PROCEEDINGS
JOINT CONVENTION MALANG 2017, HAGI – IAGI – IAFMI- IATMI (JCM2017)
Ijen Suites Hotel, Malang, September 25 – 28,2017

Geological Study Using Quantitative Analysis Of Geosite and Geomorphosite in Sawahlunto City, West Sumatra : The Application towards Geoturism Potential Of Indonesia

Ray Diwatra Linggadipura [1], Mega Rizky Nuriana Sari [1]*
[1]Undergraduate Student at Geological Engineering Study Program of Sriwijaya University, Palembang
[*]Corresponding Author : ray.diwatra@yahoo.com

Abstract

Sawahlunto is famous for natural resources especially coals with good quality and also known for the oldest underground coal mines city in Indonesia. But looking from geological prespective, Sawahlunto has various geological phenomenons caused by tektonical deformations, which happened during formation of its region. Sawahlunto is located on Ombilin Basin (intramontane basin) which based on the morphological features is located along the hills, and based on the stratigraphy composed of Pra-Tertiary and Tertiary litology. Sawahlunto has prospects in the field of geoturism based on many interesting geosite and geomorphosite, looking from its geological phenomenon and panorama aspects. Methods used in this research consist of field observation, laboratory analysis, and also quantitative analysis of geosite and geomorphosite, based on Kubalikova (2013). Parameters of quantitative analysis of geosite and geomorphosite on each location that used are scientific and intrinsic values, educational values, economical values, conservation values, and added values. From field observations, 7 geosite were determined including Mbah Soero Pit, Cemara Peak, Kubang Hill, Landu Waterfall, Bikan Waterfall, Biru Lake, and Malakutan River. The result of quantitative analysis of all parameters included in each geosite and geomorphosite in order are 73,6%, 75,1%, 58,4%, 35,9%, 67,4%, 59% dan 55,4%. Finally this analysis showed that Sawahlunto City is suitable for future geoturism area and also for geological field study campus which focuses on learning aspects such as sedimentology and stratigraphy, geomorphology, and structural geology. Geoturism area of Sawahlunto City heavily influenced by geological processes that controlled each geosites. To support those geoturism potential, infrastructures and promotions needed to be improved so those sites could help increasing Sawahlunto City profits and economical environments.

Keywords: Geosite and geomorphosite, Geotourism, Sawahlunto

Introduction

Indonesia has abundant amount of natural resources, including geological resources like coal, geothermal, oil & gas, etc. Apart from those things, Indonesia also has alternate geological resources potential in the form of Geotourism sites, as seen from tourism activities that specially focused on panorama and geological aspects (Downling, 2011 in Kubalikova, 2013). Geotourism is a brand new field in terms of researches, where a research on the definition, methods, and assessment process of new geotourism sites was done recently in 2001 by Geomorphosite group of International Association of Geomorphologist (Giusti, 2010 in Kubalikova, 2013).

This research was located in Sawahlunto City region, West Sumatra (Figure 1). Tectonically, Sawahlunto is engaged in Ombilin basin, where it is a part of Intramontana Basin that determines Sawahlunto morphology as hill type landforms. Based on the Stratigraphy, Sawahlunto is consist of Pre-tertiary and Tertiary lithologies. Sawahlunto is known for its characteristics of natural resources, including good-quality coals and also known as the underground coal mines city in Indonesia, but looking form the geological conditions, Sawahlunto has varied geological phenomenons caused by tectonical deformation factors that formed Sawahlunto region. Based on those geological phenomenons and panorama aspects, Sawahlunto has geotourism potential due to many interesting geosites and geomorphosites.

