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Analysis of Ground Water Potential in Gowa Regency, South Sulawesi Province Using the Overlay Method

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ABSTRACT

One source of raw water that is often used by humans is groundwater, namely water that occupies cavities in the layers of rock beneath the earth's surface. Groundwater is often used as a source of raw water or a source of clean water by the community apart from river and lake water. Each region has its own level of groundwater potential that can be utilized. The purpose of the analysis carried out is to determine the distribution of potential groundwater in each sub-district area in Gowa Regency through the use of a Geographic Information System (GIS), by applying the overlay method to a number of variables which are factors that influence the presence of groundwater, such as slope, use land, soil type, geology, and rainfall. The results of the analysis that has been carried out show that Gowa Regency has groundwater potential that is spread over each of its sub-districts, where it is divided into a number of potential levels of groundwater availability starting from very low, low, medium, high, and very high.

Keywords: Geography information system, Gowa regency, Groundwater, Overlays

ABSTRAK

Salah satu sumber air baku yang sering dimanfaatkan oleh manusia adalah air tanah, yaitu air yang menempati rongga-rongga pada lapisan batuan di bawah permukaan bumi. Air tanah seringkali dijadikan sebagai sumber air baku atau sumber air bersih oleh masyarakat selain dari air sungai dan danau. Setiap daerah masing-masing memiliki tingkat potensi air tanahnya tersendiri yang dapat dimanfaatkan. Tujuan analisis yang dilakukan adalah untuk mengetahui sebaran potensi air tanah pada setiap wilayah kecamatan yang terdapat di Kabupaten Gowa melalui pemanfaatan Sistem Informasi Geografis (SIG), dengan menerapkan metode *overlay* terhadap sejumlah variabel yang merupakan faktor yang mempengaruhi keberadaan air tanah, seperti kemiringan lereng, penggunaan lahan, jenis tanah, geologi, dan curah hujan. Hasil dari analisis yang telah dilakukan menunjukkan bahwa Kabupaten Gowa memiliki potensi air tanah yang tersebar pada setiap wilayah kecamatannya, dimana hal tersebut terbagi atas sejumlah tingkatan potensi ketersediaan air tanah dimulai dari tingkat sangat rendah, rendah, sedang, tinggi, dan sangat tinggi.

Kata Kunci: *Air tanah, Kabupaten Gowa, Sistem Informasi Geografi, Overlay*

INTRODUCTION

The needs of human life will continue to increase, including human needs for raw water resources. This is considering the function and role of water which is very important to human life. Raw water is often used in domestic use such as for bathing, washing, and so on. In addition, raw water is also used in industry, agriculture, and many others. One of the raw water sources that is often used comes from groundwater (Putra, 2018). Groundwater is water that occupies cavities in rock layers below the earth's surface or soil surface in a saturated state. Groundwater moves from the top layer of the soil surface into the soil through soil pores, rock pores, or rock cracks (Bisri, 2012; Baharuddin et al., 2023).

The presence of groundwater below the surface is not all at the same depth, but depends on the thickness of the surface layer above and the impermeable layer. About 97% of the total amount of fresh water on earth consists of groundwater that is below the earth's surface. There are a number of physical factors that are considered to affect the presence of groundwater in an area, including soil type, lithology, rainfall, slope, to land use (Sulaiman et al, 2017).

One of the problems that often occurs in Indonesia is the decline in the quantity and quality of raw water as a result of excessive exploitation of groundwater. Phenomena such as increasing population growth rates, increasingly massive industrialization, and expansion of agricultural areas make the need for raw water also continue to increase, causing excessive exploitation of groundwater. In addition, excessive exploitation of groundwater can also cause other phenomena such as land subsidence due to empty cavities in the ground that should be filled with water (Franto &; Gusa, 2018).

Gowa Regency is a regency in South Sulawesi Province which is included in the Jeneberang Watershed. Therefore, there are many streams in addition to the main streams that flow through this area. This makes most of the use of raw water by the people of Gowa Regency sourced from river water (Lestari, 2021). Based on data from the Central Statistics Agency (BPS) in 2020, this area has experienced an increase of around 11,300 inhabitants every year since 2010. This phenomenon certainly makes the community's need for raw water also increase every year.

Although there are many rivers as raw water sources, this does not mean that Gowa Regency does not experience water availability problems for the community. There are still many problems related to the availability of raw water in this area, one of which is what happened in Bontonompo District, which is one of the districts in Gowa Regency (Hamzar et al., 2021). The community in Bontonompo District, or more precisely in Bontonompo Village, experiences a deficit in the availability of raw water which is often used by the community due to the high demand for raw water every day. It is known that the main source of water used comes from river water through treatment by PDAM. Therefore, in facing these problems, the community began to dig wells to get groundwater as a source of water to meet their needs.

This phenomenon shows that raw water sources in Gowa Regency that can be utilized by the community do not only come from river water, but can also come from groundwater through digging or drilling wells. This also indicates that Gowa Regency has groundwater potential that really needs to be mapped to determine its distribution in each region. The hope is that areas that have groundwater potential can be explored so that they can be used as additional sources of raw water, so as to overcome community problems related to raw water needs. This analysis was then carried out to determine the potential of groundwater owned by each sub-district area in Gowa Regency using a Geographic Information System (GIS).

Mapping or zoning of groundwater potential owned by an area is generally carried out with the help of geoelectric techniques, namely by detecting rock layers and the condition of aquifer layers below the surface using a set of tools (Franto & Gusa, 2018). However, mapping in this way requires a fairly long process and can only cover a small area. So that this analysis was carried out using Geographic Information System (GIS) technology, which is an automatic method that is considered effective to be able to measure groundwater potential in a wide area coverage, in this case covering the entire area of Gowa Regency. Geographic Information Systems (GIS) provide thematic configurations that are able to process spatial data that are so complex, such as groundwater potential variable data, and only take a short time (Verma & Patel, 2021.

