ENVIRONMENTAL GEOLOGICAL POTENTIAL OF KALIGESING AREA, PURWOREJO DISTRICT

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Abstrak

Penelitian ini dimaksudkan sebagai survei geologi lingkungan dengan tujuan untuk mengetahui karakteristik geologi lingkungan daerah Kaligesing, meliputi potensi sumber daya maupun bencana alam. Daerah Kaligesing termasuk dalam Kubah Kulon Progo pada peta RBI Lembar Purworejo. Metode penelitian berupa survei geologi lapangan, untuk memperoleh data geomorfologi, stratigrafi, struktur geologi serta tata guna lahan. Data yang diambil adalah aspek geologi lingkungan meliputi sumber daya alam dan bencana alam. Analisis dilakukan secara deskriptif. Analisis potensi pengembangan daerah dilakukan berdasarkan karakteristik geologi lingkungan setempat. Sumber daya alam yang potensial adalah pasir dan batu, serta tanah dan lahan yang relatif subur. Air permukaan didukung oleh sungai Jogobesan, bersama anak-anak sungainya. Airtanah dapat diperoleh dari mataair maupun sumur gali, dengan muka airtanah yang relatif dangkal. Mataair berdebit kecil hingga sedang (≤ 1 liter/detik). Bencana alam yang cukup potensial adalah erosi dan gerakan tanah. Banjir hanya berpotensi pada wilayah yang sempit dan setempat-setempat. Secara umum, geologi lingkungan daerah penelitian terbagi menjadi zona geologi lingkungan Pegunungan Gunungapi Purba dan Kars Jonggrangan yang masing-masing memiliki kekhasan tersendiri.

Kata kunci: *sumber daya alam, bencana alam, geologi lingkungan*

Abstract

This research is intended as an environmental geological survey with the aim to know the geological characteristics of Kaligesing area environment, covering the potential of natural resources and disaster. The Kaligesing area is included in the West Progo Dome on the Indonesian Topographic Map of Purworejo Sheet. The research method is a field geological survey, to obtain the data of geomorphology, stratigraphy, geological structure and land use. The environmental geology data include geological resource and hazard. Analysis has been done as descriptive work. Analysis of land development potential is based on local environmental geological characteristics. Potential natural resources are sand and stone, as well as relatively fertile soil and land. The surface water is supported by the Jogobesan stream, along with its tributaries. Groundwater can be obtained from springs and wells, with relatively shallow groundwater levels. The springs are small to medium (≤ 1 liter / sec). Potential natural disasters are erosion and soil movement. Flooding is only potentially in a narrow and local area. In general, the environmental geology of the study area is divided into the environmental geological zones of the Ancient Volcanic Mountains and Jonggrangan Karst with their own characteristics.

Keywords*: natural resource, hazard, environmental geology*

1. Introduction

This environmental geological study was conducted in Kaligesing, Purworejo District, Central Java Province (Figure 1). The study area is astronomically located at the coordinates of $07^0$40'10" - 07^0 47'43" southern latitude and $110^0$2'20.4" - $110^0$8'10.56" eastern longitude. It is included in Purworejo Sheet, number 1408-231 according to topographic map of Bakosurtanal published on 2001. The study area is the middle, western region of the West Progo Dome Physiographic Zone [1].

Environmental geological research has been developed in various regions throughout Indonesia to assist communities in terms of providing natural resources and mitigating natural disasters of geology. The environmental geological condition of a region needs to be studied in order to create a method of utilization of environmentally geological resources. In addition, disaster aspects should also be examined so that we can do the right natural disaster mitigation.

Environmental geological aspects include geological resources and natural disasters. The geological resources include land, water, and rock. The geological natural disasters include erosion, soil movement, flood, earthquake and tsunami. The environmental geological characteristics of each region

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vary, therefore, each region needs to be assessed for each potential so that we can get the right information about the resources and disaster aspects in a region.

