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Application of the Analytical Hierarchy Process (AHP) Method for Zoning Potential Groundwater in the Kalianda and Surrounding Area, South Lampung District, Lampung Province

Selma Nurul Fauziah [1,*], Yogi Adi Prasetya [2], Agim Yustian Bakhtiar [3], Rikza Nur Faqih An Nahar [4,5]

*Email: selma.fauziah@tka.itera.ac.id

[1] Program Studi Rekayasa Tata Kelola Air Terpadu, Fakultas Teknologi Infrastruktur dan Kewilayahan, Institut Teknologi Sumatera, Lampung Selatan, Provinsi Lampung
[2] Jurusan Teknik Geologi, Fakultas Teknik, Universitas Jenderal Soedirman, Purwokerto, Provinsi Jawa Tengah
[3] PT. Wirakarya Sakti (Sinarmas Forestry), Kabupaten. Tanjung Jabung Barat, Provinsi Jambi
[4] Renard Centre of Marine Geology, Ghent University, Ghent, Belgium
[5] Program Studi Teknik Geologi, Fakultas Teknologi Industri, Institut Teknologi Sumatera, Lampung Selatan, Provinsi Lampung

Abstract

Management related to groundwater resources is needed, especially in areas experiencing rapid regional development, such as Kalianda, South Lampung Regency. The initial step in management is identifying groundwater potential, using the geographic information system. This research aims to map groundwater potential zones using the Analytical Hierarchy Process (AHP) method in the Kalianda area. The methods used were geological mapping, AHP processing via GIS, and comparative analysis with aquifer productivity maps and the numbers of well distribution in the research area. From geological mapping, lithology was obtained in the form of Alluvium Unit, Mount Rajabasa Laharic Deposit Unit, Mount Rajabasa Andesite Lava Unit 1, Mount Rajabasa Andesite Lava Unit 2, Mount Rajabasa Andesite Lava Unit 3, Mount Pandan Pyroclastic Breccia Unit 1, and Mount Pandan Pyroclastic Breccia Unit 2. The results of the groundwater potential zone analysis divided the research location area into four zones: low potential zone covering 42.34%, medium 21.17%, quite high 15.45%, and very high 21.03% of the research area. The low and medium potential zones are the zones with the largest constituents spread across the southeast and south, and the moderately high and very high groundwater potential zones spread across the north and along the coast. In addition, the zoning results are proportional to the number of wells in each zone.

Keywords: Groundwater, AHP, Analytical Hierarchy Process, Groundwater Potential Zone

I. INTRODUCTION

Managing groundwater resources is necessary to fulfill the basic human necessities of water. Increased population growth, environmental and water resource degradation, and increased water scarcity encourage research related to groundwater conservation and its regulation to be improved [1]. Groundwater is a type of water source that has long been utilized by living things; it exists below the surface, which is inside porous media or rock cracks. Groundwater exists in an aquifer system with certain hydrogeological conditions. This can be studied through geological and geophysical investigations, such as in research by Sukamoro [2], in which groundwater in two aquifer systems was found through field investigations.

Groundwater exploration is conducted in various ways, for example, by digging the ground to the shallow aquifer layer or drilling towards the deeper aquifer layer. If not managed properly, the exploitation may cause water crisis problems in the future. The first step that needs to be taken is to identify the potential or availability of groundwater in an area.

Research on groundwater potential is linked to various needs, such as for agriculture [3], industrial [4], and other purposes, especially in areas with rapid development [5]. Kalianda is an area in South Lampung Regency, Lampung Province, that has been experiencing rapid regional development. Population growth, built-up areas, and industrial areas will be directly proportional to water demand. The increase in water demand, including groundwater, must be

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accompanied by sufficient supply. However, there has been no research related to identifying groundwater availability or potentiality in the area of Kalianda.

Technological advances in computing and spatial data processing encourage the improvement of water resource management through numerical simulation methods, remote sensing, and geographic information systems (GIS). Several studies have recommended the application of models with these methodologies to support optimization in the management of groundwater resources [6]. The application of GIS with the Analytical Hierarchy Process (AHP) method has been used in several studies to determine groundwater potential zones. Some previous studies that discussed groundwater potential zones have been conducted by Arulbalaji et al. in 2019 [7], Dar et al. in 2020 [8], and Zghibi et al. in 2020 [9].

This study aims to determine the geological conditions of the research area and map groundwater potential zones in the Kalianda area by applying AHP Figure 1. The research benefits as a step to initiate ongoing research related to sustainable groundwater resource management. It is hoped that the study results will be the basis for recommendations for local governments in creating water source distribution and improving the management of water resources in the area.