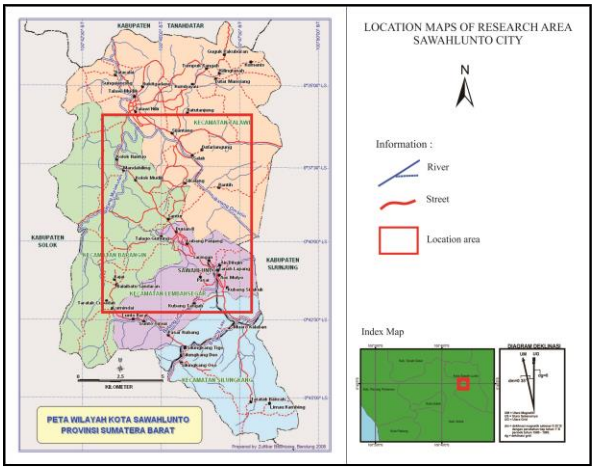

Figure 1. Location Maps of Research Area

Geotourism is a form of Natural tourism which focused on panorama and Geological aspects (Downling, 2011 in Kubalikova, 2013). Geotourism introduces a site, conservation of geodiversity, and also understands it as a part of knowledge that needs appreciation and more learning (Newsome and Downling, 2010 in Kubalikova, 2013). Not only geologically, but also to show the uniqueness of geomorphological features and the process that can be gained by tourists from such location of interest (Kubalikova, 2013).

Based On Sampurno (1995) in Hendratno (2002), there are some types of geological phenomenons that can became a base of geotourism promotions, such as :

a. Active geological process including volcanic eruption and its products, Earthquake danger zone, active rock faults movements, geothermal manifestation, and landslide-prone areas.

b. Natural beauty formed by fast past or present geodynamics processes, such as the formation of morphology landforms in the form of mountains, rivers, beaches, karst, hills, and coral reefs.

c. Past cultural aspects that adapts to geodynamical developments, such as the destruction of ancient relics sites caused by past natural disasters.

d. Geological resources exploitation, such as hydrocarbon exploitation and valuable earth minerals (gold, silver, copper, etc.) mining either on a large scale or small scale.

e. Geological resources exploitation which cause problems or complications to the surrounding environments.

Methods

This research used four methods with the basis on geotourism potentials Sawahlunto had. First, we gathered previous literatures and gained information based on the topographic map generated from satellite images of 1:80.000 scale. Second, collected field data by field observation with the purpose to gain direct knowledges on Sawahlunto and the surrounding areas. The data collected from the field were lithology samples, morphology conditions, and water samples in one of the geosites. Third, Rock samples obtained from field data gathering were tested in the laboratory to support geological interpretations of the condition in each geosites. Fourth, geosites and geomorphosites analysis were performed based on quantitative assessment by Kubalikova (2013) and qualitative descriptives according to Sampurno (1995) in Hendratno (2002). Main aspects of the assessment are scientificdan intrinsic values, educational values, economical values, conservation values, and added values.

Result and Discussion

Based on the result of field observation, there are seven potential geosites for the development of Geotourism in Sawahlunto region. Of the seven potential sites are plotted according to satellite imageries resulted in Tracking map of Sawahlunto which were projected in 3D (Figure 2). The reinforcement process to transform Sawahlunto into Geotourism sites were conducted by performing analysis and quantitative assessment of Geosites and Geomorphosites based on Kubalikova (2013), with the parameters including scientific & intrinsic values, educational values, economic values, conservation values, and added values (Table 1). Based on the assessment of Geosites and Geomorphosites analysis showed the quantification data of Sawahlunto feasibility as a Geotourism Potential which can be seen in Table 2.