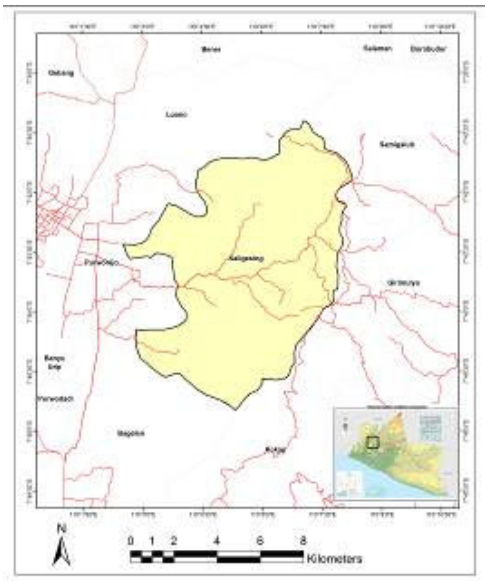

Figure 1. Location of research area.

Environmental geology is a part of geology that is very useful for human life directly. By understanding the geological characteristics of the environment, we can develop the right area according to the carrying capacity of each environment. Aspects of land, rocks and water will be an important concern in the environmental geological analysis. The potential for natural disasters also forms part of what is studied as a barrier to assessing environmental carrying capacity. The problem is about environmental geology description in order to know about its potential of land development.

2. Methodology

The research began with literature study of the geological conditions of West Progo Dome [1]. Furthermore, by knowing the regional physiography of West Progo Hills, the geological survey activity was conducted directly in the field. The research tool is standard geological equipment (compass, hammer, loupe, GPS) and completed by topographic map of Purworejo sheet. The geological description in the field was focused on environmental geological data (natural resources and natural disasters). Data analysis was done by classifying the environmental geological zone based on geological characteristics of the research area [2]. Description of natural resources was also focused on water issues, especially groundwater because the research area is in urgent need of information on local hydrogeology.

3. Geology of Kaligesing Area

3.1. Geomorphology

Morphology of research area usually has coarse relief. In general, the morphology of Kaligesing and surrounding areas can be divided into 4 units based on van Zuidam & van Zuidam-Cancelado classification (1979) (Table 2), as described below (Figure 2).

a. Undulating to Rolling Karst Unit

This unit is located on the southeast with an area of 4.6 km^2 or 19.1% of the entire study area. The location of this unit is located in Pucung ngroto village until Tlogoguwo village. This unit has a slope of 15^o - 20^o with a large slope value that is affected by the topography of each different region. The delta height varies to 123 m, between 616 m and 739 m elevations.

b. Steeply Slope Karst Cone Unit

This unit is composed of a steeply sloped karst cone with a relatively sharp peak, located in the central and northern regions of this unit with an area of 0.6 km^2 or 2.9% of the entire study area. The

location of this unit is located on Mt. Pupur, Mt. Rawacacing, Mt. Gambar, Mt. Jaran. This unit has a 30°-50° slope with a large slope value that is affected by each slightly different topography. The existing high difference reaches 162.5 m, between the elevation of 650 m and 812.5 m. Some caves can be found in this unit.

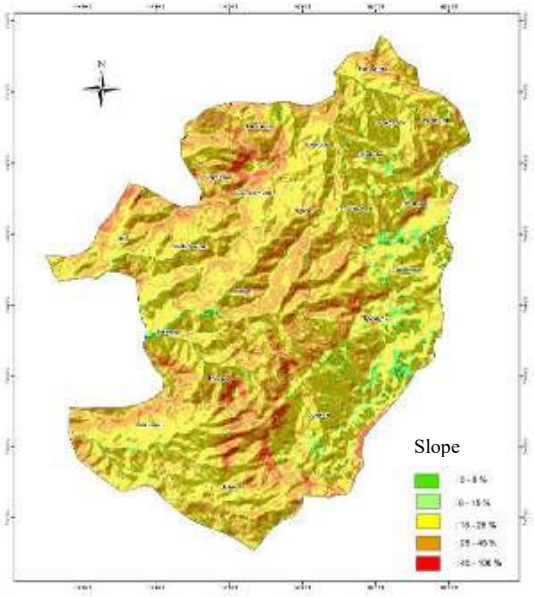

Figure 2. Slope map of Kaligesing.

c. Moderately Sloping Structural Hill Unit

This unit is composed of structural hills of moderate to steep slopes that extend in the middle and east of 10.8 km^2 or 50.9% of the entire study area. The location of this unit to the west is limited by Dusun Tawangsari, north by Seblereng, east by Karanggede and south by Pandanrejo Hamlets. This unit has an average slope of 15º-50º.

