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Research article

Determination of Zoning Recharge Area and Spring Conservation in the Upstream Sub-Basin of the Jali River, Gebang District, Purworejo Regency, Central Java Province

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Abstract

Human needs for clean water can be obtained from various sources, one of those is springs. The spring is the main water source for the people in Redinkidul Hamlet. The dependence of the community on springs shows that there is a need for conservation of spring recharge areas. The purpose of this study was to determine the ability of recharge areas to absorb water and provide conservation direction for spring recharge areas. The research method used is survey and mapping methods to obtain data on existing conditions in the field, scoring and overlay methods to determine the condition of the recharge area based on the results obtained. The scoring parameter refers to Permen PU No. 2 of 2013. The results obtained show that the spring recharge area zone has a moderate class with a score of 11-13. The highest score obtained is on the parameters of land use and rainfall. Based on these results, the proposed conservation directives are in the form of technical conservation directions in the form of bund terraces and spring support buildings. This conservation is needed so that the potential of the spring is maintained.

Keywords: *recharge area, conservation, springs, overlay, scoring*

1. Introduction

Springs are groundwater that comes to the surface (Todd, 2005). The phenomenon of springs can occur due to groundwater levels cut off by topography, geological structures, and contact between rocks. Springs are the primary water source used to meet domestic water needs, especially for Redinkidul Hamlet, Redin Village, Gebang District, Purworejo Regency, Central Java Province. Meanwhile, another hamlet in Redin Village uses PDAM as a source of domestic water. The high dependence of the community on springs because the area does not have dug wells and the high topographical conditions make it difficult for the PDAM pipe to pass through the site. Redin Village has three springs used by 217 families or 729 people, namely Setalang Kulon 1, Setalang Kulon 2, and Setalang Wetan Springs.

The research area is classified as an area that has a high-class drought hazard index according to the Drought Hazard Map of Purworejo Regency by the National Disaster Management Agency (known as BNPB) of Purworejo Regency. Based on the Regional Spatial Plan (known as RTRW) of Purworejo Regency, the research area is included in a protected area. These areas include protected areas managed directly by the community (such as areas around springs) and water catchment areas. In this case, the recharge area is a water catchment area, which is an area that functions as a place to fill water (aquifer) by infiltrating rainwater into the soil surface. The recharge area is divided into two, namely the groundwater recharge area and the air spring protection zone (Putranto et al., 2020). The existence of human activities in the recharge area and changes in chemical geophysical conditions such as climate, soil, rocks, land use, and local slope causes changes in the quality of the recharge area. This research was carried out considering the community's dependence in Redin Village on springs which is relatively high, so that good quality recharge areas are also needed. Recharge area preservation is required to be considered because of the important factor in the potential of springs both in terms of quality and quantity.

Previous research regarding the conservation direction of spring recharge areas in Piyungan District, Bantul Regency, found two recharge area zones: sinister and good class recharge areas. The conservation direction taken is with a combination of bench terraces and mounds at the spring border (Prastiwi et al., 2019). Previous research was also conducted by Amri et al. (2014) regarding the criticality of recharge areas and water catchments in the area around the Musi River power plant, Bengkulu. This research was conducted due to land-use changes and high deforestation rates, which led to the high criticality of land in recharge areas and water catchments. The results showed that the recharge area was generally classified as good, namely 43,215.39 ha (71.56%). Meanwhile, the water catchment area has the critical potential of 34015.34 ha (56. 34%).

Activities in the recharge area also affect the quality of the springs. This is shown by research conducted by Wang et al. (2017), where the increase in land use for agriculture, economic forestry, and residential areas causes high EC and NO3 values. This is also influenced by fertilizers, manure, and household waste that occur in the recharge area. Caro-Borrero et al. (2020) stated that many rural areas face water shortages, so this is a big challenge for water sources. The existence of an increase in population, distribution management, and infrastructure development must also be resolved. The role of government agencies is needed to conserve water sources properly.

This study aimed to determine the ability of recharge areas to absorb water by zoning the area and conducting evaluation by providing conservation directions for recharge areas and springs. Issues that arise related to water sources are reduced water availability or drought and the issue of water pollution. These problems can arise from various factors, one of which is the influence of activities in the affix area. The regulations governing the management of recharge areas or catchment areas are already contained in each local area of RTRW. However, it is also necessary to implement and participate from the community and government to take part in managing the additive areas.

