IDENTIFICATION OF GROUNDWATER POTENTIAL USING GEOGRAPHIC INFORMATION SYSTEMS AND REMOTE SENSING (CASE STUDY: MOJOKERTO REGENCY)

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Received: May 18, 2023 | **Accepted:** June 7, 2023 | **Published:** June 7, 2023
DOI: 10.12962/j27745449.v4i1.700 | **Issue:** Volume 4 Number 1 2023 | **E-ISSN:** 2774-5449

ABSTRACT

The impact of the drought problem in Mojokerto Regency resulted in thousands of people having access to clean water. So, it is necessary to plan the utilization of groundwater resources well. Therefore, more serious handling is needed in an effort to overcome the problem of groundwater supply. One of them is the availability of groundwater potential maps. This study aims to determine the identification of aquifer potential and groundwater potential in Mojokerto Regen cy in 2020. This research uses SPO T - 7 satellite imagery to see vegetation density using the NDVI method and uses 5 parameters, namely rainfall, soil texture, rock type/geology, slope, and land use. This study used the AHP method in determining the priority weight value of each parameter. Based on the results of the study, the results were obtained with 3 classifications with the largest area being an area with mode rate groundwater potential of 52,621.285 Ha and the smallest area being an area with low groundwater potential of 2,426.327 Ha. Previous research identified groundwater potential using the NDVI method with Landsat 8 imagery which has a resolution of 30 meters. Therefore, this research is expected to produce better vegetation density by using SPOT-7 imagery to obtain more detailed groundwater potential, because the resolution of the image SPO T -7 is 6 meters. So that this research can be considered in efforts to process the potential of groundwater resources in Mojokerto Regency.

Keyword: Groundwater Potential, Aquifer, AHP, SPOT-7, NDVI.

Introduction

Groundwater is rainwater runoff that flows beneath the earth's surface and forms geological stratification, potential differences in soil moisture, and gravitational forces. Surface water is often referred to as groundwater (Asdak. 2010). In areas that often experience drought, resulting in difficulties with clean water. Mojokert o Regency is one of the areas that is classified as drought-pro ne (Kusuma. 2018). To deal with the proble m of drought, it is necessary to deal with the supply of clean water by providing a map of groundwater potential. Identification of groundwater potential in previous research is by utilizing geospatial information system metho ds and remote sensing metho ds. In previous studies, potential areas of groundwater have been identified with a geographic information system used to obtain aquifer maps using a tiered quantitative overlay method on several parameters.

The parameters used to obtain the distribution of potential aquifers are vegetation density, slope, soil texture, rainfall and land use. From the overlay results obtained, an overlapping process will be carried out between the distribution of the aquifer potential and the groundwater basin parameters to obtain the distribution of groundwater potential. Remote sensing is used to provide information on vegetation density generated by the NDVI (Normalized Difference Vegetation Index) method. From previous research the ND VI (Normalized Difference Vegetation Index) method with Landsat 8 imagery has a resolution of 30 meters. To get better results of vegetation density, identify the NDVI Algorithm (Normalized Difference Vegetation Index) using SPOT-7 Imagery with a resolution of 6 meters. The Analytica l Hierarchy Process (AHP) is a Geographic Information System

(GIS) calculation metho d that can be used as an approach to assessing groundwater potential. The AHP methodology facilitates objective decision-making.

It is hoped that this research can provide information in identifying aquifer potential and groundwater potential based on Geographic Information Systems and Remote Sensing in Mojokerto Regency. Which later can be used as information material in dealing with drought and scarcity of groundwater.

Methodology

In identifying areas that have the potential to have groundwater in the Mojokerto Reg enc y area, namely by using the Geographic Information System and Remote Sensing methods. Where the Geographic Information System is used to obtain aquifer maps using a tiered quantitative overlay method on several parameters. The parameters used to obtain the distribution of potential aquifers are vegetation density, slope, soil texture, rainfall and land use. From the overlay results obtained, an overlapping process will be carried out between the distribution of the aquifer potential and the groundwater basin parameters to obtain the distribution of groundwater potential. Remote sensing is used to provide information regarding vegetation density generated by the NDVI method from SPOT -7 imagery.