The study area was composed by rocks from the Old Andesite and Jonggrangan Formations. In addition also found andesit intrusion that is equivalent to the Old Andesite Formation. Geological map of research area can be seen in Figure 3.

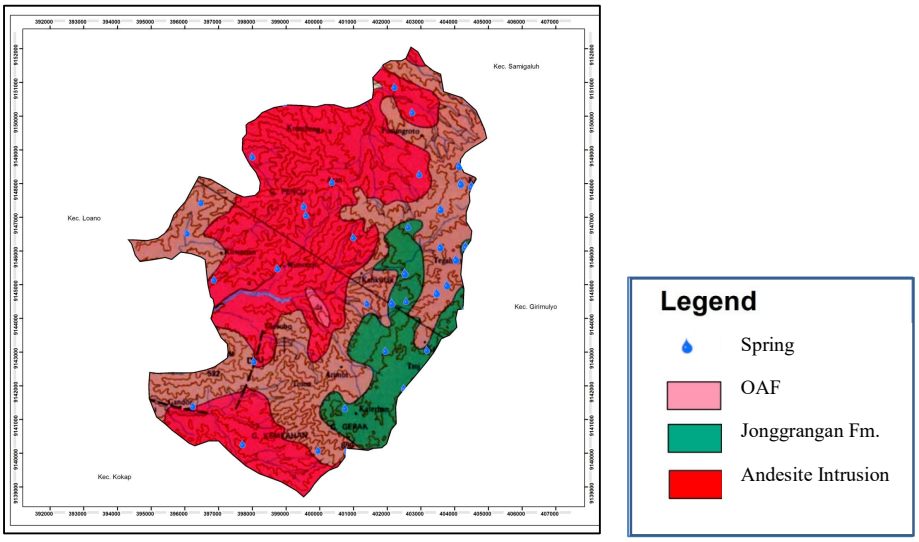

Figure 3. Geological map of Kaligesing [3]. Springs distribution shown by blue dots.

3.2. Stratigraphy

In general, the study area consists by two formations namely the Old Andesite Formation (OAF) and Jonggrangan Formation (Figure 3). Old Andesite Formation composed by Oligocene-Miocene rocks such as breccias with fragments of andesite, lapilli tuff, tuff, lapilli breccia, agglomerate; lava flows and volcanic sandstone. The Jonggrangan Formation laid unconformably on the Old Andesite Formation. This formation deposited at Miocene time. Jonggrangan Formation consists of conglomerates, arenaceous marl, tuffaceous marl, bedded limestone and coral limestone with intercalation of lignite.

The research area's lithology is divided into three units namely andesite breccia, andesite intrusion and reef limestone units. Andesite breccia unit has the most widespread distribution and was found in Tanggulangin, Jatimulyo, Giripurwo, Sumberejo, and surrounding areas. Andesite intrusion unit is scattered in the Sidang, Lendah, Tumpak, and surrounding areas. Reef limestone unit is scattered in Kalilu, Sibolong, Blumbang, and surrounding areas. The condition of lithology as a whole experiences a moderate to high degree of weathering. High levels of weathering are found in andesitic breccia and reef limestone units, whereas moderate weathering rates are mainly found in andesite intrusion unit.

3.3. Geological Structure

Geological structures that exist in the research area were strongly influenced by the processes that occur in Oligocene - Miocene. The existing structures are joints and faults. Strong structure in the study area consists of two types of shear and tension joints. While the estimated fault found in the research area is a normal fault that is relatively northwest-southeast direction. These structures are quite intensive. One indication is the effective dissolution of the weak zones formed by these structures.

3.4. Hydrogeology

The Kaligesing region is part of the non - groundwater basin area [4]. This area generally occupies the physiography of the West Progo Dome. The hydrogeological map is shown in Figure 4 below.

