Potential of groundwater recharge zone in the groundwater basin of Majalengka Regency

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Abstract. Water is an important natural resource in supporting the lives of all living things. The increasing population in Majalengka District adding a large amount of water usage. The extraction of groundwater that has been carried out over time has also increased, thus, a study is needed to reveal groundwater recharge zone so that we can predict the groundwater reserves in a certain area. Therefore, a study entitled Potential Groundwater Recharge Zone in CAT Majalengka needs to be conducted because CAT is a location where rainwater falls and can also be used as data to estimate the groundwater reserves in a certain area. The method used in this study was SMCE (Spatial Multi-Criteria Evaluation) by using a quality point system on each variable used. The variables used in this study were lithology, rainfall, slope, altitude, land use, soil texture, and flow density. The results of this study showed that the potential groundwater recharge zones in CAT Majalengka were dominated by high and very high classifications. High and very high classification potential dominated at an altitude of 500-1000 meter above sea level.

1. Introduction

Water is an important natural resource in supporting the lives of all living things [1]. One source of water that is still widely used by humans comes from the soil or called groundwater. Groundwater is one of the natural resources that supports human health, economic development and ecological diversity [2]. The presence of groundwater in a place can be caused by the interaction of climate factors, geology, hydrology, physiography, and ecology so that differences in physical conditions between regions determine the presence of groundwater in the region [3]. Also, what is quite worrying is the change in groundwater recharge areas into settlements, industries, and others.

The groundwater recharge area is a water catchment area that can naturally add groundwater to the Groundwater Basin (CAT) [4]. A good natural recharge area is an area where the surface water percolation process takes place so well that it becomes groundwater without obstruction. If the function of the recharge area does not function properly, it can cause no groundwater that can be stored or used [5]. The recharge area serves to accommodate rainwater discharge, so indirectly it also has an impact on flood control. The recharge areas can be used in the CAT area to meet groundwater availability. The groundwater recharge area is widely used by the community for daily activities such as bathing, washing, and latrines as well as for rice fields, especially in CAT Majalengka. Meanwhile, water demand is increasing along with the increasing rate of population growth. Areas that have not yet been served clean water through the Regional Water Company (PDAM) make people try to get clean water so that groundwater becomes the main choice in meeting the need for clean water. This resulted in an increasingly widespread extraction of groundwater by the community, resulting in groundwater
subsidence. On the other hand, there is a conservation area that changes its function into a cultivation area such as a residential area. The impact is an increase in the quality and quantity of water needs while decreasing the availability of groundwater in the area of land conversion.

Along with its development, Majalengka Regency continues to improve public services for the community. Especially at this time, the government of West Java Province built an International Airport in Kertajati Sub-District. The increasing development of public services indirectly affects the increase in groundwater utilization because groundwater usage will increase so it needs a large utilization. This causes the existence of groundwater to decrease. Besides, changes in land functions also cause water that should be absorbed, to run off which flows into the river and continues into the sea. The direct impact of this is the reduced availability of groundwater or drought [6]. Hence, the reasons underlying the research with the title Potential Groundwater Potential Areas in CAT Majalengka are important because of the CAT location. This CAT should be able to be used as an area that has the potential for groundwater recharge areas that can be used as the fulfillment of the necessities of life and even the agricultural sector in Majalengka Regency. Another benefit of this research is that it can reduce the risk of problems that have been presented so that the Majalengka CAT area can become an area with abundant groundwater reserves in the rainy season and dry season.

2. Methods
The Majalengka Groundwater Basin is one of the CATs in Majalengka Regency. Geographically, Majalengka CAT is in between of 108°15'30" - 108°24'30" BT and 6°45'30" - 6°56'30" LS. The area of Majalengka CAT is 179.52 Km², it means that the area of Majalengka CAT is only 15% of the area of Majalengka Regency (ie approximately 1,204.24 Km²). The variables used in this study are physical factors in the form of land-use, geology, hydrology, soil texture, and topography.

This study used various kinds of research data which are then grouped into primary data and secondary data. Primary data is data obtained during the field survey and data processing. Meanwhile, secondary data is obtained previously from various agencies and is not the result of field surveys. Primary data included land-use data that has been validated during a field survey at CAT Majalengka.

![Figure 1. Map of Sample Points Distribution](image-url)
Also, retrieval of soil texture data is obtained from the results of taking 17 soil samples and testing in the laboratory. In this study also interviewed Majalengka society with a questionnaire with a purposive sampling system, where the location of the informants has been determined criteria first. The interview results were used to gather information from the public regarding the Majalengka CAT area. The following is the distribution of the sample points.