Vegetation Index

Vegetation index is a form of spectral transformation that is applied to multi-channel images to highlight aspects of vegetation density or other aspects related to density, for example biomass, Leaf Area Index (LAI), chlorophyll concentration, and so on. Practically, this vegetation index is a mathematical transformation that involves several channels at once, and produces new, more representative images in presenting vegetation phenomena (Arnanto, 2013). Vegetation index or NDVI is an index that describes a plant based on the level of greenness. The vegetation index is a mathematical combination between the red band and the NIR (Near-Infra red Radiation) band which has long been used as an indicator of the presence and condition of vegetation (Lillesand and Kiefer, 1979).

$$\mathrm{NDVI} = \frac{(NIR-RED)}{NIR+RED} \quad (1)$$

Table 1. Vegetation Density Index Class

Range of Vegetation Index Values	Score	Influence Level
0,36 – 1	4	Influential
0,26 – 0,35	3	Currently
0,15 – 0,25	2	Less Influence
(-0,03) – 0,15	1	Very Less Influenced
(-1,0) – (-0,03)	5	Very influential

Accuracy Tests

Accuracy tests performed on this category of data in general are tests of visual interpretation results, digital classification, and grouping of values resulting from spectral transformation. The technique used is a contingency table which in remote sensing is better known as a confusion matrix table. The confusion matrix table is a matrix table that connects the pixels resulting from the classification and ground truth data whose information can be retrieve d from verified field data and maps. There is a lot of information that can be retrieved from the confusion matrix, including overall accuracy, producer accuracy, user accuracy, kappa coefficient, and tau coefficient (Wicaksono, 2010). Field validation is done by making a confusion matrix to get the overall accuracy value. The overall accuracy value shows the number of pixels that are classified correctly in each class compared to the number of samples used to test accuracy in all classes, using the following formula (Wicaksono, 2010):

$$\text{Overall accuracy (\%)} = \frac{\text{the number of pixels that are correctly classified}}{\text{number of accuracy test samples}} \times 100 \quad (2)$$

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) method is a decision support method developed in 1980 by Thomas L., Saaty. In this method the existing problems are described in hierarchical form, the hierarchy created consists of several levels starting with objectives, criteria, and alternatives. The steps in performing calculations on the AHP method consist of three levels: the purpose of the decision is at the top level, followed by the second level consisting of criteria then the alternatives are at the third level for evaluation.

Classification of Groundwater Potential

Classification is carried out to determine the level of groundwater potential for area development, and the groundwater supply capability of each level (Sholicin, Asmaranto and Jannati, 2014).

Then to determine the level of suitability as a water catchment area is done by adding up the multiplication results between the weight values and scores in each parameter class, using the formula:

$$\text{Nilai Total} = (Nb * Np) + (Bb * Bp) + (Cb * Cp) + (Tb * Tp) + (Kb * Kp) + (Lb * Lp) \quad (3)$$

Making class intervals uses the following formula (Sigit. 2011):

$$i = \frac{Kt - Kr}{k} \quad (4)$$

Result and Discussion

Identify areas that have the potential to have groundwater in the Mojokerto Regency area, namely by using the Geographic Information System and Remote Sensing methods. Where the Geographic Information System is used to obtain aquifer maps using a tiered quantitative overlay method on several parameters. The parameters used to obtain the potential distribution of aquifers are vegetation density, slope, soil texture, rainfall and land use. From the overlay results obtained, an overlapping process will be carried out between the distribution of the aquifer potential and the groundwater basin parameters to obtain the distribution of groundwater potential.

Remote sensing is used to provide information regarding vegetation density generated by the NDVI method from SPOT-7 imagery.