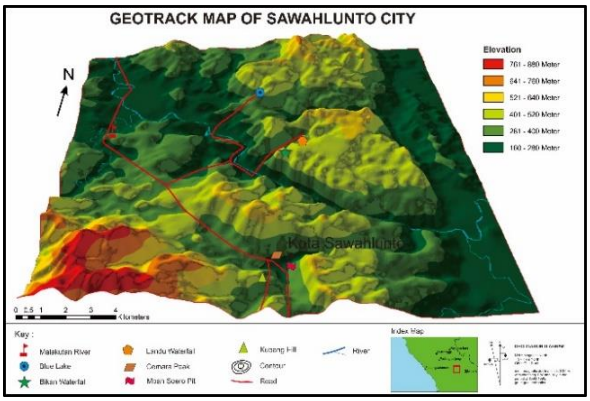

Figure 2. Geotrack Map of Sawahlunto City

- Mbah Soero Pit

Mbah Soero Pit is administratively located in Air Dingin, Lembah Segar district, Sawahlunto, West Sumatra. Mbah Soero pit is located approximately 1 km away from downtown area. Based on Geosites & Geomorphosites analysis with assessment parameters according to Kubalikova (2013), produces results as follow: Scientific and Intrinsic value 75%, educational value 87.5%, economic value 100%, conservation value 62.5%, and added value 42.8%. Overall, Mbah Soero pit has a level of feasibility at 73.6% to serve as a feature in Geotourism. Based on those results, Mbah Soero pit can be declared feasible due to good site condition in which the local government has taken over and developed its tourism aspects before hand, the short distance between the site and downtown area, affordable transportation access, and also due to its significant Dutch colonialism legacy and cultural values (Figure 3).

Figure 3. Mbah Soero Pit Which Used to be an Underground Mining Coal

Geologically and historically speaking, Mbah Soero pit is the first underground coal mines of Indonesia, where it was a former underground coalmines developed by Dutch authorities in Colonialism era. Mbah Soero is located on Sawahlunto formation with the coal characteristics of Bituminous – Antrachite coal ranks. With the neglection of underground mines over the passage of time, these former Underground coal mines can be used as tourist attraction with the main appeal is tourist's direct interaction with coals in the mining holes and the admiration at the construction aspects of Sawahlunto coal mines long pit.

- Cemara Peak

As the name suggest, Cemara peak is a highland located at Saringan, Lembah Segar District, Sawahlunto, West Sumatra. Cemara peak is approximately 1.5 km away from The Downtown area of Sawahlunto. Based on Geosites and Geomorphosites analysis with assessment parameters according to Kubalikova (2013), produces results as follow: scientific and intrinsic value 75%, educational value 87.5%, economic value 66.6%, conservation value 50%, and added value 35.7%. Overall, Cemara peak has a level of feasibility at 75.1% to serve as a feature in Sawahlunto Geotourism. Based on those results, Cemara Peak can be declared as feasible dua to ready supporting infrastructures that has been built and developed around as a potential tourist location. In geological terms, Cemara peak was formed due to the formation of Paleo High form Sawahtambang formation sedimentation above Sawahlunto Formation (Figure 4).

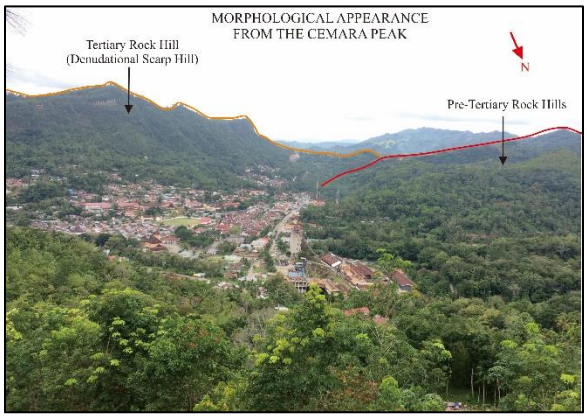

Figure 4. Morphological appearance from the Cemara Peak

Sawahtambang formation lithology is composed of resistant Conglomeratic Sandstones which made the condition of the peak formed until now remains sturdy despite the existence of weathering rocks in some places. At first glance, Cemara Peak could be viewerd as highlands surrounding Sawahlunto. The main appeal is the top of Cemara peak in which tourists can see the landscape of Sawahlunto the surrounding areas stretches far and wide as eyes could see, and also showing the existing morphology where tourists can learn more about geomorphology and landforms from up there.

- Kubang Hill

Kubang hill is a Pre-Tertiary rock hills located in Kubang Utara Sikabu village, Lembah Segar district, Sawahlunto, West Sumatra. Kubang hill is approximately less than 1.5 km from downtown of Sawahlunto. Based on the geosites & geomorphosites analysis with assessment parameters according to Kubalikova (2013), the results are as follow: scientific and intrinsic value 37.5%, educational value 25%, economic value 33.3%, conservation value 58%, and added value 35.7%. Overall, Kubang hill has a geotourism feasibility level around 58.4% which establish them as a potential feature of Sawahlunto Geotourism. In geological terms, Kubang Hill is an early Triassic of Pre-Tertiary rock formations that were elevated as anticlinal hills with the lithology of resistant meta-sediment limestones (Figure 5).