Secondary data used in this study are physical characteristics data consisting of altitude and slope, land use data, soil texture data, geological data and hydrological data consisting of drainage systems and rainfall at the study site Table 1. The data needed from the agency is an administrative map of the research area with a scale of 1: 25,000, rainfall data is obtained from rainfall observation stations that cover the research area. Geological data obtained from processing geological map data in the research area. Data on soil types derived from processing geological data in the research area. DEM data (Digital Elevation Model) and land use data are generated from processing image data following the research area. Drainage system data is generated from processing between rainfall data, soil type and land use in the study area.

| Data                         | Data Types                          | Sources                                      |
|------------------------------|-------------------------------------|----------------------------------------------|
| Rainfall                     | Average of Annual Rainfall 2018 in the form of tabular data | PSDA Majalengka Regency                      |
| Land use                     | Shapefile (shp)                     | Bappelithangda Majalengka Regency            |
| DEM                          | GeoTIFF                             | SRTM, from earth USGS Earth Explorer         |
| Geology Map, Page-Majalengka | Shapefile (shp) and Map             | Geological Research and Development Center in Bandung |
| Drainage System              | Shapefile (shp) and Map             | The result of data processing                |

The results of data collection and processing are carried out by spatial analysis using the weighting method [7]. Weighting is done by looking for literature on variables that will be calculated by weighting [7,8]. Furthermore, the literature weighting data was averaged to produce weights in this study [9]. Then do the multiplication between the weights with the scale of each variable unit [7,9]. Scale determination is done by identifying how much the variable unit influences the groundwater basin. The following is a classification table of the affixed region variables Table 2.

| Variables          | Classification of Recharge Area Scoring |
|--------------------|-----------------------------------------|
|                    | Very Low | Low  | Moderate | High   | Very High |
| Slope (%)          | >40      | 25 - 40 | 8 - 25   | 2 - 8   | 0 - 2      |
| Elevation (masl)   | 0 - 25   | 25 - 100 | 100 - 500 | 500 - 1000 | >1000 |
| Lithology          | Metamorphic and Igneous Rocks | Solid Rocks | Volcanic Rocks | Loose Deposition | Alluvium Deposition |
| Soil Texture       | Clay     | Sandy Clay Loam | Sandy Loam | Loamy Sand | Fine Sand |
| Flow Density (km/km²) | < 0,1 | 0,1 - 0,2 | 0,2 - 0,3 | 0,3 - 0,4 | >0,4 |
| Rainfall (mm)      | < 500    | 500 - 1000 | 1000 - 2000 | 2000 - 3000 | > 3000 |
| Land use           | Buitled Land | Settlements | Shrub and Paddy Field | Plantations and Dryland Agriculture | Forests |
3. Result

Potential recharge areas can be identified using the weights of each research variable used. Each of these variables has its scale in determining the potential of the recharge area, here are the effects of each variable unit Table 3. Table 3 showed that land use has the highest results, it means that the variable of land use has the highest impact than the other variables to identify the potential of the groundwater recharge area (CAT).

**Table 3. Effects of Variables Unit based on Weights [7,8,9]**

| Variables          | Variables Unit                          | Criteria   | Scale | Weights Value | Results |
|--------------------|-----------------------------------------|------------|-------|---------------|---------|
| Lithology          | Metamorphic and Igneous Rocks           | Very Low   | 1     | 0,213         |         |
|                    | Solid Rocks                             | Low        | 2     | 0,426         | 2,13    |
|                    | Volcanic Rocks                          | Moderate   | 3     | 0,639         |         |
|                    | Loose Deposition                        | High       | 4     | 0,852         |         |
| Rainfall           | 2000 - 3000                             | High       | 4     | 0,64          |         |
|                    | >3000                                   | Very High  | 5     | 0,8           | 1,44    |
| Land Use           | Forests                                | Very High  | 5     | 0,97          |         |
|                    | Shrubs and Paddy Field Settlements      | Moderate   | 3     | 0,582         |         |
|                    | Plantations and Dryland Agriculture     | High       | 4     | 0,776         |         |
| Soil Texture       | Sandy Loam                             | Moderate   | 3     | 0,429         |         |
|                    | Fine Sand                              | Very High  | 5     | 0,715         | 1,29    |
|                    | Clay                                   | Very Low   | 1     | 0,143         |         |
| Flow Density (km/km²) | < 0,1                               | Very Low   | 1     | 0,07          |         |
|                    | 0.1 - 0.2                              | Low        | 2     | 0,14          |         |
|                    | 0.2 - 0.3                              | Moderate   | 3     | 0,21          | 1,05    |
|                    | 0.3 - 0.4                              | High       | 4     | 0,28          |         |
|                    | > 0.4                                  | Very High  | 5     | 0,35          |         |
| Slope              | 0 - 2%                                 | Very High  | 5     | 0,71          |         |
|                    | 2 - 8%                                 | High       | 4     | 0,568         |         |
|                    | 8 - 25%                                | Moderate   | 3     | 0,426         | 2,13    |
|                    | 25 - 40%                               | Low        | 2     | 0,284         |         |
|                    | >40%                                   | Very Low   | 1     | 0,142         |         |
| Elevation (masl)   | 100 - 500                              | Moderate   | 3     | 0,318         |         |
|                    | 500 - 1000                             | High       | 4     | 0,424         | 1,28    |
|                    | > 1000                                 | Very High  | 5     | 0,53          |         |