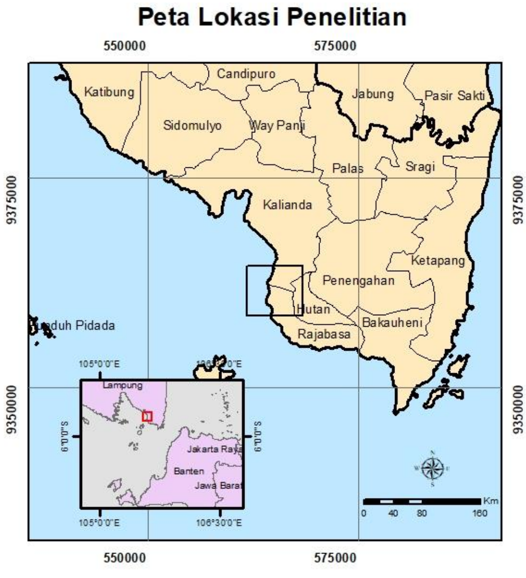

Figure 1. Map of research location

II. LITERATURE REVIEW

A. Regional Geology

Kalianda is located on the coast of Lampung Bay along the foot of Mount Rajabasa. Mount Rajabasa is located in Lampung Province, precisely in South Lampung Regency, and is an active volcano of the stratovolcano type formed from layers of lava flows and pyroclastic breccia deposits [10]. According to the geological map of the Tanjungkarang quadrangle [11], the research location was composed of the Qhv formation, which is the Rajabasa volcanic deposits consisting of andesitic-basaltic lava, volcanic breccia, and tuff [12].

As can be observed from the geological map of the Panengahan quadrangle belonging to the Geological Survey Center Figure 2, the research location was composed of several formations, which are:

- Qppv (volcanic rocks of Mount Pandan)
- Qhrv (volcanic rocks of Mount Rajabasa)
- Qlh (lava deposits)

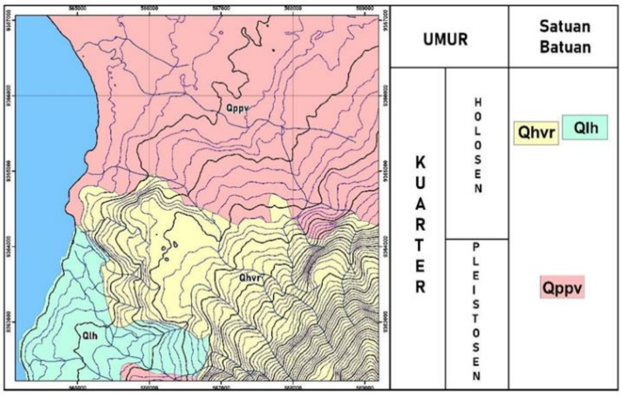

Figure 2. Geological map of the research location, modified from the Panengahan quadrangle (modification taken from Sidarto et al., 2017)

B. Groundwater Potential Zones

Groundwater potential zones are defined as areas assessed based on the possibility of the potential availability of groundwater sources [13]. Groundwater potential zones play an important role in efforts to provide groundwater for the needs of living things. Factors that influence the groundwater potential of an area include:

1) Lithology

Lithology is an important factor in determining potential zones. This is related to the different infiltration capacities of each rock unit, which are mainly controlled by hydraulic properties such as porosity and permeability, which can be a "gap" for water to flow [14].

2) Type of Soils

Soil can be defined as a natural aggregate of loose mineral particles, with or without organic matter, which can be decomposed by mechanical treatment [15]. Due to mechanical or chemical weathering processes, soil is formed through the weathering of various parent materials in the form of rocks.

Mechanical weathering generally affects the physical properties of the soil in the form of grain size. This type of weathering is mainly caused by the presence of energy that can damage the material, such as erosion and material contraction. This causes the parent material to decompose, but its chemical properties do not change. On the other hand, chemical weathering is a weathering that occurs due to chemical reactions. Chemical reactions can be in the form of oxidation of materials by water vapor, oxygen, or other substances either in the atmosphere or in solution. This causes the material to change or be altered into another material that is different from the previous material so that it can become softer and more brittle than before [15].

Soil plays an important role in the rate of water infiltration into the soil. Soil properties are formed according to the parent material and have their own hydraulic parameters.

3) Morphology

Morphology is the condition of the earth's surface as a manifestation of processes that work on the earth's surface by endogenous and exogenous forces.

Morphology is the result of material expression on the surface in response to the processes that are working, for example, exogenous processes caused by water flow, thus reflecting the surface reaction to water.

4) Slope Gradient

This is a feature that represents the level of height difference and distance of a landform. The slope gradient is a parameter controlled by geodynamic factors that work on a regional scale. In terms of water, slope gradient greatly affects surface runoff and infiltration rates. This is because water takes time to infiltrate into the soil.

5) Land Use or Land Cover (LULC)

This parameter provides an important picture of how the rate of water infiltration is affected by the presence of land cover on the surface. This data comes from satellite imagery data such as Landsat or Sentinel and is categorized based on the information contained in the data, such as land cover in an area.

6) Precipitation Rate

Precipitation rate plays an important role because it is a source of local water supply and influences the amount of water that seeps into the ground.

7) Watershed Density

Watershed density or flow density is the ratio of river length to area. This function is influenced by local lithology conditions and is the inverse function of permeability properties [7].

8) Lineament Density

Lineament is a straight-line appearance on the earth's surface that is controlled by geological structures. Lineament is related to the geotectonic processes that work and produce secondary permeability that becomes the entry path for water [14]. Linearity data can be obtained by lining up linearity features from satellite imagery. Linearity density is the ratio of the length of the linearity to the area that functions to determine how the distribution of linearity features is in an area [16].

III. METHODS

Geological mapping was used to obtain geological data in the form of rock units in the research area. Then, the petrography method was conducted by making a thin section of rock with a thickness of 0.03 mm, which was then analyzed using an optical microscope in the petrology laboratory of the Sumatra Institute of Technology. Subsequently, data processing using the AHP method was performed using GIS software.