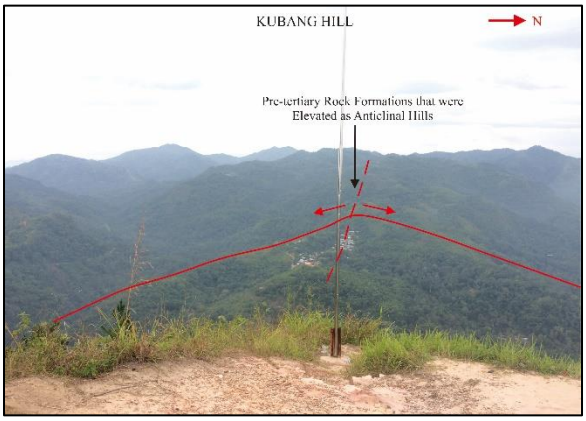

Figure 5. Kubang Hill is a Pre-Tertiary rock hills that were elevated as anticlinal hills with the lithology of resistant meta-sediment limestones

Kubang hill geosite can be avowed feasible due to good accessibilty, early infrastructures that can be expanded to attract more tourist and diverse culture values that holds against time. The main appeal of Kubang hill is Pre-Tertiary rocks elevated from ancient sea bed that surround the hill. Tourists can easily see the outcrop of Basement Rocks of Ombilin. Also, Kubang hill can be developed as a potential asset of Pre-Tertiary rocks mining for locals with the benefit of usages on building and road constructions.

- Landu Waterfall

Landu waterfall is located in Rantih Village, less than 3 km away from Sawahlunto. Based on Geosites and Geomorphosites analysis with assessment according to Kubalikova (2013), it has scientific & intrinsic value of 37.5%, educational value 62.5%, economic value 0%, conservation value 62.5%, and added value 54.6%. Overall, Landu waterfall has a feasibility level of 35.9% for a potential geotourism features. In geological terms, Landu waterfall is a part of fault hills with lithology mainly composed of sandstones of Sawahtambang formation and

deposits of talus materials at the bottom of the waterfall (Figure 6).

Figure 6. Landu Waterfall and The Bottom of the Waterfall Have Deposits of Talus Material

The formation of Landu waterfall is interpreted as a result of the existence of geological structures in the form of a normal fault. Landu Waterfall can't be categorized as feasible geosite yet due to difficult access to the location, lack of tourism facilities, and not yet known by general publics. Eventhough this location has tourist attraction such as fault scraps landscape across the waterfall and a potential usage as a swimming and bathing spot. Landu waterfall height can reach 30 meters and surely will become a tourist's attention. Foremost, the development of tourism infrastructures is much needed.

- Bikan Waterfall

Bikan waterfall is located in Rantih village, 2.5 km away from Sawahlunto. Based on geosites and geomorphosite sanalysis with assessment according to Kubalikova (2013), the results are: scientific and intrinsic value 75%, educational value 87.5%, economical value 33.3%, conservation value 62.5%, and added value 78.5%. Bikan waterfall has a feasibilty level as potential features in Sawahlunto geotourism at 67.4%. In geological terms, Bikan Waterfall is located at fault hills area with the lithology mainly composed of sandstones of Sawahtambang formation (Figure 7).