METHODOLOGY

Analysis of groundwater potential in Gowa Regency using a Geographic Information System (GIS) is carried out by overlay method or analysis of data from each parameter overlapping, producing a new data that is a combination of the parameter data. The variables in question are physical factors that can affect the potential presence of groundwater in an area, which include soil type, lithology, rainfall, slope, and land use (Sulaiman et al., 2017).

The analysis technique used is to use AHP (Process Hierarchy Analysis), or an analytical technique in the form of an approach by presenting relationships between certain factors, characteristics, or attributes of a data to solve complex problems (Kristanto et al., 2020). The analysis was conducted by determining the role of each variable in determining the potential of groundwater in Gowa District, by scoring each class of variables. The greater the role of a variable, it will have a large score on groundwater potential analysis.

The data needed in this analysis include: 1. Data on the Administrative Area of Gowa Regency District from the Geospatial Information Agency; 2. Geologic Map of Indonesia Ujung Pandang Sheet 1975; 3. Land Use Data of Gowa District by Geospatial Information Agency; 4. Gowa Regency Rainfall Data in 2011 – 2020 by BBWS Pompengan Jeneberang; 5. World Soil Type Data by USDA; and Digital Elevation Model (DEM) Data SRTM 30 m South Sulawesi in 2022. The stages of the implementation of this analysis activity are as follows:

1. Create a land use map of Gowa Regency with data sources derived from the processing of Gowa Regency land use data by BIG;
2. Make a slope map of Gowa Regency with data sources derived from the processing of DEM SRTM 30 meters South Sulawesi in 2020;
3. Create a soil type map of Gowa Regency with data sources derived from USDA processing of soil type data worldwide;
4. Make a rainfall map of Gowa Regency with data sources derived from the processing of BBWS Pompengan Jeneberang rainfall post data for 2011 – 2022.
5. Make a geological map of Gowa Regency with data sources derived from the Indonesian Geological Map Ujung Pandang Sheet Year 1975, Scale 1: 1,000,000.
6. After all parameter maps have been made, the next step is to score each class of variables that have been considered to affect the groundwater potential of an area.

Table 1 illustrates the variables and the scores that have been given in each class are contained in this research.

Table 1. Variable determination of groundwater potential

Variable	Criterion	Class	Score
Use	Jungle		5
Land	Shrubs		4
	Pond		3
	Meadow		3
	Plantation		3
	Paddy		3
	Rainfed rice fields		3
	Dam		3
	Fields/Fields		3
	Vacant Land		2
	Settlements and Places of Activity		1
Slope	0-8	Flat	5
Slope	8-15	Ramps	4
	15-25	A bit steep	3
	25-45	Steep	2
	>45	Very Steep	1
Soil type	Andisol		5
	Alfisol		4
	Entisol		3
	Inseptisol		2
	Ultisol		1
Rainfall	>3500	Very High	5
(mm)	3000-3500	Tall	4
	2500-3000	Keep	3
	2000-2500	Low	2
	<2000	Very Low	1
Geology	Alluvium deposits		3
	Marine sedimentary rocks		2
	Intermediate and alkaline igneous rocks		1
	Volcanic rocks		1
	Intrusive rocks		1

7. After scoring, the next step is to overlay the map which becomes a variable, to form an area unit to be able to see the groundwater potential in each unit of the area.
8. After overlaying, the next step is to calculate the total score of the overall groundwater potential variable in each unit area, using following 1.

   Total Score = (PL Score) + (KL Score) + (JT Score) + (CH Score) + (GL Score) (1)

   with PL is land use, CH is rainfall, JT is soil type, KL is slope, and GL is geology.

9. After calculating the total score, then a class division is carried out for groundwater potential, so that the level of groundwater potential owned by each region can be known. The division of groundwater potential classes is carried out by entering formula 2.

$$I = \frac{b-c}{k} \quad (2)$$

   with I is the large interval class, c is the number of lowest scores, b is number of highest scores, and k is number of desired classes.

Thus, the interval magnitude of each class of groundwater potential in each unit of area is interval 3, where the division of groundwater potential classes as shown in Table 2 (Sulaiman et al., 2017).

Table 2. Classification of groundwater potential

No.	Class	Class interval	Groundwater potential
1	I	≤ 9	very low
2	II	10 – 12	low
3	III	13 – 15	keep
4	IV	16 – 18	tall
5	V	≥ 19	very high

10. After class division, it can be known the potential of groundwater owned by each sub-district area in Gowa Regency, which is adjusted to the data of the sub-district administrative area in Gowa Regency by BIG. Finally, all maps that have been made are then given a layout in accordance with applicable cartographic rules.

RESULTS AND DISCUSSION

Land Use of Gowa District

Table 3 shows that Gowa Regency consists of a number of land uses, including jungles, grasslands, shrubs, rice fields, rainfed rice fields, plantations, moor/fields, dams, ponds, residential areas, to vacant land. Land use that dominates in the Gowa Regency area is jungle, rice fields, and fields as shown in figure 1.

Table 3. Percentage of land use of Gowa Regency

No.	Land Use	Area (km^2)	Percentage (%)
1	Jungle	539.17	30.35
2	Shrubs	327.60	18.44
3	Dam	0.48	0.03
4	Pond	0.88	0.05
5	Pasture	0.45	0.03
6	Plantation	27.89	1.57
7	Paddy	406.22	22.86
8	Rainfed rice fields	39.78	2.24
9	Fields/fields	379.76	21.37
10	Vacant land	7.93	0.45
11	Settlements and places of activity	46.56	2.61
	Total	1776.72	100