2. Methodology

The research was carried out from October 2019 to April 2020 in the upper Kali Jali sub-watershed. Administratively, the research area is located in a part of Redin Village, the location of the existence of springs and areas that utilize the springs. In part of the Kemiri Village, there is a spring recharge area in the research area. The three springs at the research location are used as the main water supply for domestic needs.

a. Data Collection

The data used in this research are primary data and secondary data. Primary data is obtained from survey results and field mapping by observing, measuring, and recording. Field mapping was carried out to get data on soil types, soil texture, and rock types in the field. Sampling was done by using the purposive sampling method for soil and rock parameters. Measurement of spring discharge was also carried out using the volumetric method at the study site. Meanwhile, secondary data was obtained through related agencies such as the Redin Village Office and the Water Resources Service (known as SDA) of Purworejo Regency.

b. Data Analysis

The determination of the recharge area in this study was carried out following the Regulation of the Minister of Energy and Mineral Resources (known as ESDM) No. 31 of 2018 concerning Guidelines for Establishing Groundwater Conservation Zones. Determining the method of delineating the recharge area boundary is adjusted to the existing conditions of the research area. Five approaches can be used: slope bending, river flow patterns, the emergence of springs, groundwater levels, and isotope hydrochemical. After determining the appropriate approach to the study area's existing conditions, delineation of the recharge area boundaries is carried out. This aims to assess the urgency of areas that need conservation and evaluation.

The research method used is the overlay method to determine the zoning of recharge areas at the research location. An overlay is carried out based on a map of rainfall, slope, soil type, and land use. The scoring method is also used to determine the recharge area's condition based on the score obtained. Overlay carried out in this study using ArcMap software. The scoring criteria are carried out using four parameters: rainfall, slope, soil texture, and land use. According to the Minister of Public Works Regulation Number 2 of 2013 concerning Guidelines for the Preparation of a Water Resources Management Plan, the four parameters were chosen. The following is the score classification for each scoring parameter which can be seen in **Table 1-4.**

Tabel 1. Classification of Recharge Area Score

Spatial Criteria	Spatial Classification	Score	Score Description
Areas with high rainfall (> 3000 mm/yr) will have the potential for higher water absorption compared to areas with low rainfall (<500 mm/yr).	>3000 mm/yr	5	Very High
	2000 – 3000 mm/yr	4	High
	1000 – 2000 mm/yr	3	Moderate
	500 – 1000 mm/yr	2	Low
	< 500 mm/yr	1	Very Low
Areas with flat land slopes (<5%) will have a higher water absorption capacity than areas with steep slopes (> 60%)	<5%	5	Very High
	5-20%	4	High
	20-40%	3	Moderate
	40-60%	2	Low
	>60%	1	Very Low
Areas with use forest land will have higher water absorption capacity compared to areas that have residential land use	Forest	5	Very High
	Shrubs	4	High
	Farm, mixed garden,	3	Moderate
	Rice fields, swamps	2	Low
	Settlement	1	Very Low
Areas that have a soil texture in the form of sand will have a higher water absorption capacity compared to areas that have a soil texture in the form of clay	Sand	5	Very High
	Clay sand	4	High
	Sandy loam	3	Moderate
	Fine sandy loam	2	Low
	Clay	1	Very Low

After scoring the four parameters, the scores obtained will be classified into several classes, whether the additive areas are good, medium, or bad. The determination of the score interval is carried out using the Likert method (Sugiyono, 2011), which is as follows:

$$\text{Interval (i)} = \frac{\Sigma a - \Sigma b}{n}$$

Where:

I : interval width

Σa : Highest amount of dignity

Σb : Lowest amount of dignity

n : Number of classification

So that we get the classification for the affix area, which is as follows:

Tabel 2. Class of Recharge Area Scoring

No	Score	Class
1.	16-20	Good
2.	10-15	Moderate
3.	4-9	Bad

3. Result and Discussion

3.1. Characteristics of recharge areas and springs

Additional areas are located in Kemiri Village, Gebang District, Purworejo Regency, Central Java Province. Delineation to the boundary of recharge areas in this study uses the slope buckling approach. Slope bending is the morphological boundary between the plains and hills, where the field is marked by ridges or ridge feet. The area located above the height is a recharge area. Delineation of recharge areas can also determine the direction of underground water flow that moves towards the spring.

Affix areas are in mixed garden land use and settlements. The rocks that make up the area are andesite and tuff breccias. Soil in the research area is a latosol soil type. The soil found in the study area has a thickness ranging from 200-500 cm. Qualitatively, the soil texture obtained in the field includes sandy clay. The research area has an annual mean rainfall of 3300 mm/year.

