and pyroclastic blocks and matrix of fine dust material up to lapillus, volcanic breccias with gravel-sized fragments to boulder, vesiculated tuff, lapili stone and structured boulders of basanit lava flow and loose soil of clay-sized grains to fine sand found on the embankment walls(Figure 1c,4d,4e,4f). While in the middle of the crater composed by weathered soil and loose material of andesite and basalt boulders sized 25-96 cm with a fertile rice field land use (Figure 1b)

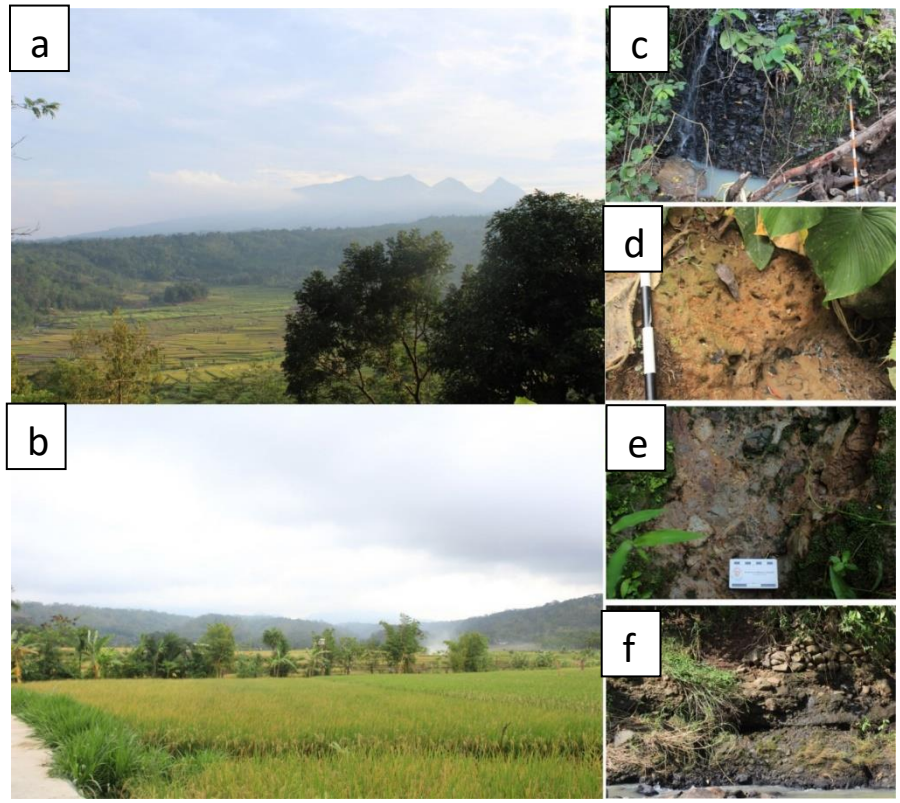


Figure 1. (a) Feature landscape of circular height depression; (b) Fertile rice field land use as a potential object to study about agriculture; (c) Basanit lava with blocky structure feature; (d) Vesiculated tuff outcorp; (e) Ignimbrit breccia as the evidence of phreatic period; (f) Volcanic breccia outcorp

By conducting a regional approach, the presence of carbonate rock of Bulu Formation as the base of Mount Muria and the presence of subsurface structure is suspected to be the trigger of the occurrence of mixing and great interaction between the heat source of volcanoes and groundwater in shallow depth which then resulted in a powerful freatomagmatic eruption to build wall of maar embankment that existed to this day.

There are 3 good potentials from the bambang maar volcano area, among others: a) as an earth education for earth students to study the characteristics and appearance of maar volcano through morphology and rocks. b) landscape and scenery tourism with the background appearance of Muria mountain, and c) agricultural education for tourists to learn how the process of rice planting from seed to harvest. So from the uniqueness, and the positive potential that exists, the area of bambang maar volcano deserve to be a landmark of public tourism and earth.