The methodological steps used in the research were determining the parameters, determining the synthesis of priority parameters, and testing the consistency of the decisions taken. The parameters used in the research were lithology parameters, soil type, morphology, slope, land use or land cover (LULC), precipitation rate, watershed density, and lineament density. The weights of the parameters were calculated and determined using the Analytical Hierarchy Process (AHP) method, which produced a CR value below the threshold of 0.1 so that the produced parameter values were consistent and could be employed in further calculations.

The intersection and overlap analysis was carried out on the parameters that have been given weights according to the calculations carried out using the following formula:

$$Total\ value = \sum(Weight * Influence\ Factor) \quad (1)$$

IV. RESULTS AND DISCUSSIONS

A. Stratigraphy of Research Area

The research area is part of the flank of Mount Rajabasa [10]. Thus, the research utilized the volcano stratigraphy principles by the Indonesian Stratigraphic Code 1996 [17]. Volcanostratigraphy is grouping volcanic rocks that have the same type and source of eruption, be it lava, pyroclastic, or laharic breccia. Based on the volcano stratigraphy analysis, the research area is divided into seven rock units, which are part of Rajabasa Volcanic Mound, Pandan Hillock, and Rajabasa Hillock. Research areas were then divided into several units (Figure 11).

Petrographic analysis was performed on each rock sample in each rock unit. This was done to determine the mineral composition of the rock and to name it according to the rock classification. Here is the explanation of the geological units:

1) Mount Rajabasa Andesite Lava Unit 1(Rl1)

Mount Rajabasa Andesite Lava Unit 1, with the code "Rl1", has a porphyritic, hypocrystalline, inequigranular texture, with subhedral-anhedral mineral forms and a mineral size ranging between 1-2.5 mm.

This unit has a mineral texture in the form of sieve, zoning, and glomeroporphyritic texture. Its mineral composition is 15.88% pyroxene, 37.19% plagioclase, 41.94% volcanic glass, and 3.5%opaque minerals. Based on Travis' classification (1955) [14], the sample of rock unit was then named Andesite. Outcrop appearance, thin section with the mineral composition of plagioclase, pyroxene, and volcanic glass groundmass shown in Figure 3.

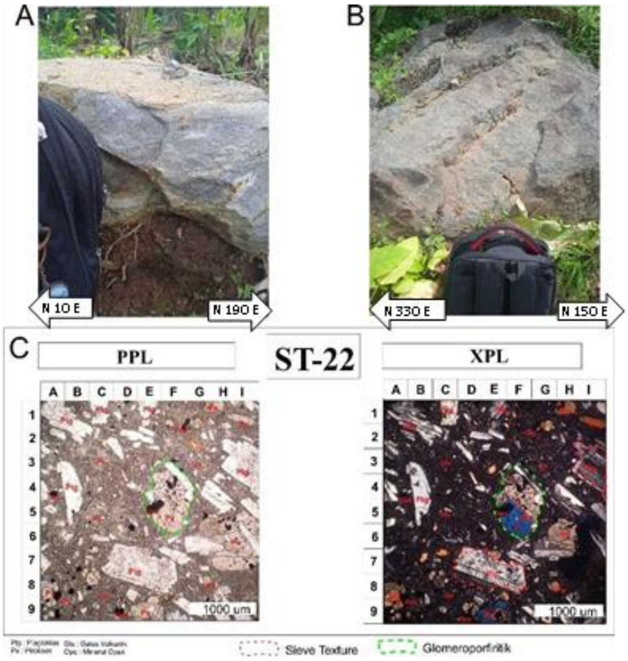

Figure 3. (A) and (B) outcrop appearance (C) Thin section with the mineral composition of plagioclase, pyroxene, and volcanic glass groundmass

2) Mount Rajabasa Andesite Lava Unit 2 (Rl2)

Mount Rajabasa Andesite Lava Unit 2, with the code "Rl2", has a porphyritic, inequigranular, and hypocrystalline texture, with subhedral-anhedral mineral form and a mineral size ranging from 1-1.5 mm. The units were spread over approximately 19.2% of the total area of the research area.

This unit has mineral textures in zoning, sieve texture, glomeroporphyritic, and reaction rims. The total composition of the constituent minerals is 11.40% pyroxene, 39.45% plagioclase, 44.65% volcanic glass, and 4.5% opaque minerals. According to Travis' classification (1955) [14], the rock sample was named Andesite. Close-up view of rock outcrop, zoom-out view, petrography results: plagioclase, pyroxene, and volcanic glass groundmass as mineral constituents shown in Figure 4.

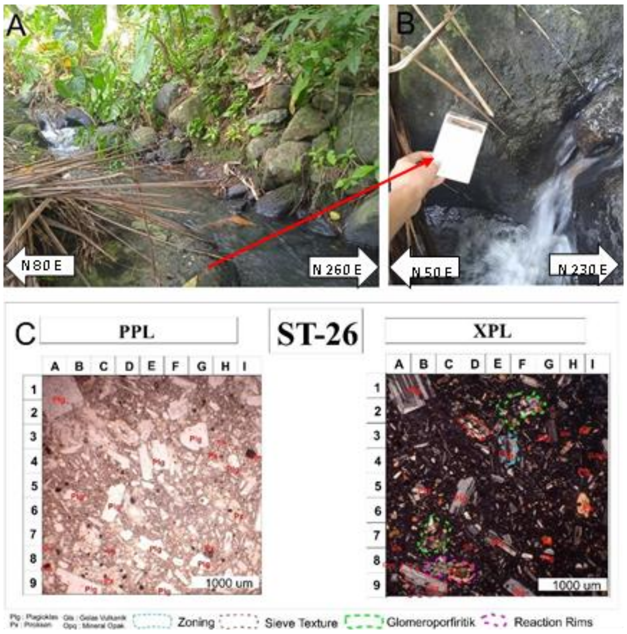

Figure 4. (A) Close-up view of rock outcrop (B) zoom-out view (C) petrography results: plagioclase, pyroxene, and volcanic glass groundmass as mineral constituents

3) Mount Rajabasa Andesite Lava Unit 3 (Rl3).