Figure 4 shows that the Kaligesing area has two aquifer zones, namely “regions without exploitable groundwater” and “aquifers of poor productivity” regions. Low productivity aquifers generally have groundwater potentials that are only beneficial to local residents whose radius is small. Usually this area has a potential groundwater that can be taken through springs or seepages. The springs are generally small to medium discharge.

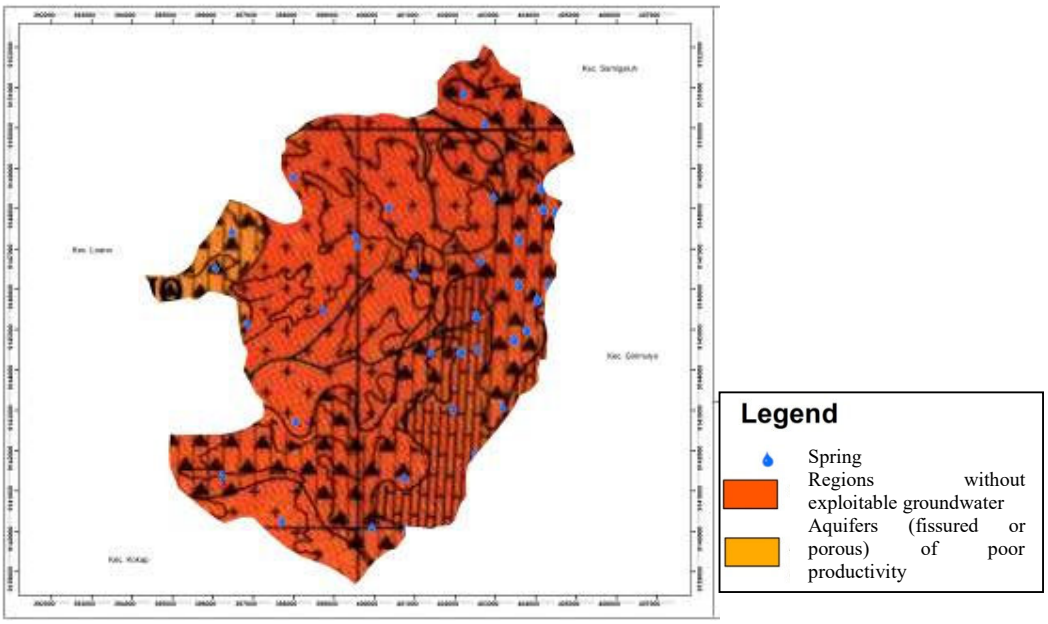

Figure 4. Hydrogeological map of Kaligesing area [4].

4. Geological Resource

4.1. Soil and Land

The soil is the result of the weathering of rock. The soil in the study area is formed by a variety of rocks that have weathered, ranging from half-weathered forming a horizon C or regolith to a rich organic material O horizon.

The soil in the study area is the result of weathering of various bed rock derived from the Old Andesite Formation, Jonggrangan and the Quaternary sediments. Soil derived from sandstone of Jonggrangan Formation has generally clayey to sandy texture, with yellowish to blackish/dark brown in color, and carbonaceous (Fig. 5).

4.2. Rock

The rocks of the research area consist of sedimentary and igneous rocks. These sedimentary rocks belong to the Old Andesite Formation and Jonggrangan, in the form of sandstones, limestones or andesite breccia, whereas igneous rocks are generally comes from intrusion or lava formed as old as the Old Andesite Formation.

The Old Andesite Formation is sometimes composed by both epiclastic and pyroclastic andesitic breccia. These rocks sometimes show closed or open packed.

Andesite lava is also found in some places, for example in Jelok, Kaligesing Sub-district. Andesite lava in Jelok, Kaligesing subdistrict shows black color, aphanitic porphyry texture, jointed to massive structure, with mineral composition such as quartz, plagioclase, biotite, pyroxene, and hornblend (Figure 6).

Figure 5. Weathered soil of limestone show blackish brown in color at Purbowono site, Kaligesing, Purworejo.

Figure 6. Andesite lava found in Jelok, Kaligesing.

Meanwhile, limestone in Purbowono is yellowish brown, non-clastic texture, reef-lapies structure, with carbonate minerals and organic material composition (Figure 7). In this area, limestones become a good aquifer to produce some springs.