3.2. Gunung Rowo Maar

Gunung Rowo Maar is located in Sitiluhur Village, TlogowunguSubdistrict, Pati Regency, located 12 km to the northwest from central government of Pati regency (Coordinate X = 496093; Y = 9264035). Gunungrowo Maar is a basin filled with water which then classifies it as wet maar type with volcanic maar crater which shows the appearance of circular depressions. The constituent rocks of Gunungrowo Maar are dominated by breccia tuffs, and also found ignimbrite breccias, tuff and lava andesite basalt. At this time maar area of Gunungrowo is used as water container for agriculture irrigation as well as dame nature tourism with Muriamountain as the background.



Figure 2. (a) Lava outcrop at Gunung Rawa Wet Maar volcano; (b) Traditional of rock mines by locals; (c) Ignimbrit breccia outcrop as a key of freaticperiod; (d) Dam Gunung Rawa in circular depression morphology; (e) Beauty scenery of dam and Muria Mountain as a potential tourism object

3.3. Banyumanis pillow Lava

Banyumanis pillow lava is located in Banyumanis village, Donorejo district, Jepara, 8 km north of pati-jepara highway (Coordinate: X = 487527; Y = 9288600). Banyumanis pillow lava is the only pillow lava in Muria peninsula area. Very well exposed in the Gajah river, the pillow lava is formed from alkali feldspar rock with strongly dilated pillow structure appearance due to normal faults trending northeast-southwest located above tuff rocks that are partially altered into hornfels in area that contact directly with lava and under breccia tuff bed that exposed on the east side.



Figure 3. (a) Fan like shape in inner body of pillow lava; (b)(c) Landscape feature of pillow lava; (d) Liniement of Gajah river and pillow lava as its bedrock; (e) Small waterfall in pillow lava; (e) A big pothole structure

The presence of pillow lava in this area formed a waterfall formation with a height of 3 meters with a fairly strong river water flow. At this location visitors is served with some educational activities about rocks and history of pillow lava formation and as a tourists place to take pictures, enjoys waterfall and fishing activities.

3.4. Puso Parasiter Cone

Located on the northeast of the pillow lava area (Coordinates: X = 488804; Y = 9289581), Puso hill is a parasiter cone with circle diameter of ± 550 m and a height of 125 mdpl. The uniqueness is its apparent positive morphological appearance when it passes through the Banyumanis area and its longitudinal ridge attached to the conical body, which is the lava body (Figure 4). Pusoparasiter cone is formed over andesite rocks while the lava is composed of alkali feldspar trakit rocks. Currently lava hills have been carried out as traditional mining activities by local residents.

The beauty and uniqueness of the positive morphology and the color of the rock exposed on the parasiter cones of Puso can be utilized as an educational destination for those who studying geography of the parasiter cone and also landscapes and scenery destination, where visitors can enjoy the scenery of the northern coastal plains of Java as well as the sight of the Lemahabang PLTU from the elevation point of Puso hill.



Figure 4. (a) Landscape feature of Puso Parasitic Cone; (b) Traditional rock mining from Pusp Parasitic Cone; (c) Scenery of Northwest Puso Parasitic Cone as a potential tourism object; (d) Landscape of parasitic cone bodyas a potential camping ground; (e) Pinus forest in southwest of Puso Parasitic cone as a potential camping ground and agriculture study

3.5. Twin Hill Ragas and Bako

Geologically the twin hills Ragas and Bako is parasiter cones formed on the body of Mount Genuk located in the North Muria Peninsula. Composed of igneous rocks trachite with sanidin as a main mneral.Currently Ragas hill is used as Feldspar mining activities and utilized as a ceramic base material.