Mount Rajabasa Andesite Lava Unit 3 has a code unit called "Rl3". The rock samples have a porphyritic, hypocrystalline, inequigranular texture, subhedral-anhedral mineral forms, and phenocryst crystal size ranging from 1 to 1.5 mm, occupying 25.07% of the research area.

The unit has a mineral texture in the form of sieve, zoning, and poikilitic texture. The amount of mineral composition is 10.25% pyroxene, 35.83% plagioclase, 48.75% volcanic glass, and 5.17% opaque minerals.

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According to Travis' classification (1955) [14], the rock sample was named Andesite. Andesite appearance from the Andesite Lava Unit of Mount Rajabasa 3 shown in Figure 5. Microscopic view of the Mount Rajabasa Andesite Lava Unit 3 shown in Figure 6.

Figure 5. Andesite appearance from the andesite lava unit of mount rajabasa 3

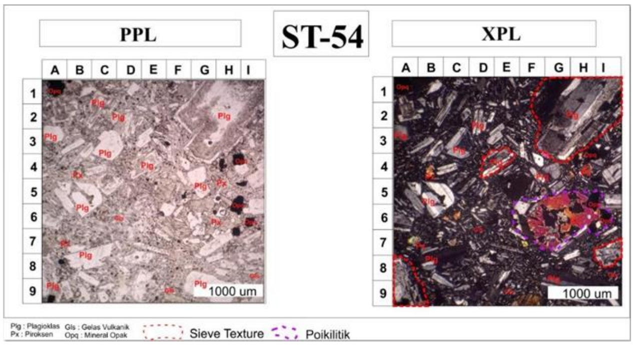


Figure 6. Microscopic view of the mount rajabasa andesite lava unit 3

4) *Pyroclastic Breccia Rocks of Mount Pandan 1 (Pap1)*

Pyroclastic Breccia of Mount Pandan 1, with the code "Pap1", has a fragment size ranging from 1-15 cm, open-packing with fine sand matrix, medium angular roundness, and poor sorting. The unit occupies about 8.83% of the total area of the research area, and the component of the fragment is an andesitic fragment.

The unit was composed of 40% lapilli, 50% block, and 10% ash components. Thus, according to Fisher's classification (1966) [19], fragments were in the form of breccia lapilli tuff. The matrix was composed of 50% glass, 45% lithic, and 5% crystals in the form of 5% opaque. According to William et al. (1954) [20], the matrix is a tuff glass. Outcrop view of mount pandan pyroclastic breccia unit 1 rocks shown in Figure 7. Petrographic observation results of fragment samples of mount pandan 1 pyroclastic breccia unit shown in Figure 8.

Figure 7. Outcrop view of mount pandan pyroclastic breccia unit 1 rocks

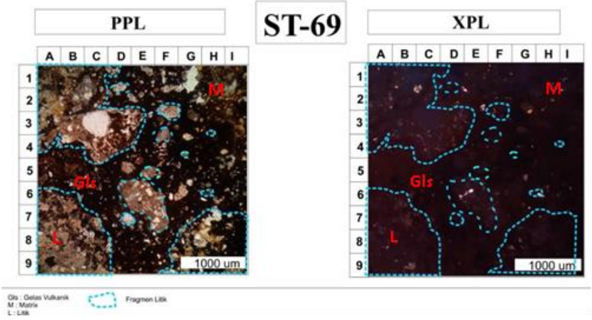


Figure 8. Petrographic observation results of fragment samples of mount pandan 1 pyroclastic breccia unit

5) *Mount Pandan Pyroclastic Breccia Unit 2* (Pap2)

Mount Pandan Pyroclastic Breccia Unit 2 has a code of “Pap2”. The grain size of the fragment ranges from 1-40 cm and has angular roundness with poor sorting and open-packing with fine sand matrix characteristics. It occupies about 26.67% of the total area of the research area, and its fragments are andesitic.

The rock sample has mineral constituents of 40% lapilli, 35% block, and 25% ash. According to Fisher’s classification (1966) [19], it was breccia lapilli tuff. Based on the petrographic analysis, the rock sample is composed of a 60% glass matrix, 35% lithics, and 5% crystals, which belong to the tuff-glass category, according to William (1954) [20]. The appearance of the mount pandan pyroclastic breccia unit 2 shown in Figure 9. Microscopic view of sample from the mount pandan pyroclastic breccia unit 2 shown in Figure 10.

6) *Alluvium Deposits*

Alluvium deposits, with the code "Al", has a covering area of approximately 6.6% of the total area of the research area. Alluvium deposits are found in lower areas from river mouths to the coast. Alluvium deposits are composed of gravel, sand, and boulders.