Figure 7. Jonggrangan limestone outcrop in Purbowono.

Andesite fragments in the breccia as well as andesite intrusive rocks and limestones found in the study area have the potential of C building materials / minerals. The availability of igneous rocks in the research area is quite abundant, and can be utilized as a people's mine, for example as a base material for concrete.

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4.3. Water Resource

Large capacity of surface water is supplied by Bogowonto Watershed, Jogobesan Sub-watershed where its main river flows in the west of the research area. The small streams develop from the upstream spread in various regions, flowing west or southwest, until it empties into this main river. The existence of irrigation made by humans is also highly dependent on the volume of water present of Bogowonto River. The tributaries that develop at upstream of Bogowonto River Basin are also very beneficial for the fulfillment of daily living needs, both for household and agricultural purposes.

Water resources in the research area, especially surface water is highly dependent on the flow conditions of Bogowonto River. Shallow groundwater conditions may also be affected by surface water, other than by seasons.

Groundwater observed in the field is generally has good quality, showing a clear color / colorless, tasteless and odorless, and not turbid. There are only a few places that have slightly brownish and turbid water. However, the colored and turbid groundwater is generally tasteless and odorless, so it may not be contaminated by bacteria, but there is only pollution by colloids from clay minerals or dissolved organic materials such as algae or moss.

Groundwater found in dug wells and springs. Dug wells were only found locally, for example at a fairly low area of Blekokan (170 m asl). The depth of the well is about 5 m, with 1 m groundwater level from the local ground surface. According to residents' information, the water of well is never runs out, but its water level fluctuates to adjust seasons. Blekokan village often rains in October, while the nearby hamlet (Jelok) sometimes does not rain and mau be drought.

Groundwater found on Blekokan well looks a bit turbid, transparent to brownish color. Groundwater is tasteless and odorless, but because of its slight turbid then groundwater is not good if used directly as clean water. Groundwater in some other wells in the vicinity generally also has physical properties similar to groundwater at this Blekokan well. Only small numbers of residents have dug wells in this area.

In addition to dug wells, springs are sometimes found in several places. The spreading of the springs can be seen in Figure 3. Water resources in the research area are obtained from surface water and groundwater of those springs. The aquifer can be a compact rock from the Old Andesite and Jonggrangan Formations or alluvial deposits.

There are more than 20 springs in the study area included in Kaligesing Subdistrict, with a small to large discharge rate. Here are some examples of springs, especially those that are large enough (> 1 liter / sec) discharge rate and have implications for the surrounding population, which is related to the fulfillment of water needs.

a. Tlogoguwo Spring

Tlogoguwo's spring emerges from the andesite breccia andesite of the Old Andesite Formation (Fig. 8). Meanwhile, springs emerging from limestones in addition supported by porosity between grains and cracks are also supported by rock-dissolved cavities. The dissolved cavity develops because it is supported by cracks, and is the result of secondary porosity formation process.

Figure 8. Spring appearance at Tlogoguwo.

b. Kaligono Spring

Spring in Kaligono, Kaligesing (Figure 9) comes out with a small discharge / seepage from the andesite breccia aquifer. The springs of the andesite breccia aquifer which has considerable porosity, supported by porosity between grains and cracks, permeability is quite good. Groundwater from this spring is colorless, odorless, clear, tasteless, with pH 4.2, and TDS 243 ppm.

Figure 9. Kaligono spring feature exists from andesite breccia.

c. Blumbangan Spring

Blumbangan spring is located in Pucung Ngroto Village. This spring has a relatively large discharge (> 6.35 liter / second). The spring is located behind the Mushola and is not far from the residential area (Figure 10). There are many wells at this location where water is exploited by pumping equipment. This type of spring based on the continuity of the outflow of spring is included in the category of annual spring, ie springs that come out throughout the year and not affected by the season, both rainy and dry seasons. Petrophysic aquifers of this spring are sedimentary rocks of sandstone, so it is a type of porous aquifer spring.

Figure 10. Blumbangan spring appearance in Pucung Ngroto Village, Kaligesing.