Figure 5. (a) Visibility of Ragas hill, (b) Visibility of Bako hill; (c) The rest of mining at Ragas Hill that create artficial lake; (d) Beauty scenery of java sea from the top of Bako Hill; (e) The morphological feature of twin hill

Located at (Coordinates: X = 496211; Y = 9289309) the appearance of positive morphology of these two hills is very prominent considering its surroundings having volcanic residual plains morphology. Its beauty lies in the color of rocks on the body of a white hill from the mineral feldspar. Former mining produces a basin which will be filled with water and form a beautiful lake with a white hill background when rainy season. Conservation efforts will soon be done by leaving the hill body for the benefit of education and tourism.

3.6. Gajah River

Exposed in the Mount Genuk slope (Coordinate: X = 493577; Y = 9284618), the fossiliferrous limestone in Gajah river is not altered into metamorphic rock. Having beautiful fossils, the body of Gajah river can be used as a place for education about lithoral fossil orgnaisme. Based on age-determining process, limestone in this area is older than the volcano itself. So it is believed that the basement of the MuriaPeninsula is a limestone. This area can be utilized as an educational tourist area for students who study earth science.



Figure 6. (a) Visibility of Gajah River with the floatstone as a bedrock; (b) Fosil of macro foram of star fish; (c) The outcorp of Fossilliferus limestone; (d) The volcanic breccia fill in vertical limestone crack; (e) Turritella fossil in Floatstone outcorp

3.7. Northen and Southern Gelis River

The northern Gelis River is located in the village of Tempur, Keling district, Jepara regency, 2.4 km north of the peak of Mount Muria. The village of Tempur is a unique village because of its location in the crater of Mount Muria and the uniqueness of rocks found in Gelis River in the form of lava with various composition variations due to Muria eruption products that contain a lot of high potassium and foid namely basalt, basanite, tephrite, latite, and phonolite all can be found in the North Gelis River and South Gelis River. Area of Gelis River is a hill area with steep slope of lava and breccia lithology dominance with weathered conditions so that geological disasters potential such as landslides is very high.

Beside its negative potential, Muria Crater Region has a very beautiful scenery and a cool fresh air. Visitors will be served with an experience like going into the Muria crater with the beauty of the panorama. Activities that can be done in this area is educational tour about feldspatoid rich igneous rocks for university students, climbing tours, river tour and agrotourism in the form of a very good coffee plantation known as the name of Coffee Tempur.



Figure 7. (a) Beauty scenery of north Gelis river with lava as a bedrock; (b) Local youth playing at Gelis river; (c) Ignimbrite breccia outcrop in south gelis river; (d) Small waterfall as a potential tourism object; (e) Songolikur peak visibility thah taken from south Gelis River; (f) Ignimbrite breccia outcrop

3.8. Tiga dan Lima Rasa Water Spring

The Tiga Rasa and Lima Rasa springs are located in Kajar Village, Dawe District, Kudus District, Central Java Province to the north of the SunanMuria Tomb, at the hillside of the Muria Mountains with the Songolikur peak located 15km from the center of Kudus city. Tiga Rasa and Lima Rasa springs located 1km from Montel waterfall. Tiga Rasa and Lima Rasa is in the same location with the Tomb of Sheikh HasanSadeli Cultural Site under the auspices of PerumPerhutami Regional Division of Central Java Unity of Pati Forest Unit with high conservation value areas. Tiga Rasa Springs is a source of water that comes from mountain water but with the uniqueness of different flavor of water per well. The water at the well gives off a soda-like flavor but with different flavor intensities. It is suspected that the discharge of water that resembles soda is influenced by the plants contained in protected forest areas. Next to the north towards songolikur peak there are Lima Rasa springs with very cold water temperature and produces froth in each source of its springs, the resulting flavor is almost the same as a flavor spring that resembles a soda. The Lima Rasa spring consisted by lava and breccia. This place has been used as a pilgrimage site as well as a spiritual tourist visit by Muslim visitors, because according to the myth, Tiga Rasa and Lima Rasa springs water can be used to make the body healthier and fresh.



