ISSN 3032-1220
The Southeast Asian Journal of Advance Engineering and Technology *Original Research*
Vol. 1, No. 2, March 2024, pp.42-49

Identification of Groundwater Potential Based on Remote Sensing and Geographic Information Systems in The City of Padang

Wahyu Pratama[1], Dwi Marsiska Driptufany[1], Defwaldi[1], Fajrin[1], Ilham Armi[1]
[1] Geodetic Engineering Study program, Institut Teknologi Padang, Indonesia

Corresponding Author:

Dwi Marsiska Driptufany
Geodetic Engineering Study Program, Padang Institute of Technology, Aie Pacah, Kec. Koto tangah, Padang, Sumatera Barat 25586

E-mail:
dwidayana@gmail.com

ABSTRACT

Water is a basic need for living creatures, including humans. The need for water can be obtained from various sources, including rainwater, surface water, or groundwater. The estimated quantity and distribution of water on Earth is 97% of the water on Earth is in the sea the remaining 1.7% is at the Earth's poles in the form of ice, 1.7% is underground water and only 0.1% is as water. surface and atmosphere. Padang City still lacks clean water because Padang City PDAM water often experiences problems. So many people use drilled wells or dug wells. Therefore, it is very necessary to identify groundwater in Padang City. Identification of Padang City's groundwater potential in this research uses Remote Sensing data and Geographic Information Systems. The Geographic Information System application is used to identify groundwater potential through overlaying a tiered quantitative method on the parameters of vegetation density, land cover, soil texture, rock type, rainfall, and slope to obtain the distribution of groundwater potential. The results of this research show that the groundwater potential in Padang City consists of several classes, namely no potential, low, medium, and high. Groundwater potential in Padang City is dominated by low groundwater potential covering an area of 37,369,903 Ha, medium area covering an area of 25,159,745 Ha, high potential covering an area of 7,493.06 Ha and no potential area covering an area of 113,030 Ha. Based on validation using data from 59 drilled wells in Padang City which was overlaid with a groundwater potential map for Padang City, it was found that 11 (18.65%) drilled wells were not suitable and 48 (81.35%) drilled wells were suitable.

Keywords: Groundwater, GIS, Remote sensing, Potential

1. Introduction

Water is a basic need for living creatures, including humans. The need for water can be obtained from various sources, including rainwater, surface water, or groundwater [1], [2], [3]. Estimation of quantity and distribution of water on earth: 97% of the water on earth is in the sea and the remaining 1.7% is in the earth's poles in the form of ice, 1.7% is in the form of underground water and only 0.1% is in the form of surface water and atmosphere [4], [5], [6]. Groundwater is any type of water that flows beneath the outer layer of soil due to the construction of topographic layers, differences in soil moisture potential, and the earth's gravitational force [7]. Water demand always increases in proportion to population growth. Groundwater is a renewable natural resource (NDR) which now plays an important role in providing water for various needs, thereby causing changes in the value of groundwater itself [8], [9], [10], [11]. Historically, groundwater was a free and economic commodity, meaning it was traded as other commodities and even in some areas had a strategic role. Limited water supply to fulfil needs becomes a trigger for social conflict in society [12], [13], [14].

Padang City is different from other cities in Indonesia, the difference is that Padang City still has extensive agricultural land and vegetation There are also many more, and the Padang City area is an area consisting of lowlands and plains tall [15], [16]. However, Padang City still lacks clean water, because Padang City PDAM water is often used to experience interference. So many people use drilled wells or dug wells. Therefore, it is very necessary to identify groundwater in Padang City.

2. Research methodology

The type of research method used in this research is a tiered quantitative method. This tiered quantitative method provides the same value for each component used in the analysis. Each component is given the same value for analysis, assuming each component has the same influence on the object being analyzed. This approach includes limiting factors for each parameter that make it up [17], [18], [19]. These limits are not absolute but are divided into several levels each of which has levels and stages.

3. Results and discussion

3.1 Groundwater Potential Parameters

1) Vegetation Density

The vegetation density of Padang City varies. This vegetation density map was created using NDVI (Normalized Difference Vegetation Index) analysis. The density of vegetation with dense description is mostly found in the eastern and southern parts of Padang City because these areas are dominated by forests which allows for high groundwater potential in these areas. Meanwhile, vegetation density with very rare information is mostly found in the western part of Padang City, because it is a community residential area which means the groundwater potential in this area is low. The vegetation density of Padang City can be seen in Figure 1.