Source: *Data Analysis 2023*

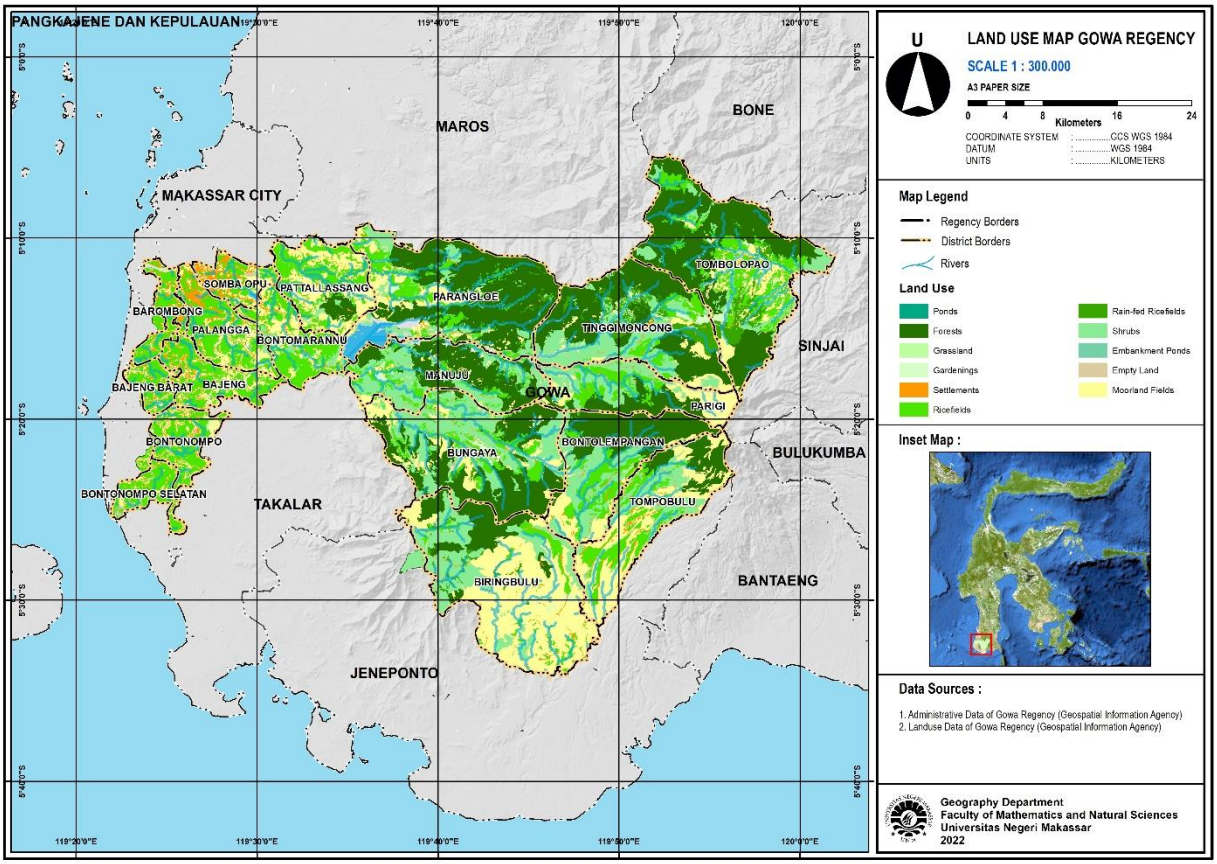

Figure 1. Land use map of Gowa district

The Slope of Gowa Regency

Table 4 shows that Gowa Regency consists of a number of areas with varying slopes, where there are flat areas (slopes 0 – 8%), gentle areas (slopes 8 – 15%), rather steep areas (slopes 15 – 25%), steep areas (slopes 25 – 45%), and very steep areas (slopes >45%). It can be seen that the area of Gowa Regency is dominated by areas with flat and gentle slopes, although some others are included in areas with slopes that are rather steep to very steep as shown in figure 2.

Table 4. Slopes in Gowa district

No.	Slope (%)	Area (km²)	Percentage (%)
1	0 - 8	477	26.80
2	8 - 15	250	14.02
3	15 - 25	350	19.63
4	25 - 45	396	22.25
5	>45	308	17.29
	Total	1781	100