7) Laharic Sediment Unit of Mount Rajabasa

Laharic Sediment Unit of Mount Rajabasa, with the code "Rlh", spread around 4.86% of the total area of the research area. Samples have reddish brownish on the top and brownish white on the bottom. Its fragment size widely ranges from 1 cm to 1 meter, has mid-angled roundness, poor sorting, and open-packing, with a dominantly weathered matrix, and a size smaller than fine sand. Fragment matrix components are andesitic fragments.

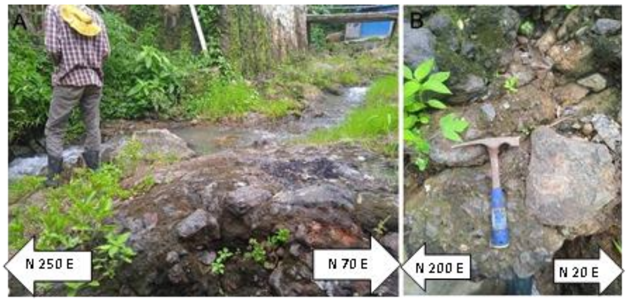


Figure 9. The appearance of the mount pandan pyroclastic breccia unit 2

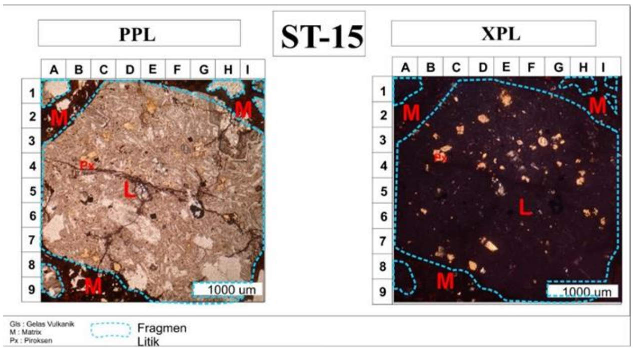


Figure 10. Microscopic view of sample from the mount pandan pyroclastic breccia unit 2

B. AHP Matrix Calculations

AHP calculations were carried out in several stages: decomposition, comparative assessment, priority synthesis, and logical consistency. These steps were carried out in Microsoft Excel software. These four stages are vital to produce comprehensive decisions. The results of the analysis obtained are shown in Table 1.

The calculation of parameter weight determination carried out using the Analytical Hierarchy Process (AHP) method generated a CR value of 0.079. The value was lower than the CR value threshold of 0.1 so that the produced parameter values were consistent and could be used in further calculations.

Lithology factors are the most significant factors related to permeability that affect the infiltration rate into the groundwater zone. Lithology with crystalline characteristics, such as igneous rocks, has an interlocking component structure.

Furthermore, the soil factor that experiences direct contact with surface water is related to water infiltration, affecting groundwater potential. Infiltration properties are caused by the presence of pores and permeability in the soil which is closely related to the movement of water in porous media.

Then, the morphological factor as a function of surface expression in responding to processes that occur on the earth's surface. The earth's surface will affect the tendency of water to run off or infiltrate into the earth. On the other hand, the slope factor influences a pattern that the steeper a slope, the more water becomes runoff rather than seeping into the ground.

Land use as a factor also affect the ability of water to infiltrate into the soil. If the land cover is impermeable, then water tends to become runoff. However, the weight of this parameter is not significant. This is because the presence of groundwater is not only influenced by direct water infiltration, but can also be influenced by groundwater flow in the aquifer.

The factor of precipitation rate is related to the supply of incoming water. This parameter determines how much water enters the soil. It is insignificant because it only refers to a water input factor in an area. Rainfall that enters the soil depends on other factors, such as soil and lithology.

The watershed density as a factor serves as an inverse of permeability, thus reducing infiltration [7]. This parameter has a negligible influence on the nature of the data delineated from the Digital Elevation Model (DEM) data, so the inaccuracy with the field data is quite significant. The lineament density factor is related to the alleged presence of a weak zone that can increase permeability secondarily. However, the data still needs to be validated for its accuracy because the lineament density and flow density data are created automatically based on DEM analysis, so the potential can be quite large.

AHP matriculation was conducted for each parameter above to produce weights for each parameter member Figure 12. The accumulated total value of each polygon that had undergone intersection and overlap analysis was then classified into four statistical zones: low potential, medium potential, quite high potential, and very high potential.