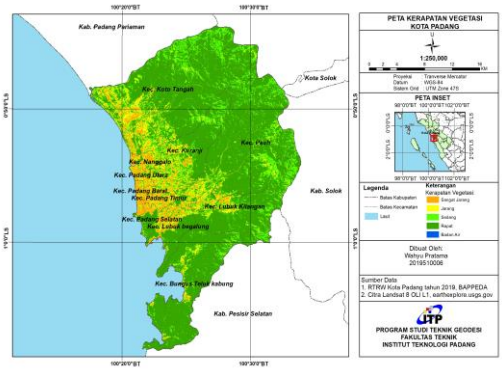

Figure 1. Vegetation density map Padang city

Table 1. Vegetation density classification and score

NDVI Index Class	Score	Vegetation Density	Area (Ha)	Percentage (%)
-0,03 sd 0,15	1	Very Rarely	4.518,763	6,4%
0,15 sd 0,25	2	Rarely	6.278,371	9%
0,26 sd 0,35	3	Currently	11.541,680	16%
0,36 sd 1	4	Closely	47.726,934	68%
-1 sd -0,03	5	Water Body	69,939	0,1%
Amount			70.135,68	100%

2) Land Cover

The land cover of Padang City has an important role in determining groundwater potential. Land cover can influence the rate of water absorption and regulate the speed of rainwater infiltration. The land cover of the eastern and southern parts of Padang City is still dominated by forest areas and agricultural land so that plant roots will retain water which allows the groundwater potential in these areas to be low. Meanwhile, land cover in the western part of Padang City is dominated by built-up land, so it can influence groundwater recharge by

increasing runoff during rain, which allows for high groundwater potential in the area. The land cover of Padang City can be seen in Figure 2.

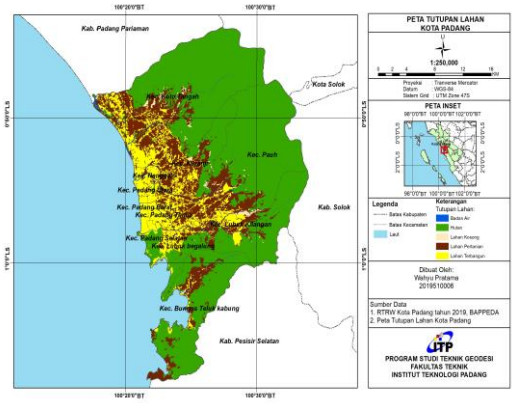

Figure 2. Land cover map Padang city

Table 2. Land cover classification and score

Land Cover Class	Score	Area (Ha)	Percentage (%)
Forest	1	45.449,719	64,8%
Agricultural Land	2	13.905,768	19,8%
Water Body	3	559,234	0,8%
Built-up Land	4	9.552,489	13,6%
Empty Land	5	668,475	1%
Amount		70.135,68	100%

3) Soil Texture

The soil texture in Padang City consists of clay, gravelly clay sand, sandy clay and clay/silty clay/clay. The dominant soil texture in Padang City is clay, this soil texture is found in the eastern part of Padang City. Then, in the western part of Padang City, the soil texture is dominated by sandy clay and gravel. The soil texture of Padang City can be seen in Figure 3.

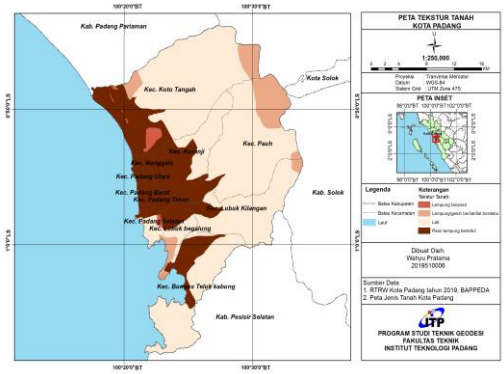

Figure 3. Soil texture map Padang city

Table 3. Soil texture classification and score

Land Cover Class	Score	Area (Ha)	Percentage (%)
Gravelly Clay Sand	5	16.750,756	1%
Sandy Loam	3	695,742	8%
Clay Loam/Dusty Clay	2	5.578,58	67%
Clay	1	47.110,603	24%
Amount		70.135,68	100%

4) Rock Type

Rock type is an important factor in determining the groundwater potential of an area. Sedimentary rocks are considered to have high groundwater potential due to their high porosity and permeability. This type of rock is found in the western part of Padang City. Igneous rocks have moderate groundwater potential, due to standard porosity and permeability. This type of rock is found in the eastern part of Padang City. The rock types of Padang City can be seen in Figure 4.