Source: *Data Analysis 2023*

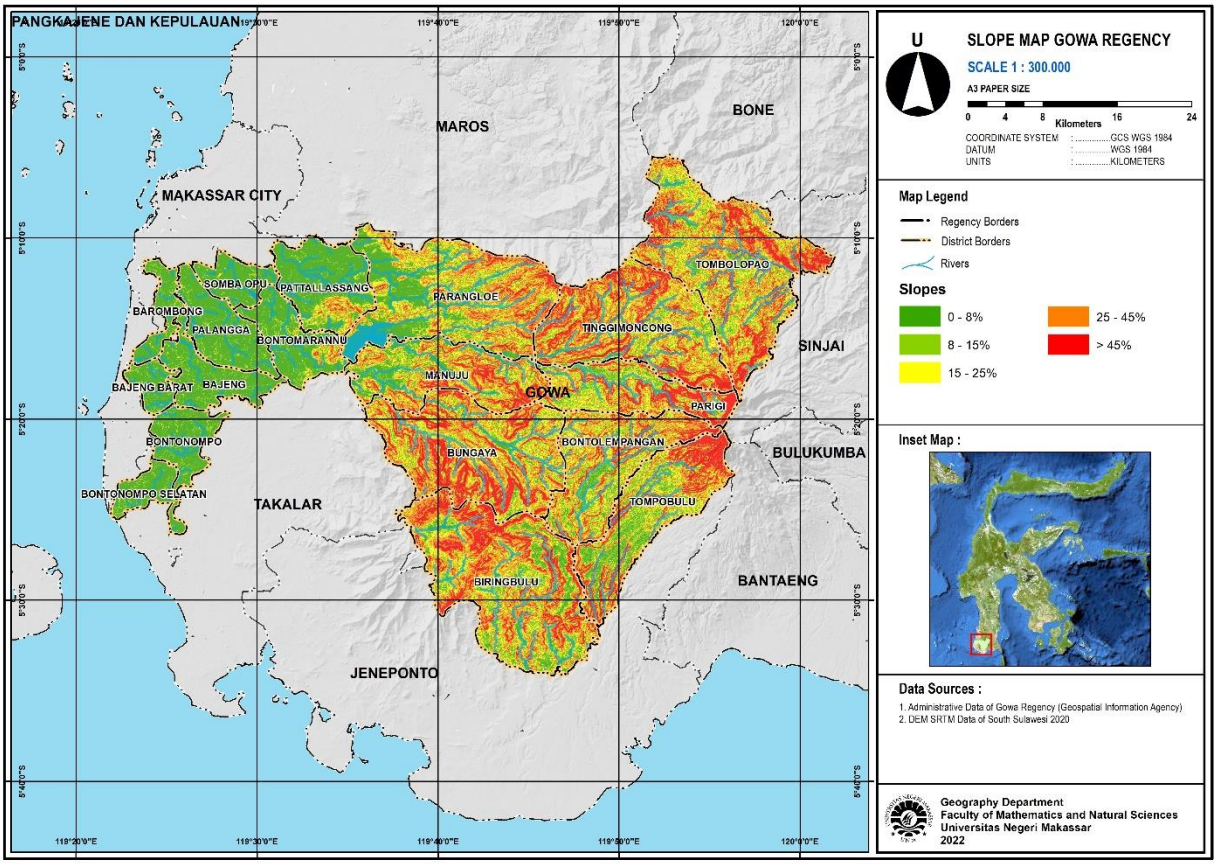

Figure 2. Gowa district slope map

Soil Type of Gowa Regency

Table 5 shows that Gowa Regency has various soil types, where according to the classification by USDA, the types of soil that can be found in Gowa Regency include Alfisol, Andisol, Entisol, Inseptisol, and Ultisol. The most common type of soil that can be found is the ultisol soil type, which spreads from north to south in the central district area as shown in figure 3.

Table 5. Soil type of Gowa district

No.	Soil type	Area (km²)	Percentage (%)
1	Andisol	123.671	6.91
2	Alfisol	274.209	15.32
3	Entisol	334.902	18.71
4	Inseptisol	329.748	18.42
5	Ultisol	727.869	40.65
	Total	1790	100

Source: *Data Analysis 2023*

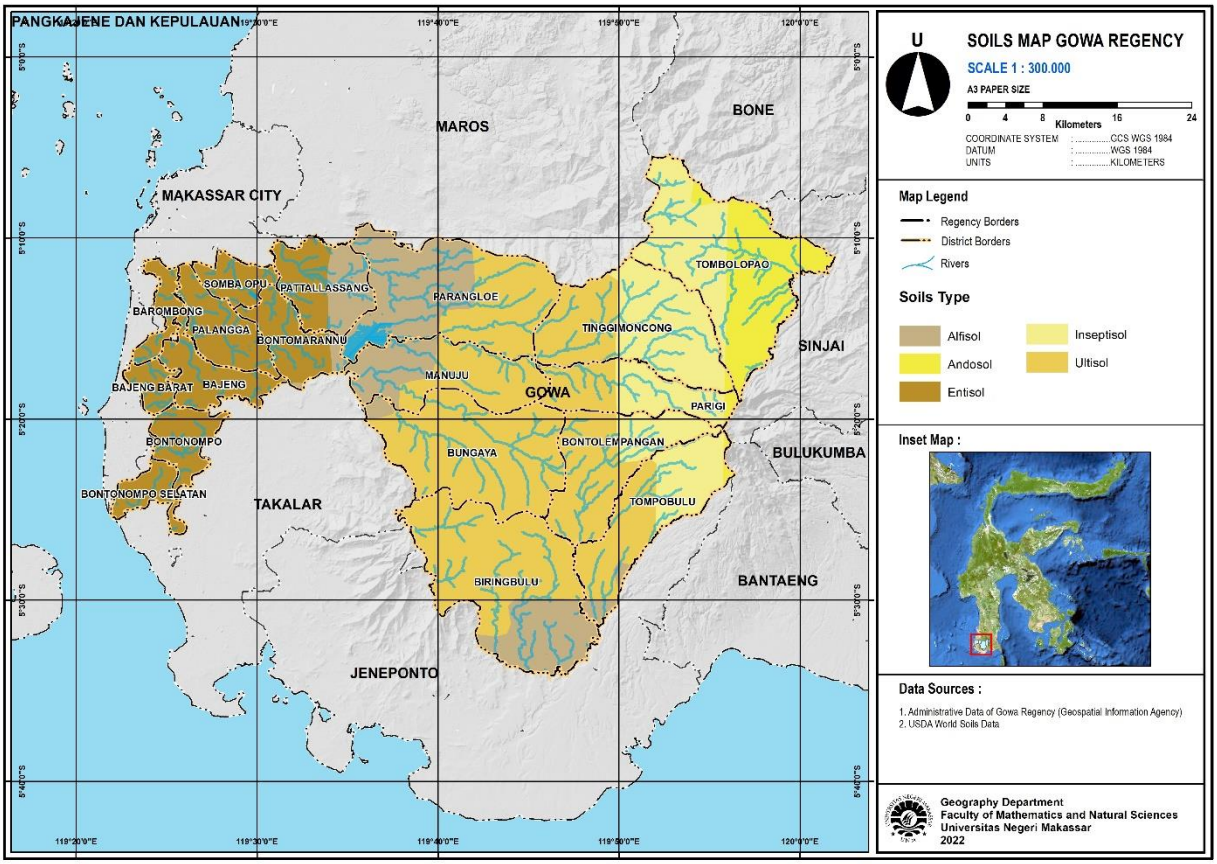

Figure 3. Gowa district soil type map

Gowa District Rainfall

Table 6 shows that Gowa Regency can also be said to have varying rainfall levels in various places, starting from low (2000 – 2500 mm) to very high (>3500 mm) levels. This level of rainfall can be known after going through the process of interpolating rainfall data from 6 observation stations, including Malino Station, Sapaya Station, Tamanyeleng Station, Senre Station, Kampili Station, and Palekko Station. Gowa Regency is dominated by areas with high rainfall levels or around 3000 to 3500 mm/year as shown in figure 4.