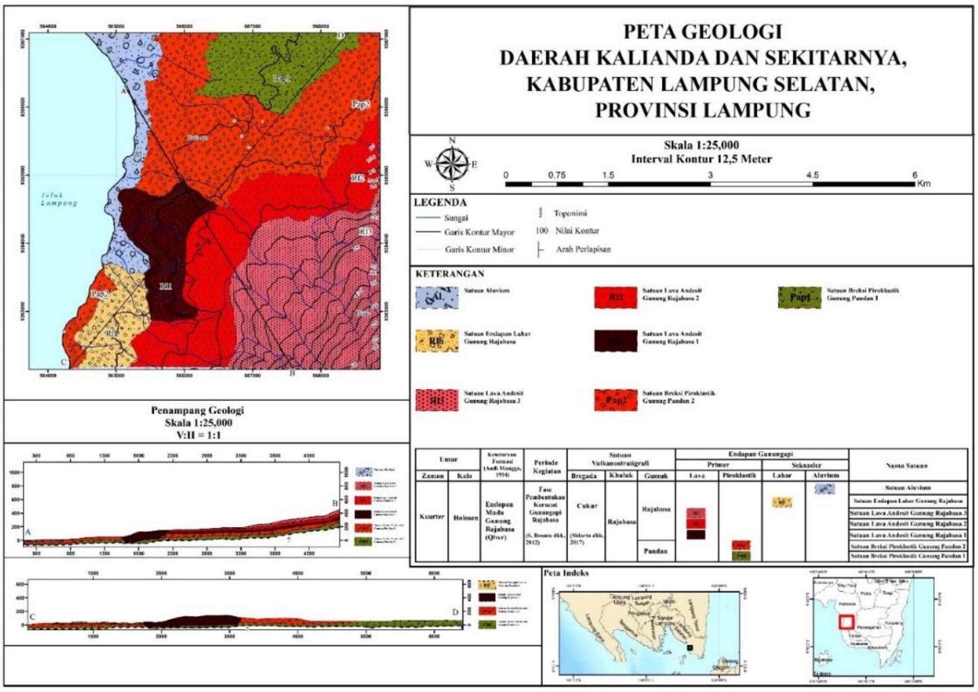


Figure 11. Geological map of research area

Table 1. Parameter, Sub-parameter, Weight AHP, and its area in research location

n	Parameter	Influence Factor (%)	Members	Weight	Area (km^2)	Area (%)
1	Lithology	32.76	Al	0.32	1.32	6.10
			Pap1	0.21	1.91	8.83
			Pap2	0.25	5.76	26.66
			Rlh	0.11	1.05	4.86
			Rl2	0.06	2.00	9.26
			Rl1	0.04	4.15	19.21
			Rl3	0.02	5.42	25.08
2	Soil	23.02	Dystrandepts	0.67	4.59	21.25
			Paleudults	0.24	4.56	21.10
			Humitropepts	0.09	12.47	57.73
3	Morphology	12.83	Wavy plain field	0.76	4.64	21.47
			Hilly	0.16	6.01	27.76
			Mountain Body	0.08	10.98	50.77
4	Slope Gradient	13.40	Class I (0-8 Percent)	0.44	9.68	45.12
			Class II (8-15 Percent	0.25	5.28	24.60
			Class III (15-25 Percent)	0.18	2.87	13.39
			Class IV (25-45 Percent)	0.09	3.11	14.50
			Class V (>45 Percent)	0.04	0.51	2.39
5	Land Use	9.00	Areas Associated with Water Body	0.44	0.18	0.84
			Areas with High Vegetation Density	0.30	14.90	68.89
			Agricultural Land	0.15	2.15	9.97
			Areas with Low Vegetation Density	0.07	0.03	0.14
			Built-up Areas	0.04	4.36	20.16
6	Precipitation Rate	4.00	Class I (3176-3241 mm/year)	0.53	1.22	5.65
			Class II (3111-3176 mm/year)	0.28	3.19	14.76
			Class III (3045-3111 mm/year)	0.12	7.83	36.21
			Class IV (2981-3111 mm/year)	0.06	9.38	43.39
7	Watershed Density	2.73	Class I (0-3.1 km/sq km)	0.44	3.47	16.07
			Class II (3.11-6.2 km/sq km)	0.25	10.10	46.73
			Class III (6.21-9.31 km/sq km)	0.18	6.90	31.94
			Class IV (9.31-12.4 km/sq km)	0.09	1.01	4.67
			Class V (12.4-15.6 km/sq km)	0.04	0.13	0.59
8	Lineament Density	2.23	Class I (10.01-12.5 km/sq km)	0.42	0.04	0.20
			Class II (7.51-10 km/sq km)	0.26	0.30	1.40
			Class III (5.01-7.5 km/sq km)	0.20	2.19	10.13
			Class IV (2.51-5 km/sq km)	0.09	5.25	24.28
			Class V (0-2.5 km/sq km)	0.04	13.83	63.98

C. Analysis of Groundwater Potential Zones in the Research Area

Based on the results of the analysis, it is known that the research area has groundwater potential that can be categorized into low, medium, quite high, and very high zones Figure 13.

Areas with low and medium potential zones have a distribution of 42.34% and 21.17%, respectively. The distribution of low and medium potential zones is in the southeast and south. This is due to the fact that the area is composed of andesite lava lithology with shallow soil character, parent material with hilly morphology, and mountain bodies with quite large slopes.

Rocks in areas with low and medium potential zones are andesite lava, whose constituent material properties are interlocked minerals. This property causes the porosity and permeability to be less than optimal for storing groundwater even though the density of lineaments in this area is quite large. This is because the density of lineaments in this area does not represent the presence of secondary permeability, so its influence is insignificant.