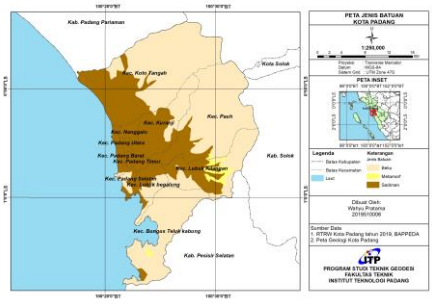

Figure 4. Rock-type map Padang city

Table 4. Rock-type classification and score

Rock Type Class	Score	Area (Ha)	Percentage (%)
Sediment	5	22.785,948	32,5%
Igneous	3	46.201,112	66%
Metamorphic Rock	1	1.148,625	1.5%
Amount		70.135,68	100%

5) Slope

The groundwater potential identifier considers the level of slope or slope of an area because it influences the size of the surface's absorption capacity for rainwater. Slopes in Padang City include all slope classes, namely flat, gentle, slightly steep, steep, and very steep slopes. The eastern part of Padang City is dominated by very steep slopes because the area is hilly. Meanwhile, the western part of Padang City is dominated by flat slopes, so water will quickly be absorbed into the ground. The slope of Padang City can be seen in Figure 5.

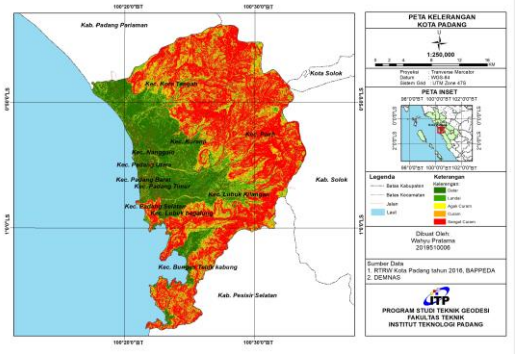

Figure 5. Slope map Padang city

Table 5. Slope classification and score

Slope Class	Score	Information	Area (Ha)	Percentage (%)
0 – 8%	5	Flat	15.575,908	22,2%
8 – 15%	4	Sloping	6.940,517	9,9%
15 – 25%	3	A bit Steep	7.700,373	11%
25 – 40%	2	Steep	12.148,528	17,3%
>40%	1	Very Steep	27.770,357	39,6%
Amount			70.135,68	100%

6) Rainfall

Rainfall is an important factor that influences groundwater potential in an area. Rain is the main source of water in the hydrological cycle. The rainfall map for Padang City was created using monthly rainfall data for the year 2022. In 2022, almost the entire area of Padang City will have low rainfall intensity. Areas with moderate rainfall intensity are only found in several sub-districts in Padang City. Meanwhile, areas with high rainfall intensity are only found in one sub-district with a very small area. Padang City's rainfall can be seen in Figure 6.

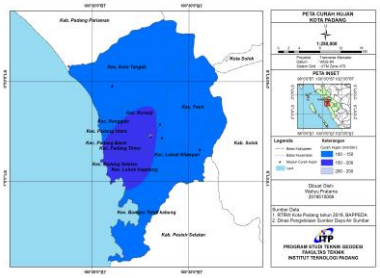

Figure 6. Rainfall map Padang city

Table 6. Padang city rainfall data

Station	x	y	Amount ch/year	Average ch/year	Average ch/month
Batu Busuk	100.45	-0.90467	4536	378	149
Gunung Nago	100.4344	-0.92451	6044	503.666	202
Ladang Padi	100.5188	-0.94692	4585	382.083	150
Simpang Alai	100.4537	-0.92731	3038	253.166	100
Koto Tuo	100.3676	-0.84024	3856	321.333	125

Table 7. Rainfall classification and score

Rainfall Class	Score	Area (Ha)	Percentage (%)
100 - 150	2	58.574,959	83,5%
150 - 200	3	11.537,918	16,4%
200- 250	4	22,808	0,1%
Amount		70.135,68	100%

3.2 Analysis of groundwater potential

The analysis of Padang City's groundwater potential is the result of an overlay of all groundwater potential parameters. Then it is classified into four classifications of groundwater potential, namely no potential, low, medium, and high. Low groundwater potential is mostly found in the eastern part of Padang City. Medium groundwater potential is mostly found in the western part of Padang City. Most of the high groundwater potential is found in the central area of Padang City. The groundwater potential map of Padang City can be seen in Figure 7.