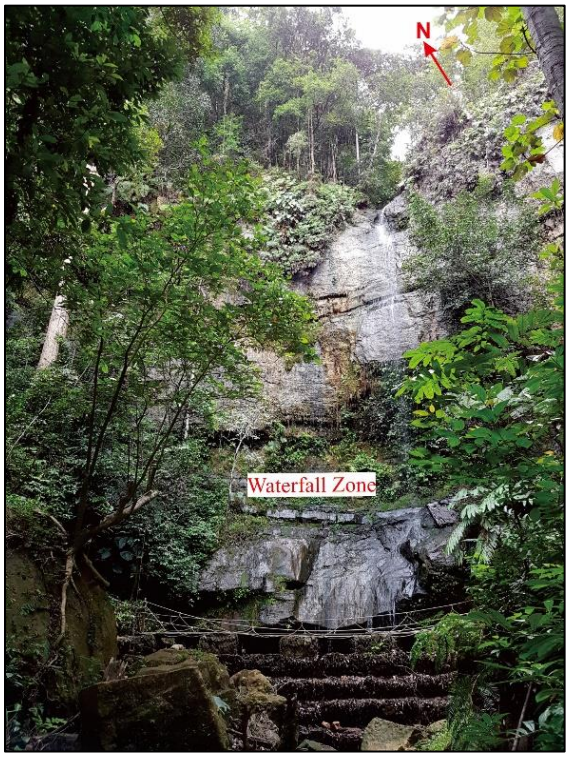

Figure 7. Bikan Waterfall Formed by Normal Fault Structure

The formation of Bikan waterfall can be interpreted as the result of geological structures activity in the form of normal fault. Bikan waterfall can be categorized as feasible for Geotourism mainly because it has been developed into a tourist location with good infrastructures. The main attraction of Bikan waterfall is the beautiful scenery surrounding the waterfall as well as the height that reaches 25 meters from the bottom of the site. Tourists can also swim or bath and enjoy the water. The geological process that formed Bikan waterfall plays a significant role to show the beauty of the waterfall to geologists and general publics.

- Biru Lake

Biru lake is located at Batu Tanjuang village, 7 km away from Sawahlunto. Based on the geosites & geomorphosites analysis according to Kubalikova (2013), results of the assessment are: scientific and intrinsic value 37.5%, educational value 87.5%, economic value 16.6%, conservation value 75%, and added value 78.5%. Overall, Blue lake has a feasibility level to serves as a feature in Sawahlunto Geotourism at 59%. The formation of Biru lake was due to coal mining activities that has been abandoned ande raises a big amount of acid wine water with blue color and now changes into a beautiful lake. Based on geochemical analysis of water contents shows that the water has a <6.4 pH and high Sulfate (SO4) but low Aluminum (Al) and Iron (Fe) content (Table 3).

Table 3. Geochemical Analysis of Water Compotition

PARAMETER	UNIT	RESULT
pH	#	<6,4
Iron (Fe)	mg/L	0,87
Chloride (Cl)	mg/L	19,85
Mangan (Mn)	mg/L	3,11
Sulfate (So_4)	mg/L	30,85
Copper (Cu)	mg/L	2,03
Aluminum (Al)	mg/L	0,78

Geologically, Biru lake is composed of mudstones as a dominant lithology with the presences of coals which is a part of Sawahlunto formation (Figure 8). Blue lake is a plausible tourist attraction due to site's condition in which it has good tourism infrastructures, the natural beauty of clear blue water, and contributions of locals to develop the site as a proper geotourism location. As previously stated, the main appeal of Blue lake are a very beautiful view of the lake with clear blue water, the view of outcrops that were once coal mines, and also the scenery of surrounding hills from up high.

Figure 8. Biru Lake Formed by Mining Activities

- Malakutan River

Administratively, Malakutan River is located at Kolok Mudik village which is approximately 4 km away from Sawahlunto. Based on Geosites & Geomorphosites analysis according to Kubalikova (2013), Malakutan River has assessments results of scientific and intrinsic value 75%, educational value 62.5%, economic value 0%, conservation value 75%, and added value 64.2%. Overall, Malakutan River has a feasibility level of 55.4% to serves as one of the features in Sawahlunto geotourism. In geological terms, morphology of Malakutan River area is mainly consist of denudational hills. The stratigraphy of the river area is composed of Pre-Tertiary and Tertiary rock units, with Pre-Tertiary lithology composed of Sandstones and Shalestones as parts of fingering between Brani Formation and Sawahtambang Formation (Figure 9).