Table 3 is the result of the integration of the literature to determine the influence of the existing variable units. Then from the table will describe the potential recharge area, the following is a table of classification of the groundwater recharge areas. The classification value of the groundwater recharge area is generated from the sum of all the variable weights used in this study. Weighting results show that 0.294 is the lowest value and 4.51 is the highest value.
Table 4. Classification of The Groundwater Recharge Area Potential

| Classification | Values     |
|----------------|------------|
| Very Low       | 0.294 - 1.14 |
| Low            | 1.14 - 1.99  |
| Moderate       | 1.99 - 2.84  |
| High           | 2.84 - 3.69  |
| Very High      | 3.69 - 4.51  |

Source: Result of Data Processing

In Majalengka CAT, the potential groundwater recharge area has two dominant classifications, namely very high and moderate classifications. Based on Figure 2, it can be seen that the Argapura Subdistrict has a very high potential for the groundwater recharge area. While Rajagalu Subdistrict and Sindangwangi Subdistrict have the classification of very high and high potential for the recharge area. Majalengka CAT is dominated by high potential classification for the groundwater recharge area with an area of 11,193,742 ha. At an altitude of > 1000 meters above sea level, it is dominated by the classification of very high potential with an area of 4,417.45 ha. Then the elevation of 500 - 1000 masl is dominated by the classification of high potential with an area of 4,121.58 ha. Besides that, at an altitude of < 500 masl dominated by the classification of high potential with a land area of 5,936.96 ha. Based on the regional physical characteristics, it can determine the hydrogeology of the Majalengka CAT, the following is a description of hydrogeology in the research area:

The hydrogeology of Majalengka CAT is dominated by Medium Productive type with Broad and Productive Distribution Area. Based on altitude classification, hydrogeology with an elevation more than 1000 masl (meters above sea level) is dominated by hydrogeology with minimum productive properties. While at an altitude of 500 -1000 masl, it is dominated by hydrogeology with medium productive properties and large area. Whereas at an altitude of less than 500 masl, it is dominated by hydrogeology with medium productive properties and large area. The aquifer system in Majalengka CAT is dominated by the cleavage system in between grains. The debit that occurs in Majalengka CAT
Based on the Hydrological map which is dominated by rare volumes, or there is no movement of water entering the aquifer system. This is because the nature of water passing on rocks in the CAT area is dominated by low properties. Based on the explanation, it can be proved that the percentage of lithology influences has a quite large value when compared with other variables. This is because lithology is a constituent of aquifers in the CAT region so that the influence factor is quite large on the potential of the groundwater recharge areas.

Based on the information in figure 3, the productive local hydrological area falls into the classification of very high potential recharge areas. While the productive hydrological region is being spread widely, small productive hydrological regions and rare hydro regions are included in the classification of high recharge potential areas. It can be stated that to produce a very high potential recharge area requires a productive area of local hydrology. Hydrogeology of groundwater basins is used as an illustration of groundwater movements in the Majalengka CAT. The relationship between hydrogeology and potential groundwater recharge areas is to relate the area in the CAT region between the description of groundwater movement and the potential groundwater recharge area that has a comparable value. Where the description of the potential recharge area of groundwater has a very high value and the description of hydrogeology having productive local characteristics can indicate the movement of groundwater in the area is very good so that the area is suitable if it has a classification of infiltration areas with very high potential.

![Figure 3 Map of Hydrogeology in Majalengka CAT](image)

4. Discussion

Based on the results of the discussion above, the potential distribution of groundwater recharge areas in Majalengka CAT is dominated by very high classifications in Argapura District while Sindangwangi and Rajagaluh Subdistricts have very high and high classifications. The classification of recharge areas can provide an overview of the Majalengka CAT hydrogeology. Hydrogeology provides an overview of groundwater flow in Majalengka CAT. The relationship between hydrogeology and the potential groundwater recharge area to show that the classification characteristics of the recharge potential area are similar to the hydrogeological conditions in Majalengka CAT. In the above explanation, the classification of groundwater recharge areas is very high having hydrogeological conditions with productive characteristics of the underground flow. This indicates that the area of potential groundwater recharge with a very high class is also supported by hydrogeological conditions that have productive local characteristics which means the groundwater flow is produced in the local scope.
5. Conclusion
The potential groundwater recharge area in CAT Majalengka has a very high and high potential dominance. The distribution of dominance in the very high classification is in Argapura District, Rajagaluh District in the south and Sindangwangi District in the south from CAT Majalengka. While the classification is dominantly spread in Maja Subdistrict, Sindang Subdistrict, Rajagaluh Subdistrict in the north and Sindangwangi Subdistrict in the north of CAT Majalengka. The most potential variable which has a high role in influencing groundwater recharge areas is land use and subsequent factors in succession are lithology, rainfall, soil texture, flow density, slope and altitude. Land use has the highest role because land use in the potential area of recharge CAT Majalengka illustrates the use of land in CAT Majalengka so that groundwater potential areas can be determined so that it can be conserved.

6. References
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