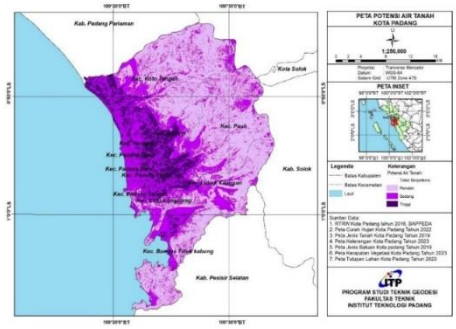

Figure 7. Groundwater Potensial Map Padang City

Table 8. Distribution of Groundwater Potential in Padang City

Subdistrict	Ground Water Potential (Ha)				Area (Ha)
	High	Current	Low	Not Potential	
Kec. Pauh	879,192	4.005,468	11.066,202	14,74	15.965,602
Kec. Bungus Teluk kabung	448,796	3.370,531	5.868,682	5,334	9.693,343
Kec. Koto Tangah	2.464,06	7.343,934	12.318,713	46,302	22.173,009
Kec. Kuranji	2.000,974	2.451,634	2.008,004	5,047	6.465,659
Kec. Lubuk begalung	498,557	1.677,044	626,476	0,079	2.802,156
Kec. Lubuk Kilangan	319,718	2.983,462	5.117,893	40,623	8.461,696
Kec. Nanggalo	404,164	549,934	0,185	0	954,283
Kec. Padang Timur	220,78	697,647	0,1	0	918,527
Kec. Padang Utara	152,297	685,208	3,238	0	840,743
Kec. Padang Barat	28,062	510,236	5,295	0	543,593
Kec. Padang Selatan	76,46	884,647	355,115	0,905	1.317,127
Amount (Ha)	7.493,06	25.159,745	37.369,903	113,030	70.135,68

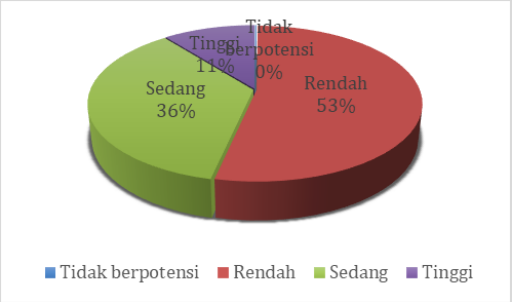

Figure 8. Percentage of groundwater potential area of Padang city

From the table and pie graph, the highest class of groundwater potential in Padang City is low groundwater potential, namely 37,369,903 Ha or 53%, medium groundwater potential, namely 25,159,745 Ha or 36%, high groundwater potential, namely 25,159,745 Ha or 36%. 7,493.06 Ha or 11%. Non-potential groundwater potential is 113,030 Ha or 0.16%.

3.3 Validation

Validation of this groundwater potential analysis uses drilled well data in Padang City. There are 59 drilled wells in Padang City. The results of the groundwater potential analysis are overlapped with the drilled well data to see the suitability and position of the points according to the groundwater potential class. The following is a picture of the results of overlapping analysis of groundwater potential with drilled well points in Padang City.

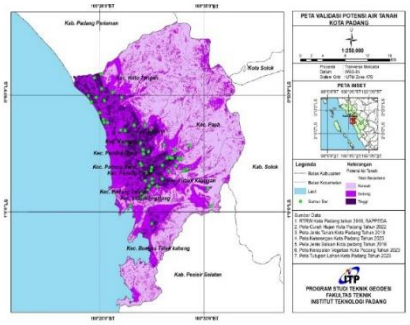

Figure 9. Groundwater Potential Validation Map Padang City

Based on the validation test results, the validation results obtained match the drilled well potential class and the processed groundwater potential class, namely: 48 or 81.35% of drilled wells match the processed groundwater potential class, and 11 or 18.65% of drilled wells do not. Following the potential class of groundwater resulting from processing. The cause of inappropriate potential classes is due to the influence of rainfall. Based on the 2022 Padang City rainfall map, Padang City rainfall is dominated by low rainfall and there is no high score (very influential) in the classification of Padang City rainfall in 2022, thus influencing the results of making a groundwater potential map.

4. Conclusions

The distribution of groundwater potential in Padang City includes various types of groundwater potential, namely non-potential, low, medium, and high classes. Areas without groundwater potential are spread across 7 sub-districts of Padang City. Areas with low to high groundwater potential are spread across all areas of Padang City. After processing, the results showed that areas with no groundwater potential had an area of 113,030 Ha, areas with low groundwater potential had an area of 37,369,903 Ha, areas with medium groundwater potential had an area of 25,159,745 Ha and areas with high groundwater potential had an area of 7,493.06 Ha. Ha. Validation results of the suitability between the drilled well potential class and the processed groundwater potential class, namely: 48 or 81.35% of drilled wells match the processed groundwater potential class, and 11 or 18.65% of drilled wells do not match the class potential groundwater resulting from processing.