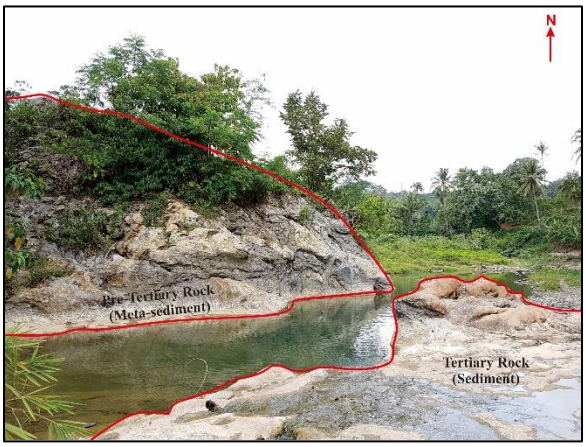

Figure 9. Malakutan River Composed of Pre-Tertiary and Tertiary Rock

Malakutan River is feasible as a Geotourism object and tourist attraction due to good access to the site, the preliminary development of tourism infrastructures which needs to be improved to attract more potential tourists, and also various cultural values. The main appeal of Malakutan river are beautiful pothole located at the river bank, various geological conditions tahta shows unique geological structures around the river, and also crystal blue water flowing through the river.

Conclusions

Based on the observation results, it can be concluded that Sawahlunto region has 7 potential geosites such as Mbah Soero Pit, Cemara Peak, Kubang Hill, Landu Waterfall, Bikan Waterfall, Blue Lake, and Malakutan River. After performing a series of feasibility quantification based on assessment by Kubalikova (2013) against seven geosites, produces results as follow: Mbah Soero Pit 73.6%, Cemara Peak 75.1%, Kubang Hill 58.4%, Landu Waterfall 35.9%, Bikan Waterfall 67.4%, Biru Lake 59%, and Malakutan River 55.4%. The assessment shows that Sawahlunto is feasible and worthy to serve as future Geotourism area of Indonesia, and also as field study campus with learning aspects such as sedimentology & stratigraphy, geomorphology, and structural geology. Geotourism objects of Sawahlunto are strongly influenced by geological processes and rock units controlling the formations of each sites. These strong appeals can generate rational and international tourism interests that in turn will attracts more geologists and the general public to visit those places.

References

Dowling, R. K., and D. Newsome, 2006, Geotourism. Oxford: Elsevier Ltd.

Dowling, R. K., 2011, Geotourism's Global Growth. Geoheritage, 3(1), 1-13. DOI: 10.1007/s12371-010-0024-7

Giusti, C, 2010, From geosites to geomorphosites. Géomorphologie: relief, processus, environnement, 5(2), 123-130.

Hendratno, A, 2002, Geowisata Merapi sebagai Perjalanan Wisata Minat Khusus di Lereng Merapi bagian Selatan, Yogyakarta. Jurnal Nasional Pariwisata II (2).

Kubalikova, L, 2013, Geomorphosite Assesment for Geotourism Purposes, Czech Journal of Tourism, 80-103.

Acknowledgement

We are grateful to Dr. Budhi Kuswan Susilo, S.T., M.T., allowing us to present this paper and who has guided and assisted in interpreting geological conditions in every geosite. Thankful to all friend Ombilin Mapping team, and Muhammad Rifky who have provided criticism, suggestions and discussion in the settlement of the full paper.

Table 1. Parameters of Geoturism Quantification (Kubalikova, 2013).