The genesic type of this spring is gravitational or depression spring. The springs are relatively located in the bend of the slope (break of slope) so that the existence of these spring formed due to groundwater table cutting by topography. This type of water is very unstable; the quantity and quality of the groundwater emitted depends heavily on the circumstances surrounding it, especially its dependence on precipitation / rain fall and the ease of contamination by human activities above the ground. Depression springs generally have a short groundwater flow path and relatively young water age, and are classified as a local groundwater flow system [5].

d. Kebonharjo Spring

The existence of this spring is relatively located near the top of the hills (Figure 11), at Kebonharjo Village, Purworejo. According to information of residents, this spring flows throughout the year with fluctuations in the discharge at the turn of the season. This spring is classified as an annual spring that comes out of the unconfined aquifer. Based on the physical properties of aquifer, this spring is included in fractured springs whose groundwater derived from cracked rock aquifers such as breccia rocks that compose at the fracture research site, may be formed by some tree roots (biological factors). In this area there are several sources of fractures that converge into streams. This springs discharge is also relatively volatile at the turn of the season, but still drains enough water for the needs of the surrounding community.

Genetic of this spring may due to fractures from the roots of trees that penetrate the local aquifer, and not from an artesian or confined aquifer. The aquifer of spring is an andesite breccia. The water discharge at this spring ranges from 9.15 liters / sec.

Figure 11. The appearance of a spring triggered by the existence of a banyan tree (left); crevices or holes in the outlet of the spring (right).

e. Ngares Spring

Based on information from local residents, Ngares spring is the spring that serve as a source of need by local people. Quantity of the spring is relatively large which is about 11.5 liter / sec, but the water quality contains a lot of limestone solution so that if used for drinking water needs of residents, the limestone solution contained must be precipitated. The Ngares spring flows throughout the season, but there are fluctuations in the discharge of the seasons (Figure 12). The aquifer of this spring is limestone with tranvertin structure.

The genetic of this spring is gravitational spring or depression type which formed by the groundwater surface being cut by the declining topography of the soil surface. This depression spring is included in shallow groundwater spring. This type of spring is very unstable; the quantity and quality of the groundwater depends greatly on the surrounding environment, particularly on precipitation / rainfall and the ease of contamination by human activity on the soil surface. Depression spring commonly has a short groundwater flow path and a relatively young water age, and is classified as a system local groundwater flow.

f. Karangwuluh Spring

Karangwuluh spring is located in Tawangsari Village, Kaligesing Subdistrict (Figure 13). This spring is used by residents as bathing and washing needs. This spring's discharge is also relatively change at the turn of the season, but still drains enough water for the needs of the surrounding community. Based on the physical properties of aquifer rocks, this spring is included in fractured springs. This fracture

spring is spring whose groundwater derived from cracked rock aquifers such as breccia rocks that compose of the study area.

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Figure 12. One of the springs (left); Water tub was built to accommodate the entire outflow of water made by residents (right).

Figure 13. Karang Wuluh spring.

Based on the power cause of the spring, it is included in the gravity of depression spring. It shows that from the origin of the water, the depression spring is being shallow groundwater springs. This water of spring is very unstable; the quantity and quality of the groundwater depends greatly on the circumstances surrounding it, especially its dependence on precipitation / rainfall and is easily contaminated by human activities. This depression spring generally has a short groundwater flow path and a relatively young water age, and is classified as a local groundwater flow system. This water spring discharge is approximately 2.5 liters / sec.

g. Sebutrong Spring

The location of this spring is located behind a resident's house located not far from the Purworejo-Jogja highway (Figure 14). This spring is used by local residents for drinking water, bathing and washing needs taken by the pump. This type of spring is a porous spring whose groundwater is derived from porous rocks such as sandstone.

Sebutrong spring is classified into the gravitational or depression spring. Depression spring is classified as local spring because their quality and quantity are strongly influenced by rainfall and the surrounding environment. Generally this type of spring is very fluctuative because of its nature is also a shallow groundwater. The discharge rate of this spring is approximately 0.5 liter / second.

The springs in many areas at Kaligesing that appear on the Old Andesite Formation are generally supported by volcanic rock aquifers of Tertiary breccia and lava, with hilly topography and fractured by

some geological structures or faults. Thus the geohydrological system of this region is characterized by a cracking aquifer and the emergence of a fissure spring.