References

[1]. Adji, Tjahyo Nugroho, and Eko Haryono. 2004. "BY: Eko Haryono." Faculty Geography of Gadjah Mada University (October 2004).
[2]. Aftriana, Careca Virma, Satyanta Parman, and Tjaturahono Budi Sanjoto. 2013. “Analysis of Changes in Vegetation Density in Semarang City Using Applications Remote Sensing.” Geo Image (Spatial-Ecological-Regional) 2(2): 14–22.
[3]. Bokings, Siti Farhah. 2020. “River Flow Balance Analysis.” Journal of Scientific Civilization, Engineering, and Technology 4(1): 28–37.
[4]. Ciptaningtyas, Drupadi, and Herry Suhardiyanto. 2016. “Thermo-Physical Properties of Charcoal Husk." Journal of Technology 10(2): 1–6.
[5]. Efendi, Rahmat. 2018. "Regional Water Balance Study Due to Water Extraction."
[6]. Eni. 1967. “No Title No Title No Title.” Angewandte Chemie International Edition, 6(11), 951–952. (Mi): 5–24.
[7]. Harmayani, Kadek Diana, and IGM Konsukartha. 2007. “Consequences of Ground Water Pollution Disposal of Domestic Waste in Slum Environments.” Settlement Journal Natah 5(2): 62–108.
[8]. Ifan Adi Pratama, Abdi Sukmono, Hana Sugiastu Firdaus. 2016. “Potential Identification Groundwater Based on Remote Sensing and Geographic Information Systems (Study Case: Kendal Regency).” 5: 122–31.
[9]. Muchlis, Muchlis, Paramita Dwi Sukmawati, Arie Noor Rakhman, and Thomas Budi Antony. 2021. “Distribution of Groundwater Salinity in Dukuhseti District Pati Regency.” Journal of Technology 14(1): 83–90.
[10]. Mukrimaa, Syifa S. et al. 2016. “No Title.” Journal of School Teacher Education Research Elementary 6(August): 128.
[11]. Nugroho, Jalu Tejo, Cici Nurmalasa Sari, and Arief Laila Nugraha. 2022. “Identification Groundwater Potential Zone Based on Geographic and Analytical Information Systems Hierarchy Process (Case Study: Yogyakarta Special Region Province).” Ellipsoids: Journal of Geodesy and Geomatics 5(1): 9–15.
[12]. Nurfaika, Nurfaika. 2021. “System-Based Shallow Groundwater Potential Mapping Geographic Information in Limboto District, Gorontalo Province.” Geodika: Journal Geography Science and Education Review 5(2): 236–46.
[13]. Rakhmat, Awaludin, Juandi Muhammad, and Usman Malik. 2019. “Interpretation Underground Water Conditions Case Study in Tenayan Raya Kota District Pekanbaru Using the Pumping Test Method.” Physics Communications Indonesia 16(1): 25.
[14]. Rosyidah, Elsa, and Ruslan Wirosoedarmo. 2013. “Effect of Soil Physical Properties on Saturated Hydraulic Conductivity in the 5 Land Uses (A Case Study in Sumbersari 47 Poor)." Agritech 33(3): 340–45.

[15]. Sari, P M. 2013. "Utilization of Remote Sensing Images and Information Systems Geographical to Identify Locations of Spring Appearance And ...." http://etd.repository.ugm.ac.id/home/detail_pencarian/62326.
[16]. Sukojo, Bangun Muljo, and Bayu Aristiwijaya. 2016. "Analysis of Landsat 8 Satellite Imagery To Identify Potential Of Spring (Case Study: Bojonegoro District)." Geoid 11(2): 111.
[17]. Sulaiman, A., Sutirto, and Yohannes Rante Lembang. 2017. "Water Potential Mapping Land Using Remote Sensing and Geographic Information Systems in Cities Kupang." Proceedings of the National Seminar series 7: 531–46.
[18]. Suwargana, Nana. 2008. "Analysis of Mangrove Forest Change Using Data Remote Sensing at Bahagia Beach, Muara Gembong, Bekasi." Journal Remote Sensing 5: 64–74.
[19]. Wibowo, Setyo Nugroho, Ir Bambang Hidayat, and Ir Johan Arif. 2017. "IDENTIFYING TYPES OF IGNEOUS ROCKS LOOKING AT THE PATTERN SHAPE BATU USES THE DISCRETE WAVELET TRANSFORM METHOD (DWT) AND K-NEAREST NEIGHBOR (KNN) Identification Pattern of Igneous Rock Using the Discrete Wavelet Transform (DWT) Method And K Nearest Neighbor." e-Proceedings of Engineering 4(2): 1677–8