Vegetation Index Data

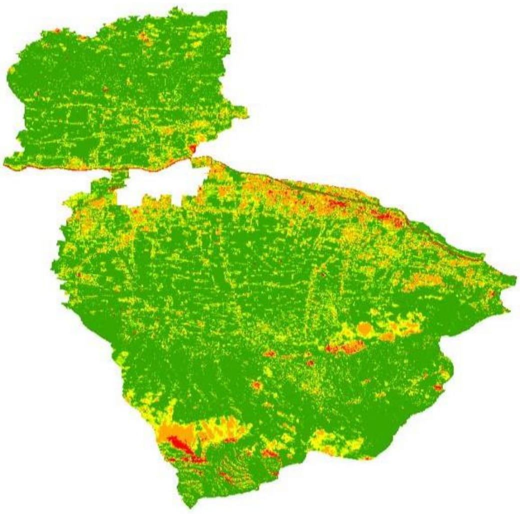

Figure 1. Results of vegetation index data with NDVI (Normalized Difference Vegetation Index) algorithm processing

The results of vegetation data using the NDVI algorithm calculation is an index that describes a plant based on its greenness level.

Confusion Matrix Accuracy Test

The results are then used as an accuracy test material to obtain the confidence level value of the classification results on images with density measurement data from field surveys as a reference for calculating the confusion matrix (accuracy test matrix). The following is the result of the confusion matrix calculation in this study as shown in table 2.

Table 2. Confusion Matrix Accuracy Test

Image Classification	Field Survey				Correct Amount	Number of Rows
	Very influential	Very Less Influenced	Less Influence	Currently	Influential	
Very influential	18	0	0	0	0	18
Very Less Influenced	0	18	0	0	0	18
Less Influence	0	0	16	2	0	18
Currently	0	0	1	17	0	18
Influential	0	0	0	1	17	18
Correct Amount					86	
Number of Columns	18	18	17	20	17	90

rom the confusion matrix table above, the total accuracy calculation is then performed as follows:

$$\text{Overall accuracy (\%)} = \frac{\text{the number of pixels that are correctly classified}}{\text{number of accuracy test samples}} \times 100 \quad (5)$$

$$= \frac{86}{90} \times 100 \quad (6)$$

$$= 95.56\% \quad (7)$$

AHP Processing Results

From the process of determining the weight of aquifer potential and groundwater potential using six parameters in the calculation; Vegetation Density(ND VI) is a param e t er to identify aquifer potential areas and groundwater potential from the proximity of vegetation density factors, land use is a parameter to identify potential aquifer areas and groundwater potential from the type of land use of origin, rainfall is a parameter to identify potential aquifer areas and groundwater potential from the annual rainfall factor, slope is a parameter to identify aquifer potential areas and groundwater potential from the topographic slope factor, soil texture is a parameter to identify potential aquifer areas and groundwater potential from the soil texture of origin, rock type is a param e t er to identify aquifer potential areas and ground water potential from the type of rock of origin.

Table 3. Criteria Weighting Matrix Results

Criteria	Total Weight
NDVI	7.04%
land use	15.03%
rainfall	24.42%
slope	17.86%
soil texture	5.55%
rock type	30.11%
Total	**100.00%**

From the calculation results above it is known that the order of priority for each parameter is as follows:

1. Rock Type Criteria has the first highest weight, namely 30.11%
2. The Rainfall Criterion has the second highest weight, namely 24.42%
3. The slope criterion has the third highest weight, namely 17.86%
4. Criteria for Land Use has the fourth weight, namely 15.03%
5. The Vegetation Density Criterion has the fifth weight, namely 7.04%
6. Soil Texture Criteria has the sixth weight, namely 5.55%

Thus, class parameter weighting for aquifer potential and groundwater potential.

Parameter Data Processing

The aquifer potential identification map is obtained from the process of scoring and weighting then overlaid between vegetation, rock type, rainfall, slope, soil type, land use, and groundwater basin. Then choose between the parameters to be overlaid in stages between the two parameters in one overlay process, with the first overlay stage namely Vegetation Index with Rock Graduation, then from the overlay results go to the second overlay process with Soil Texture, followed by the third overlay process with Slope, then the fourth overlay with Rainfall and the last overlay with land use. Then add up the loyal scores of overlapping parameters, the results of which will be classified into the aquifer potential class with the class values as follows:

$$KI = \frac{105-63}{3} = 14 \quad (8)$$

3 classes are used with score intervals, the results of which can be seen in the following figure 2.