Table 6. Rainfall of Gowa Regency

No.	Rainfall (mm/year)	Broad (km^2)	Percentage (%)
1	2000 - 2500	375.63	20.99
2	2500 - 3000	528.03	29.48
3	3000 - 3500	708.77	39.59
4	> 3500	178.4	9.94
	Total	1791	100

Source: *Data Analysis 2023*

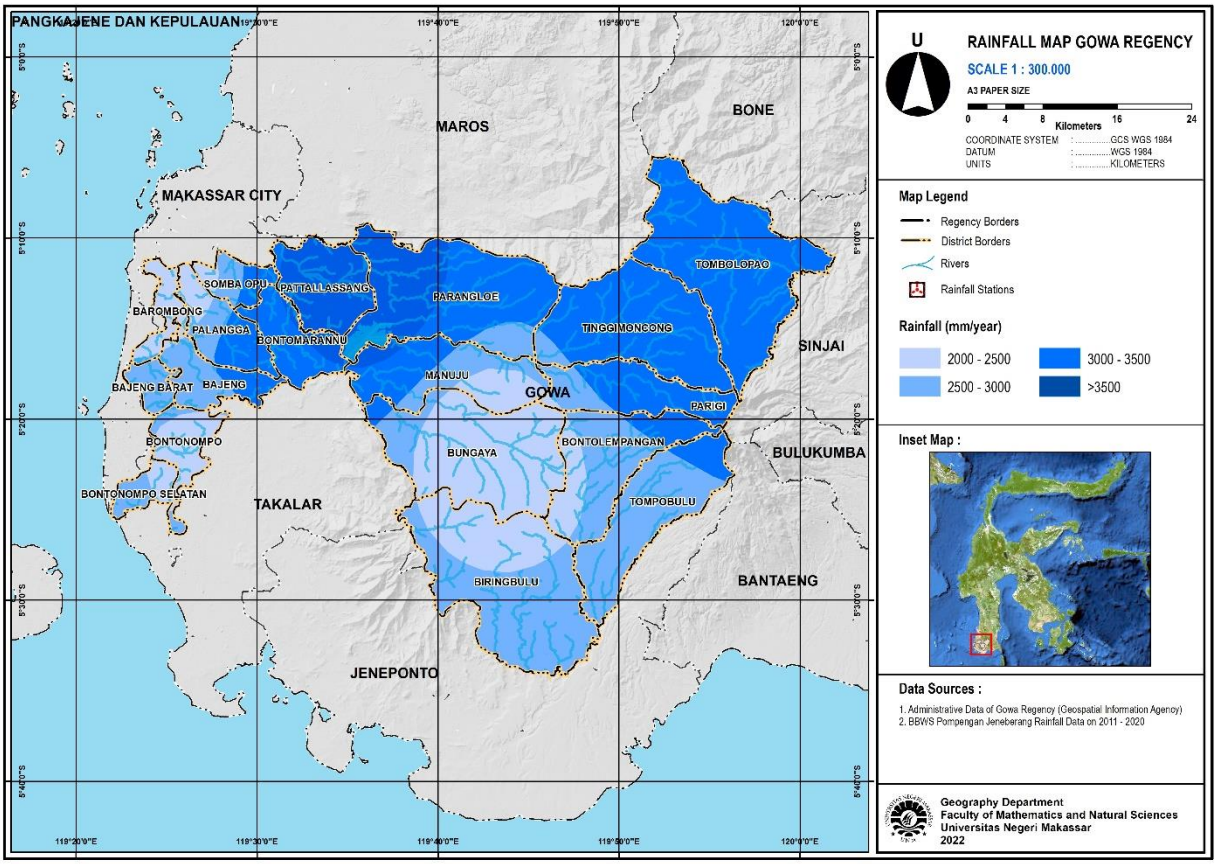

Figure 4. Gowa district rainfall map

Geology in Gowa Regency

Table 7 shows that the geologically, a number of rock types or geological formations can be found in Gowa Regency which include intermediate and alkaline igneous rock formations, then Baturappe-Cindako volcanic rock formations, intrusive igneous rock formations, marine sedimentary rock formations, to alluvium deposit formations. The type of geology that dominates in Gowa Regency is igneous rock formations, intermediates, and bases as shown in figure 5.

Table 7. Geological formations of Gowa district

No.	Geologic Formations	Area (km²)	Percentage (%)
1	Alluvium deposits	304.66	17.02
2	Marine sedimentary rocks	55.27	3.09
3	Intermediate and alkaline igneous rocks	929.53	51.92
4	Volcanic rocks	491.03	27.43
5	Intrusive rocks	9.92	0.55
	Total	1790	100