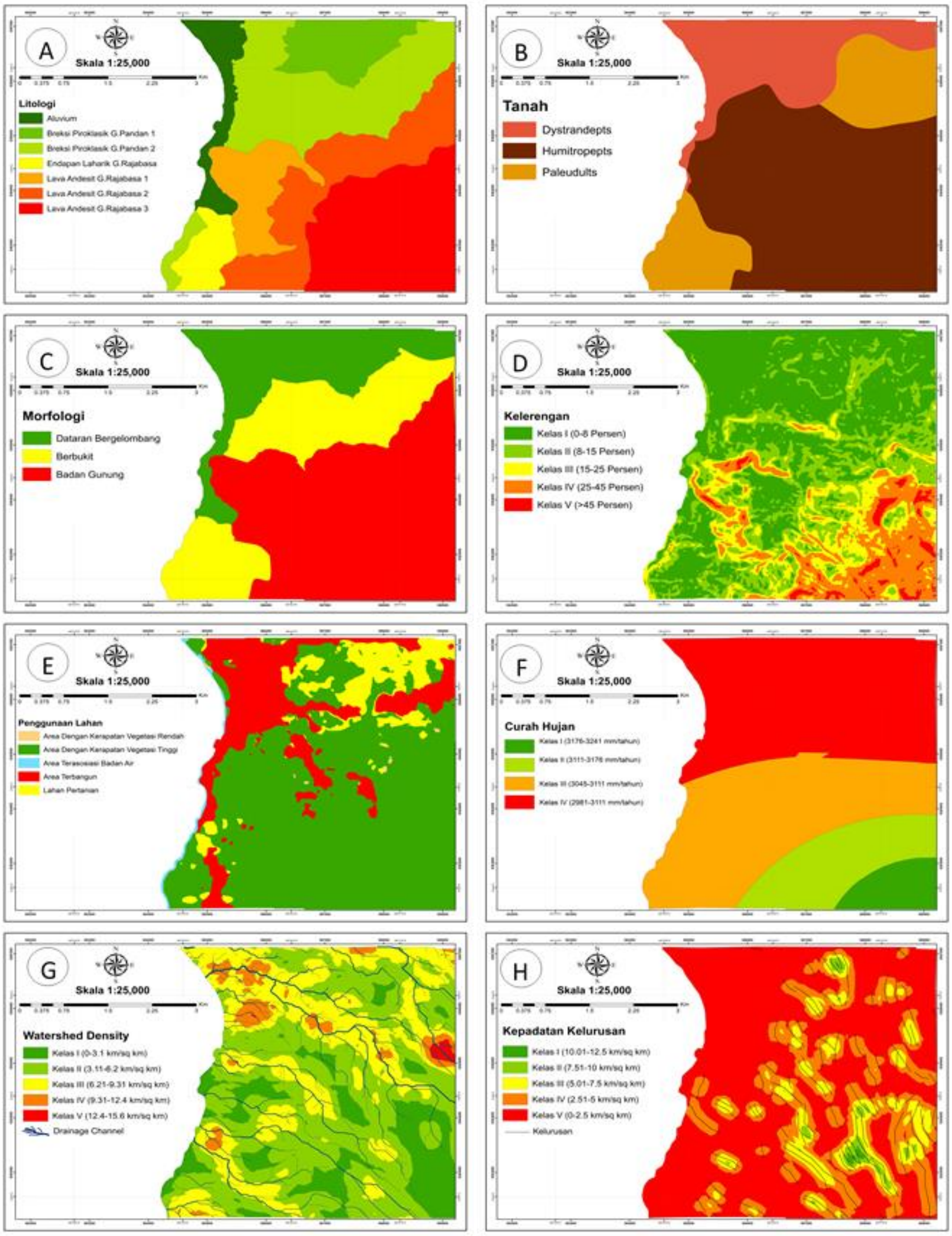
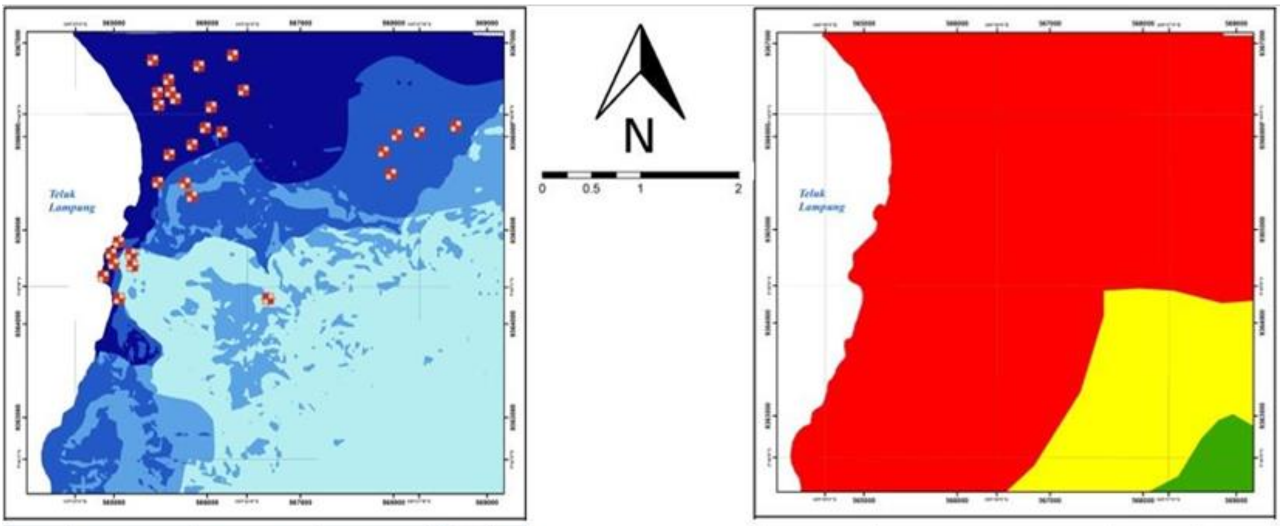