Figure 8. (a) Air tiga rasa water springoutcorp as a religion tourism in Colo; (b) Explanation of air tiga rasa as a high conservation area; (c)(d) Cold bubble at air lima rasa; (e) Visibility of air lima rasa water spring, (f) Ojek colo as a fun attraction in Muria religion tourism

Based on the geological and geomorphological features appearance, geosite can be assessed with scientific value, aesthetical value, reacreational value, culture value and geoheritage resources also have a significant level of national level, state and district. Tabel 1 presents the existences of gological values of some potential geosite on the Muria peninsula and its geoheritage level.

Tabel 1. The geoheritage values and significance lvel of some potential geoheritage sites in Muria Peninsula

No.	Potential Geoheritage Site	Scientific value	Aesthetical value	Recreational value	Cultural value	Significant value
1.	Dry maar Bambang	+	+	+	+	District
2.	Wet maar Gunung Rawa	+	+	+	+	District
3.	Pillow lava Banyumanis	+	+	+	-	District
4.	Volcano parasite Puso	+	+	+	-	District
5.	Twin volcanoes Ragas and Bako	+	+	+	-	District
6.	Litoral fossiliferous sedimen at Gajah River	+	+	-	-	District
7.	North Gelis River and South Gelis River	+	+	+	+	State
8.	Springs close together but with different flavors	+	+	+	+	State

With some values already possessed by existing geosites, some good activity on education and tourism can also be done in this geosite. Regarding educational activities, excursion activities as well as learning about fossils, volcanic rocks and limestone rocks can be done complexly in areas of Muria peninsula. Yet to get more attention and attraction, tourism activities are also very important to be build and be done in the research area. Some tourist activities that can be done in the research area are described in table X.

Table 2. Some possible geotourism programmes and activities in potential geoheritage sites of Muria Peninsula

No.	Potential Geoheritage Sites	Potential Programs and Activities						
		Swimming	Boating	Rock Climbing	Camping	Hiking	Fishing	Praying
1.	Dry maar Bambang	-	-	-	v	v	-	-
2.	Wet maar Gunung Rawa	-	v	-	v	-	v	-
3.	Pillow lava Banyumanis	v	v	-	v	v	v	-
4.	Volcano	-	-	-	v	v	-	-

	parasite Puso							
5.	Twin volcanoes Ragas and Bako	-	-	v	v	v	-	-
6.	Litoral fossiliferous sedimen at Gajah River	v	-	-	v	v	v	-
7.	North Gelis River and South Gelis River	v	v	v	v	v	v	-
8.	Springs close together but with different flavors	-	-	-	v	v	-	v

Existing and potential programs and activities in geosite must also be in line with the basic principles of geopark that is conservation and regional development for the community. So that will form a collaboration between governments, educational institutions and local communities to jointly realize the main goals of geopark.

4. Conclusion

Geological heritage is interpreted as a geodeversity that has more value or uniqueness as an inheritance because it becomes a recording of an event on earth that has ever been or is happening and needs to be protected and developed. Some geosite on the muria peninsula have been inventoried as a potential geoheritage site that is Bambang dry maar and wet maar GunungRawa; Banyumanis pillow lava; Puso volcano parasite, and twin volcanoes Ragas and Bako; litoralfossiliferous sediment at Gajah River; various lithology at North Gelis River and South Gelis River; springs close together but with different flavors. Some potential geoheritage may also contribute as geological-based tourist sites, activities that can be implemented include swimming, boating, rock climbing, camping, hiking, fishing and praying. Further research which needs to be done is classification, characterization of assessment and evaluation and promotion to further develop the area of Muria peninsula as a prospective geopark site.

Acknowledgments

We are grateful to the Geological Survey Center, Geological Agency, which has provided a manual on Inventory of Geological Diversity and Identification of Geological Heritage. Dr. Muhammad Widjanarko – Chairman of Muria Research Center, Muria Kudus University has helped a lot in the field. UPN Veteran Yogyakarta has facilitated the research so well.

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