Table 4. Aquifer potential classification

Class Intervals	Aquifer Potential Class
91 - 105	Big
77 - 90	Currently
63 - 76	Small

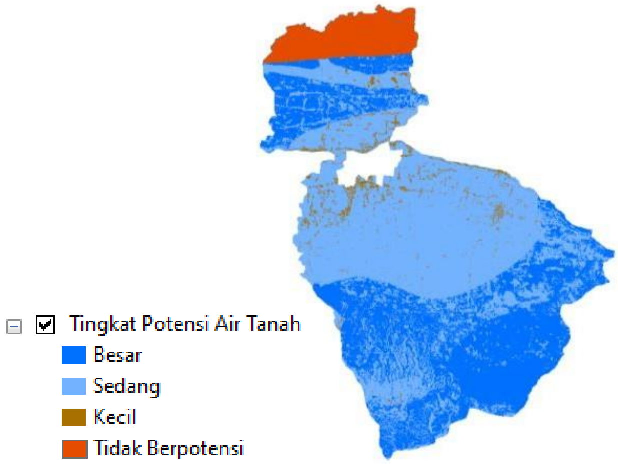

Figure 2. the results of the calculation of the Analytical Hierarchy Process (AHP) and classification into groundwater potential data.

Groundwater Potential Validation Test

From the results of observing the distribution of drilled wells from each class of groundwater potential, the amount of spring water discharge is obtained with discharge values as follows: Large (> 50 litters/ second), Medium (25-50 litters/ second), and Small (<25 litters /second). The distribution of drilled wells can be seen in the following figure:

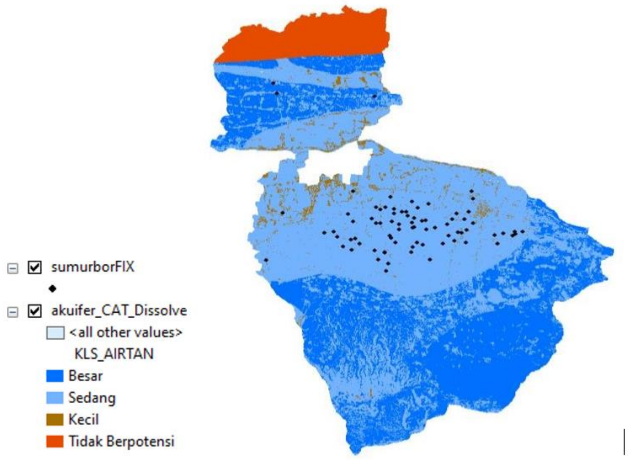

Figure 3. results of groundwater potential data and data on the distribution of drilled well points.

Table 5. Test the accuracy of the potential groundwater confusion matrix

Groundwater Potential Map	Borehole Discharge Point			Correct Amount	Amount Line
	No Potential	Small	Medium	Big	
No Potential	0	0	0	0	0
Potential	0	45	0	1	46
Small	0	8	20	0	28
Medium	0	2	0	2	4
Big				11	
Total	**0**	**55**	**20**	**3**	**78**

From the confusion matrix table above, the total accuracy calculatio n is then carried out as follows (Wicak so no , 2010):

$$\text{verall accuracy (\%)} = \frac{\text{the number of pixels that are correctly classified}}{\text{number of accuracy test samples}} \times 100 \quad (8)$$

$$= \frac{67}{78} \times 100 \quad (9)$$

$$= 85{,}89\% \quad (10)$$

Conclusion

In utilizing the SPOT-7 Geographic Information and Imagery System in identifying groundwater potential with a case study in Mojokerto Regency, the results of groundwater potential areas in Mojokerto Regency show that the largest area is an area with moderate groundwater potential of 52,621.285 Ha and the smallest area is an area with low groundwater potential of 2,426.327 Ha and the results of the groundwater potential validation use the borehole discharge point with a conformity percentage of 85.89%. Of the 90 data obtained 73 appropriate data and 17 inappropriate data.

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