Figure 12. Map of each AHP parameter. (A) lithology, (B) soil type, (C) morphology, (D) slope gradient, (E) Landuse/Landcover (LULC), (F) precipitation rate, (G) watershed density, and (H) lineament density



Kelas	Keterangan	Nilai AHP	Luas (sq Km)	Persentase Luas (%)
Kelas I	Potensi Rendah	0.072263 - 0.135242	9.11	42.34
Kelas II	Potensi Sedang	0.135243 - 0.192624	4.56	21.17
Kelas III	Potensi Cukup Tinggi	0.192625 - 0.312063	3.33	15.45
Kelas IV	Potensi Sangat Tinggi	0.312064 - 0.473953	4.53	21.03

Kode Warna	Produktivitas Akuifer (Debit)	Luas (sq Km)	Luas (%)
	Langka (Langka)	0.59	2.74
	Setempat Produktif (Langka)	3.70	17.13
	Produktif Sedang Dgn Penyebaran Luas (Debit <5 L/Detik)	17.31	80.13

Figure 13. (Left) Groundwater potential zone map using ahp method and distribution of observation wells, (Right) aquifer productivity map (ministry of energy and mineral resources of indonesia, 2022) [21]

The character of the soil depth in the low and medium potential zones is also not too deep. Field observations show fresh andesite rocks can still be found in a reasonably shallow profile. Some rock masses are often found emerging from the ground in areas with mountain body morphology. In addition, information from residents said that fresh andesite rocks can be found easily just by digging the ground briefly.

Areas with fairly high and very high groundwater potential zones were spread in the northern part and along the coast in the research area. These zones had a distribution of 15.45% and 21.03%, respectively. They had a lithological character in the form of alluvium and volcanic breccia, some of which had been weathered. In addition, the soil in the fairly high and very high groundwater potential zones had a thick depth. Many cultivated areas were found in these locations, such as agricultural land in the form of corn fields, rice fields, and banana plantations. These conditions act as a medium for groundwater. The presence of pores and good pore connectivity in loose sediments, weathered rocks, and thick soils cause groundwater to be stored well.

Although the land covers of these areas were mostly built-up, they had excellent groundwater potential. The situation was mainly possible because groundwater in this area not only comes from direct sources such as recharge from surface water infiltration but also from groundwater flow in aquifers. Groundwater potential zone map using ahp method and distribution of observation wells, and aquifer productivity map (ministry of energy and mineral resources of indonesia shown in Figure 13. In general, the distribution of areas with good potential in the research results compared to areas with moderate productivity on the aquifer productivity map from the Ministry of Energy and Mineral Resources of Indonesia has a similar pattern. However, the two areas are still different. This is due to differences in the methods and parameters used to map the area's groundwater potential.

As a recommendation, based on the results of the research analysis, it is expected that areas with quite high and very high potential can be utilized in efforts to equalize clean water. The Water Company owned by the government can be expected to drill well facilities that can be constructed in areas with very high groundwater potential along with water distribution installations. Distribution pipes and large reservoirs, for instance, can also be constructed, especially in areas with low potential. These acts serve as part of the equalization effort as mandated in the Indonesian Constitution 1945, Article 33, paragraph 3, and to prevent uncontrolled groundwater exploitation in the future, which can cause new problems such as groundwater subsidence and seawater intrusion.

In addition, stakeholders in the related areas are expected to draft regulations related to water resources so that these resources can be managed and utilized optimally for the surrounding community for the common good. Further studies are also needed, especially related to groundwater quality standards in this area, so that the characteristics of the quality of groundwater in this area can be known. It is hoped that the availability of groundwater sources in this area has good and sufficient quality and can be inventoried. Distribution of observed wells in research area shown in Table 2.

Table 2. Distribution of observed wells in research area

Groundwater Potential Zone	Percentage (%)	Amount of Wells
Low	6.67	2
Medium	3.33	1
Quite High	23.33	7
Very High	66.67	20

V. CONCLUSIONS

Stratigraphy of the research location was analyzed using volcano stratigraphy analysis, which resulted in 1 volcano mound, and 2 hillocks, with 7 rock units that can be sorted from the oldest as follows: Mount Pandan Pyroclastic Breccia Unit 1 (Pap1), Mount Pandan Pyroclastic Breccia Unit 2 (Pap2), Mount Rajabasa Andesite Lava Unit 1 (Rl1), Mount Rajabasa Andesite Lava Unit 2 (Rl2), Mount Rajabasa Andesite Lava Unit 3 (Rl3), Mount Rajabasa Laharic Deposition Unit (Rlh), and Alluvium Unit (Al).

The research area was divided into 4 groundwater potential zones: a low potential zone covering 42.34% of the research area, a medium potential zone covering 21.17% of the research area, a fairly high potential zone covering 15.45% of the research area, and a very high potential zone covering 21.03% of the research area. The low and medium potential zones were the zones with the largest constituents spread across the southeast and south. It is supported by lithological factors in the form of andesite lava, shallow soil, hilly morphology, and mountain bodies with quite large slopes. The fairly high and very high groundwater potential zones were predominantly spread across the north and along the coast due to the lithological characteristics in the form of alluvium and volcanic breccia, some of which have weathered and acted as a medium for groundwater.

For further research development, data updates, such as soil type data, rainfall, or land cover that can change for continuous monitoring, are especially needed. In addition, policymakers can help provide water in low-potential zones to continue meeting the water demands of the community in the area.

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