Source: *Data Analysis 2023*

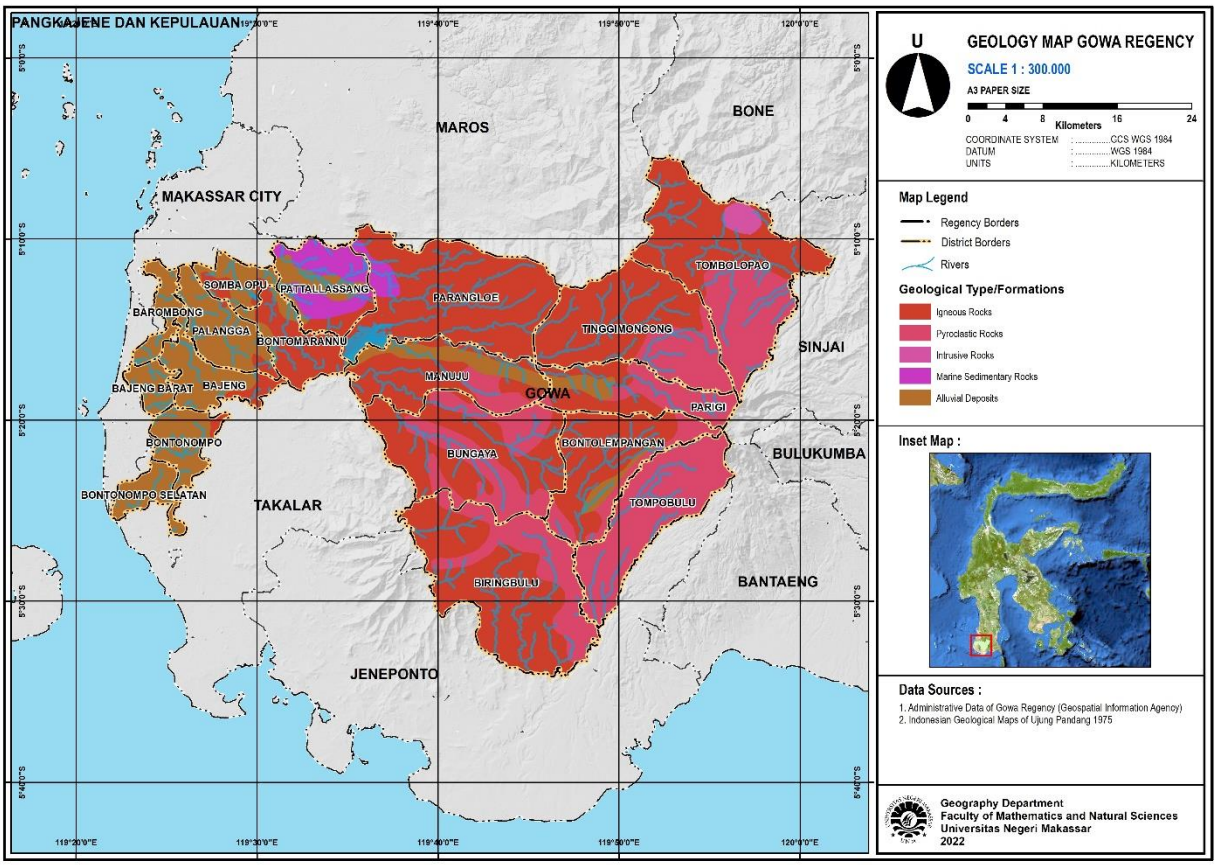

Figure 5. Geologic map of Gowa district

Groundwater Potential of Gowa Regency

Table 8 shows that the groundwater potential in Gowa Regency is then spread and divided into a number of classes, namely very low groundwater potential, low groundwater potential, medium groundwater potential, high groundwater potential, to very high groundwater potential. Most areas in Gowa Regency have a moderate level of groundwater potential. Areas that have moderate groundwater potential have a percentage of 45.35% of the total existing groundwater potential, or there are about 793.83 square kilometers of areas that have moderate groundwater potential as shown in figure 6.

Table 8. Groundwater potential of Gowa district

No.	Groundwater Potential	Area (Km²)	Percentage(%)
1	Very low	77.64	4.44
2	Low	530.89	30.33
3	Keep	793.83	45.35
4	Tall	331.72	18.95
5	Very high	16.28	0.93
	Total	1750	100

Source: *Data Analysis 2023*

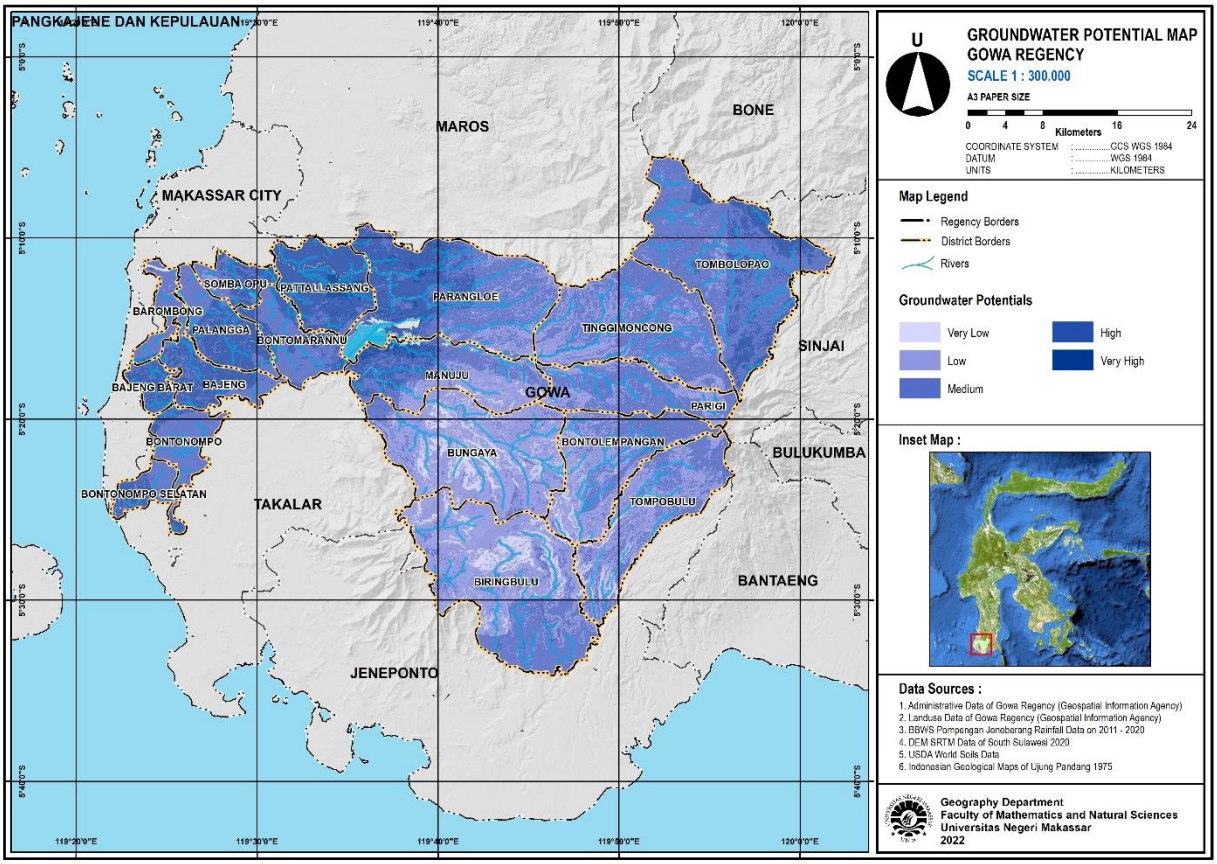

Figure 6. Map of groundwater potential of Gowa district

Gowa Regency is an area included in the Jeneberang Watershed, so there are many rivers along its territory. The number of river flows is used by the community, one of which is as a source of raw water that is often used in daily life. However, that does not mean that water sources in Gowa Regency can only come from river water, but there are also other sources such as groundwater.