Figure 14. Sebutrong spring.

In addition to being dominated by cracked breccias, the springs in Kaligesing sub-district especially in Tlogoguwo Village are dominated by Jonggrangan Formation rocks that have been precipitated as in Ngares springs that have good porosity and permeability. Quantity of water produced in this spring is quite good. Unfortunately, limestones of Jonggrangan Formation will have implications for the quality of existing springs due to the high content of carbonate materials.

5. Geological Hazard

5.1. Erosion

Erosion in the research area occurs in a variety types, starting from the lowest intensity (sheet erosion) to the river. At some highs, gullies develop quite intensively. Gully erosion is widely developed in the research area. Generally this erosion forms a narrow water bodies in basin. Sometimes the valley is narrow, gullies develop with more dominant vertical erosion.

Vertical erosion sometimes develops in relatively upright river basins, although the cliffs are not very high. Sometimes vertical erosion is characterized by small waterfall.

Some rivers show mature age with widespread flood plains. Rivers that have such conditions usually provide a larger horizontal erosion process than vertical erosion.

In the lower areas, horizontal erosion begins to appear. This horizontal erosion is sometimes characterized by a fairly wide valley or low cliff.

In some river valleys, there are low cliffs but the slopes are quite steep. The river valley which is not so wide, usually marks as relative balanced erosion between horizontal and vertical erosion.

5.2. Flood

Potential floods occur around a large river like Jogobesan. The floodplains produced by its tributaries are generally not so wide. This flood potential occurs in some river cuts that have relatively low cliffs.

Flood potential will be greater if the water flow basin has begun to have sedimentation. This sedimentation will provide the effect of shallowing of river so the potential for flooding will increase, especially if there is a sudden water delivery and large discharge caused by rain in the upstream area.

5.3. Mass Wasting

Soil movement often occurs in the research area, especially in high areas. The movement of land occurs after rain falls with considerable rainfall. The sliding type of soil movement of avalanche materials potentially occurs in river cliffs.

Factors causing mass wasting include:

a. Precious rainfall with a long duration.
b. Subdued soil that is less dense and saturated water due to rain, resulting in heavy soil mass increases.

The soil forming as a result of weathering andesite breccia often results in minor sliding as the soil receives heavy loads from the mass of water. This condition is usually triggered by a fairly steep slope in the river cliffs, but not too dangerous because many rivers have low cliffs.

The soil formed as a result of weathering limestone of Sentolo Formation also potentially has the ground motion. Sometimes the weathered soil still leaves debris materials that are still a fairly, fresh origin (regolith) but because it is less compact then the landslide potential is quite large.

6. Development Potential

The environmental geology can be determined from many aspects, characterized by each parameter of conditional geology. It can be analyzed as individual problem of certain area [6]. Environmental geology of the Kaligesing area can be made by taking into account geological and natural resources and natural disasters. The study area can be divided into four zones (Figure 15). The possibilities for the development of this area can be summarized in Table 2 - 3.

Research areas can be developed into several landuse, including:

1. Tourism areas, especially in relatively high places with the presence of waterfalls and springs; panoramic tour (viewing post), religious tourism.
2. Mining areas, especially sandstone andesite and limestone.
3. Settlement areas, especially in relatively flat or gentle sloping areas, relying on water from springs or dug wells that tap water from alluvial or soil deposits.