Scientific and intrinsic values		Value
Integrity (A)	Totally destroyed site	0
	Disturbed site, but with visible abiotic features	0,5
	Site without any destruction	1
Rarity (number of similar sites) (B)	More than 5 sites	0
	2-5 similar sites	0,5
	The only site within the area of interest	1
Diversity (number of different partial features and processes within the geosite or geomorphosite) (C)	Only one visible feature/processes	0
	2-4 visible features/processes	0,5
	More than 5 visible features/processes	1
Scientific knowledge (D)	Unknown site	0
	Scientific papers on national level	0,5
	High knowledge of the site, monographic studies about the site	1
Educational values		Value
Representativeness and visibility/clarity of the features/ processes (A)	Low representativeness/clarity of the form and process	0
	Medium representativeness, especially for scientists	0,5
	High representativeness of the form and process, also for the laic public	1
Exemplarity, pedagogical use (B)	Very low exemplarity and pedagogical use of the form and process	0
	Existing exemplarity, but with limited pedagogical use	0,5
	High exemplarity and high potential for pedagogical use, goedidactics and geotourism	1
Existing educational products (C)	No products	0
	Leaflets, maps, web pages	0,5
	Info panel, information at the site	1
Actual use of a site for educational purposes (excursions, guided tours) (D)	No educative use of the site	0
	Site as a part of specialized excursions (students)	0,5
	Guided tours for public	1
Ecomonical values		Value
Accessibility (A)	More than 1 km from the parking place	0
	Less than 1 km from the parking place	0,5
	More than 1 km from the stop of public transport	1
Presence of tourist infrastructure (B)	More than 10 km from the site existing tourist facilities	0
	5 – 10 km tourist facilities	0,5
	Less than 5 km tourist facilities	1
Local products (C)	No local products related to a site	0
	Some products	0,5
	Emblematic site for some local products	1
Conservation values		Value
Actual threats and risks (A)	High both natural and atrophic risks	0
	Existing risks that can disturb the site	0,5
	Low risks and almost no threats	1
Potential threats and risks (B)	High both natural and athrophic risks	0
	Existing risks that can disturb the site	0,5
	Low risks and almost no threats	1
Current status of a site (C)	Continuing destruction of the site	0
	The site destroyed, but now with management measures for avoid the destruction	0,5
	No destruction	1
Legislative protection (D)	No legislative protection	0

	Existing proposal for legislative protection	0,5
	Existing legislative protection	1
Added values		Value
Cultural values: presence of historical/archaeological/ religious aspects related to the site (A)	No cultural features	0
	Existing cultural features but without strong relation to abiotic features	0,5
	Existing cultural features with the strong relations to abiotic features	1
Ecological values (B)	Not important	0
	Existing influence but not so important	0,5
	important influence of the geomorphologic feature on the ecologic feature	1
Aesthetic values (C): Number of colours (D); Structure of the space and viewpoints (E)	1 color	0
	2-3 colors	0,25
	More than 3 colors	0,5
	Only 1 pattern	0
	2 or 3 patterns clearly distinguishable	0,25
	More than 3 patterns	0,5
	None	0
	1-2	0,25
	3 and more	0,5

Table 2. Result in the Quatification of Elegibility.

Parameters	Mbah Soero Pit	Cemara Peak	Kubang Hill	Landu Waterfall	Bikan Waterfall	Biru Lake	Malakutan River
Scientific and intrinsic values							
A	1	1	0,5	0,5	0,5	0,5	1
B	1	1	0,5	0,5	0,5	0,5	1
C	0	1	0,5	0,5	1	0	0,5
D	1	0	0	0	1	0,5	0,5
(%)	75	75	37,5	37,5	75	37,5	75
Educational values							
A	1	0,5	0,5	1	1	1	1
B	0,5	1	0	1	1	0,5	1
C	1	1	0	0	0,5	1	0
D	1	1	0,5	0,5	1	1	0,5
(%)	87,5	87,5	25	62,5	87,5	87,5	62,5
Economical values							
A	1	1	0,5	0	0,5	0,5	0
B	1	1	0,5	0	0,5	0	0
C	1	0	0	0	0	0	0
(%)	100	66,6	33,3	0	33,3	16,6	0
Conservation values							
A	0,5	1	0,5	0,5	1	0,5	1
B	0,5	0,5	0	0,5	0,5	0,5	1
C	0,5	1	0,5	0	0,5	1	1
D	1	0,5	1	0	0,5	1	0
(%)	62,5	75	50	25	62,5	75	75
Added values							
A	1	0	0	0,5	0,5	1	0,5
B	0	1	0,5	0,5	1	0,5	1

C	0,25	0,5	0,25	0,25	0,5	0,5	0,25
D	0	0,5	0,25	0,25	0,25	0,5	0,25
E	0,25	0,5	0,25	0,25	0,5	0,25	0,25
(%)	42,8	71,4	35,7	54,6	78,5	78,5	64,2
Total(%)	73,6	75,1	58,4	35,9	67,4	59	55,4