Gowa Regency also has the potential for the existence of groundwater in each region. Through the groundwater potential map that has been made, it can be seen that each region, especially the sub-district area, each has a different level of groundwater potential. Based on the results of the analysis that has been carried out, it has been found that Gowa Regency as a whole has moderate groundwater potential, it is proven that 45.35% of the total area of Gowa Regency or around 793.83 Km2 has moderate groundwater potential. The areas with high to very high groundwater potential have a percentage of 19.88%, while areas with low to very low groundwater potential have a percentage of 34.77% of the total area. So that the tendency of the existence of groundwater in Gowa Regency is in a low to medium level. It can be seen that areas that include very high to high groundwater potential are in Pattallassang District, then areas with high to medium groundwater potential are spread in Somba Opu, Pallangga, Bajeng, West Bajeng, Bontonompo, South Bontonompo, Parangloe, Tombolo Pao, and Manuju Districts. Areas with groundwater potential are currently in the Barombong District, then areas with medium to low groundwater potential are spread in the Tinggimoncong and Parigi Districts, and the last is an area with low to very low groundwater potential spread in the Bungaya, Biringbulu, Tompobulu, and Bontolempangan areas.

Land Use

Land use is the first factor to consider in conducting an analysis of groundwater potential in Gowa District. Gowa District land use maps can be generated by utilizing Gowa Regency land use data by the Geospatial Information Agency. Based on the results of the analysis that has been carried out, it can be seen that Gowa Regency is dominated by land use in the form of jungle forests with an area of 539.7 km2 or 30.35% of the total land use in Gowa Regency.

Land use greatly affects the potential of groundwater in Gowa Regency, because land use affects the infiltration capacity owned by each land unit (Wijaya &; Purnama, 2018). For example, the use of residential land will have a low infiltration capacity, because with settlements, the existing surface material will automatically become impermeable to water. So that the score given is also low for land use in the form of settlements. In contrast to types of land use such as forest forests that easily infiltrate, so they are given a high score or very influential on the potential existence of groundwater.

Slope

Slope is the next factor considered in analyzing groundwater potential in Gowa Regency. Slope Slope Maps can be produced by utilizing DEM SRTM data with a resolution of 30 meters for South Sulawesi Province. Based on the slope map, it can be seen that Gowa Regency is an area that has wavy topography, with varying slopes. Gowa Regency is dominated by areas with gentle slopes with an area of 477 Km2 or a percentage of 26.8% of the total area in Gowa Regency. It can be seen that the further east you go, the more dominated it will be by areas with slightly steep to very steep slopes.

Slope is considered in analyzing the potential presence of groundwater, because it can also influence the level of infiltration that occurs, where in areas with flat or gentle slopes the level of infiltration will also be higher, so the potential for groundwater presence is also high (Masitoh et al, 2021). Based on this statement, areas with steep to very steep slopes have the potential for low groundwater because the infiltration level is also low.

Soil Type

The next factor considered in analyzing groundwater potential in Gowa Regency is soil type. Soil type maps can be produced by utilizing world soil type data by the United States Department of Agriculture (USDA). Based on the soil type map, it can be seen that Gowa Regency has various soil types, starting from alfisol, ultisol, inseptisol, entisol and andisol soil types. Gowa Regency itself is dominated by ultisol soil with an area of 727,869 Km2 or a percentage of 40.65% of the total area in Gowa Regency.

Soil type can influence the presence of groundwater in an area, because we know that soil is the first medium through which surface water passes, which can come from surface flow itself or from precipitation. Different types of soil will cause the soil properties to also differ, where each condition of the soil properties will also provide a different response or influence on the presence of ground water (Pratama et al, 2018). The different soil properties referred to include the infiltration capacity of the soil, as well as the soil's ability to store water. Soil types such as andisol can have a high influence on the potential for groundwater, because the texture of andisol soil is characterized by a high dust content, so it has good infiltration capabilities (Juarti, 2016). Therefore, areas dominated by andisol soil types have a high influence on the potential for groundwater in Gowa Regency.

Rainfall

As one part of the hydrological cycle on the earth's surface, rainfall is also a factor to be considered in analyzing groundwater potential in Gowa Regency. Rainfall maps can be produced using the isohyet method, by utilizing rainfall data from measurements from 6 observation stations by BBWS Pompengan Jeneberang. Based on the rainfall map, it can be seen that Gowa Regency has varying levels of rainfall, starting from low rainfall (2000 – 2500 mm) to very high (>3500 mm). Around 39.59% of the area in Gowa Regency or around 708.77 Km2 has high levels of rainfall and dominates the entire area of this district.

Rainfall has an important role in the availability of groundwater in a particular area or land unit. If the rainfall is higher, the potential for groundwater availability in an area will also be high, because the capacity of the water source, namely rainwater, is also large. If rainfall is low, then the potential for groundwater will also be low (Rahmadani et al, 2018).

Geological Conditions

The final factor considered in analyzing groundwater potential in Gowa Regency is geological conditions. A geological map can be produced by digitizing the Indonesian Geological Map, Ujung Pandang Sheet, Scale 1: 1,000,000 in 1975. Based on this geological map, it can be seen that Gowa Regency consists of varied types of geology, starting from alluvium deposits, the Baturappe-Volcano rock formations. Cindako, intermediate and alkaline igneous rock formations, and marine sedimentary rock formations, as well as intrusive rock formations. Gowa Regency itself is dominated by intermediate and alkaline igneous rock geology with an area of 929.53 Km2 or a percentage of 51.92% of the total area in Gowa Regency.