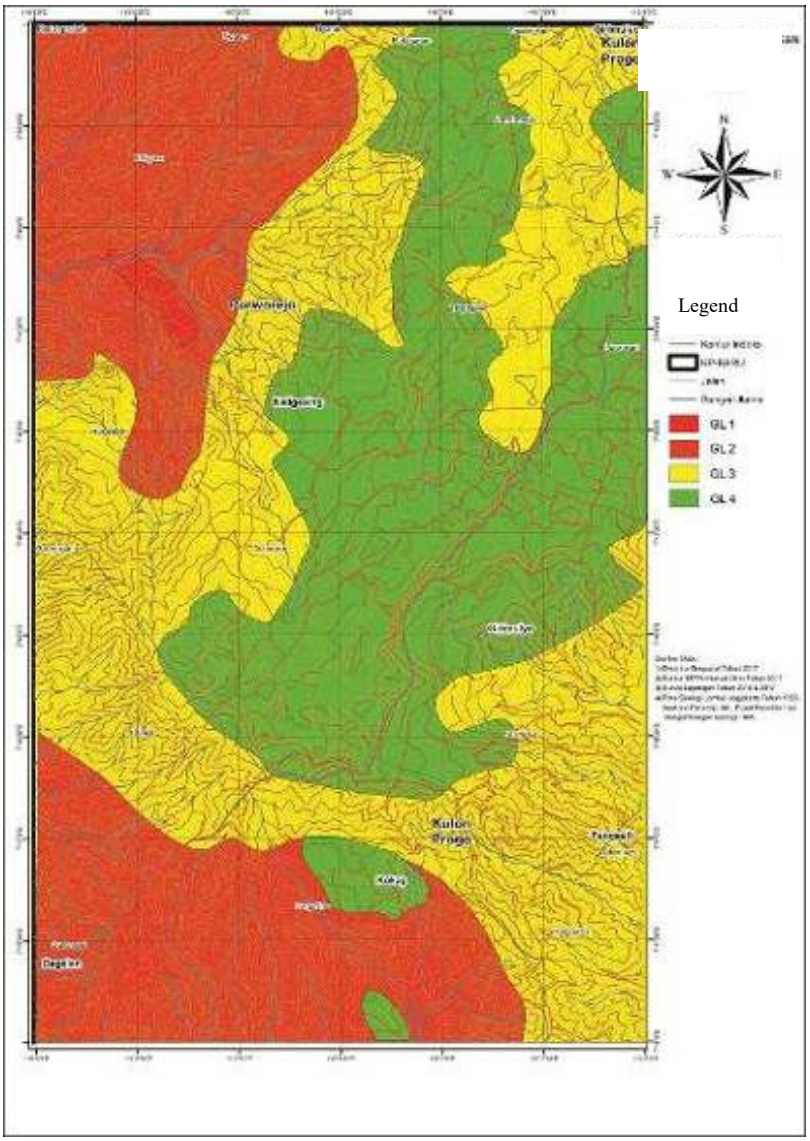

Figure 15. Geological map of Kaligesing area.

A very potential natural disaster is primarily ground movement. Some suggestions for mitigation of soil movements that can be given include:

a. On steep cliffs around the river, especially those adjacent to the village, it needs to be planted with more trees that can strengthen and bind the soil / rocks.
b. Residential area development activities should not cut the cliffs into steep cliffs as they will cause ground movements, or seek out local terraces or reclamation.

Table 2. Environmental geology zone of ancient volcano at Kaligesing area.

Environmental Geology Zone	Ancient Volcanic Mountainous
Landform	Steeply hills – mountainous, dendritic – sub dendritic drainage pattern.
Rock, mineral and soil	Volcanic breccia, lava, intrusion, fertile land.
Geological structure	Joint, fault
Hydrogeology	Surface water (streams), spring, local occurrence of groundwater
Hazard	Mass wasting
Development Potential	Plantation, agriculture, forestry, mining, geotourism

Table 3. Environmental geology zone of Jonggrangan Karst at Kaligesing area.

Environmental Geology Zone	Jonggrangan Karst
Landform	Plateau, many caves
Rock, mineral and soil	Reef limestone, bedded limestone, marl, carbonate sandstone
Geological structure	Cracks
Hydrogeology	Deep – shallow groundwater
Hazard	Collapse of cave walls
Development Potential	Conservation area, mining of C-materials excavation, geotourism

4. Conclusion

The Kaligesing area is generally composed of ancient volcanic landscapes and Jonggrangan karst. Natural resources that can be found in this area include rocks, soil and water potential. Rocks that can be used for building materials are andesite breccia, lava and limestone. Soil in this area is quite fertile, while the water can be obtained from surface water or groundwater contained locally as a spring. The dominant geological natural disasters are landslides and erosion, while the potential for flooding is only small. By looking at the geological characteristics, the research area can be divided into at least two environmental geological zones namely Jonggrangan karst and ancient volcanic mountainous zone.

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