Geological conditions will have an influence on the potential presence of groundwater, because lithology or rock characteristics can influence the rate of infiltration by contributing to grain size, porosity-permeability, and clay minerals in the soil (Yangga & Budianta, 2016). The type of geology in the form of alluvium deposits can have a big influence on the potential for groundwater in Gowa Regency. This is because alluvium deposits consist of mud, sand and gravel which are loose materials, and are generally located in areas of flood runoff and riverbanks. Geological conditions in deposit areas generally have a high level of porosity, due to the variety of materials carried by river currents. High porosity will cause the level of infiltration in the area to be higher, thus affecting the presence of ground water (Sulaiman et al, 2017).

CONCLUSION

Through the results of this analysis, it can be concluded that Gowa Regency has the potential for groundwater to be at a moderate level, and spread throughout its territory. There are a number of things that can influence the presence of groundwater, such as land use, slope slope, soil type, rainfall, and geological conditions. So the hope is that areas that have high groundwater potential can use groundwater as an alternative source of raw water supply apart from river water.

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REFERENCES

Baharuddin, I. I., Badwi, N., & Zhiddiq, S. (2023). Analisis potensi air tanah di kabupaten Gowa Provinsi Sulawesi Selatan. In *Prosidibg Seminar Nasional Dies Natalis 62* (Vol. 1, pp. 174-180). https://doi.org/10.59562/semnasdies.v1i1.761.

Bisri, M. (2012). *Air Tanah*. Malang: Universitas Brawijaya Press.

Franto, F., & Gusa, R. F. (2018). Pemetaan zonasi akuifer air tanah untuk sumber air bersih masyarakat desa Balunijuk. *PROMINE, 1*(1), 1-14. https://doi.org/10.33019/promine.v1i1.65.

Hamzar, H., Suprapta, S., & Arfan, A. (2021). Analisis kualitas air tanah dangkal untuk keperluan air minum di kelurahan Bontonompo Kecamatan Bontonompo Kabupaten Gowa. *Enviromental Science*, *3*(2), 150-159. http://dx.doi.org/10.35580/jes.v3i2.20048.

Juarti, J. (2024). Analisis indeks kualitas tanah andisol pada berbagai penggunaan lahan di Desa Sumber Brantas Kota Batu. *Jurnal Pendidikan Geografi: Kajian, Teori, dan Praktek dalam Bidang Pendidikan dan Ilmu Geografi*, *21*(2), 58-71. https://doi.org/10.17977/um017v21i22016p058.

Kristanto, W. A. D., Astuti, F. A., Nugroho, N. E., & Febriyanti, S. V. (2020). Sebaran daerah sulit airtanah berdasarkan kondisi geologi daerah perbukitan kecamatan Prambanan, Sleman, Yogyakarta. *Jurnal Sains & Teknologi Lingkungan*, *12*(1), 68-83. https://doi.org/10.20885/jstl.vol12.iss1.art6.

Lestari, A. S. P. I. (2021). Analisis beban pencemaran di sungai jeneberang Kabupaten Gowa Provinsi Sulawesi Selatan. *Teknosains: Media Informasi Sains dan Teknologi*, *15*(2), 144-150. https://doi.org/10.24252/teknosains.v15i2.17715.

Masitoh, F., Rusydi, A. N., & Pratama, I. D. (2021). Pendekatan hidrogeomorfologi dan pendugaan geolistrik untuk identifikasi potensi airtanah di Jedong Malang. *Jambura Geoscience Review*, *3*(2), 84-96. https://doi.org/10.34312/jgeosrev.v3i2.10252.

Pratama, I. A., Sukmono, A., & Firdaus, H. S. (2018). Identifikasi potensi air tanah berbasis pengindraan jauh dan sistem informasi geografis (studi kasus: kabupaten Kendal). *Jurnal Geodesi Undip*, *7*(4), 55-65. https://doi.org/10.14710/jgundip.2018.22408.

Putra, A. R. (2018). *Analisis potensi air tanah pada cekungan air tanah brantas*. Tesis. Fakultas Teknik Sipil, Lingkungan, dan Kebumian. Surabaya : Institut Teknologi Sepuluh Nopember

Rahmadani, H. N., Azani, A. A., & Rejeki, H. A. (2019). Distribusi temporal curah hujan dan ketersediaan air tanah periode 2000 – 2010 (studi kasus: stasiun meteorologi susilo sintang dan stasiun meteorologi maritim Bitung). *Jurnal Seminar Nasional Geomatika, 7*(2), 473 – 482.

Sulaiman, Sutirto, & Lembang, R. (2017). Pemetaan potensi air tanah menggunakan penginderaan jauh dan sistem informasi geografis di kota Kupang. In *Prosiding Seminar Nasional Seri 7: Menuju Masyarakat Madani dan Lestari (Diseminasi Hasil-hasil Penelitian)*, 531 – 546.

Wijaya, K. A., & Purnama, I. L. S. (2018). Kajian kerentanan airtanah terhadap potensi pencemaran di kecamatan kasihan kabupaten Bantul. *Jurnal Bumi Indonesia*, *7*(1), 1 – 14.

Verma, N., & Patel, R. K. (2021). Delineation of groundwater potential zones in lower Rihand River Basin, India using geospatial techniques and AHP. *The Egyptian Journal of Remote Sensing and Space Science*, *24*(3), 559-570. https://doi.org/10.1016/j.ejrs.2021.03.005.

Yangga, T. A., & Budianta, W. (2016). Pengaruh karakteristik litologi terhadap laju infiltrasi, studi kasus daerah ngalang dan sekitarnya, Kecamatan Gedangsari, Kabupaten Gunung Kidul, Daerah Istimewa Yogyakarta. *In Seminar Nasional Kebumian Ke – 9*.