The spring in the study area is included in the spring's annual type, meaning that the spring flows throughout the year. However, there was a decrease in spring water discharge during the dry season with a decrease of 1.300.000-3.200.000 L/year. The total annual discharge from the three springs was 121.997.974 L/year. This value is obtained from direct measurements in the field. These springs appear due to fractures in the rock, or it can be called a fractured spring. According to Todd and Mays (2005), springs in the study area are included in class 6, namely 0.2149 L / second if classified based on the amount of water discharge. The following is a map of research boundaries. The northern area marked with a pink line is the location of the spring recharge area.

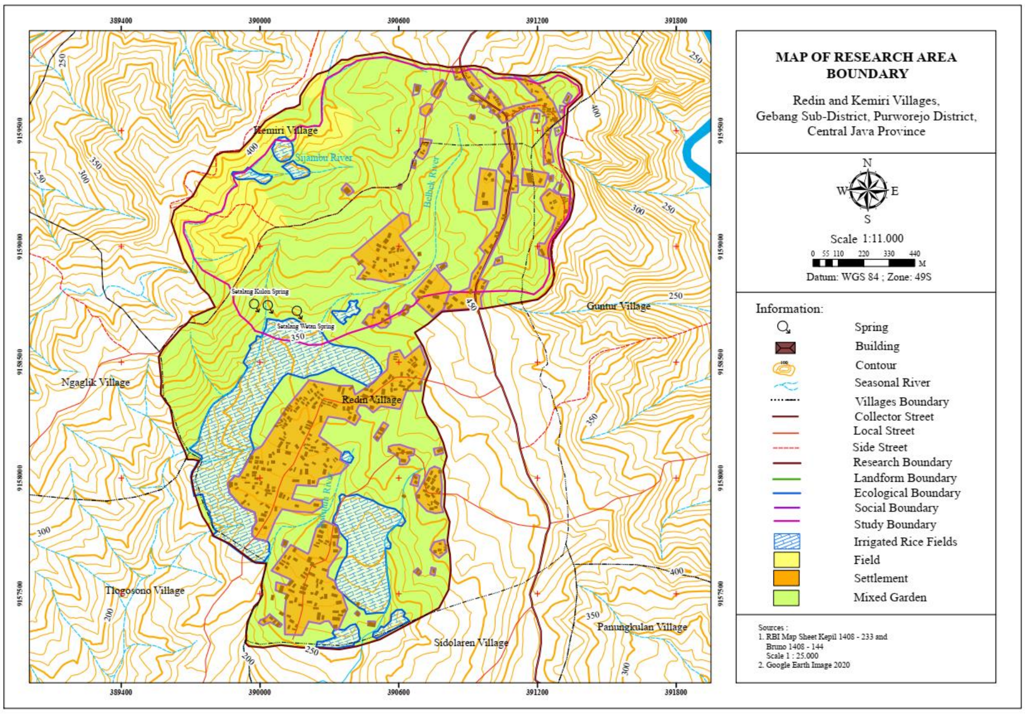

Figure 1. Map of Recharge Area Boundary

3.2. Evaluation of the Existing Conditions of the Imbuhan Area

The recharge area is an area that can absorb water. Water that becomes input or input is water that comes from rainwater. The size of the rainfall can affect how much water enters the soil, in this case the infiltration process. However, climate change can also affect reducing infiltrated water (Pujiraharjo et al., 2014). The processed rainfall data is the annual rainfall data for Sawangan Station, Ngasinan Station, Watujagir Station, and Maron Station. Based on the calculation, the average annual rainfall is 3300 mm/year. The existing rainfall data is also processed into regional rainfall maps using the isohyet method (Figure 2), and two rainfall zoning data are obtained, namely 3150-3300 mm/year and 3300-3450 mm/year. Based on this value, a score of 5 was obtained for the rainfall parameter. The following is a table of rainfall at the research location.

Tabel 3. Rainfall

Spatial Classification	Score	Large of Area (Ha)	Pecentage (%)
>3000 mm/yr	5	141,1618	100
2000 – 3000 mm/yr	4	0	0
1000 – 2000 mm/yr	3	0	0
500 – 1000 mm/yr	2	0	0
< 500 mm/yr	1	0	0

The following scoring parameter is the hill's slope. The hill's slope can determine whether the falling rainfall will seep into the ground or become run-off. The steeper the hill in a place, the more difficult it will be for the falling rainwater to penetrate the ground and run off more. Meanwhile, the plains will absorb more water into the soil (Dalimunthe et al., 2019 and Prastiwi et al., 2019). The following is the distribution of slope slopes in the recharge area, shown in Table 4 and Figure 3.

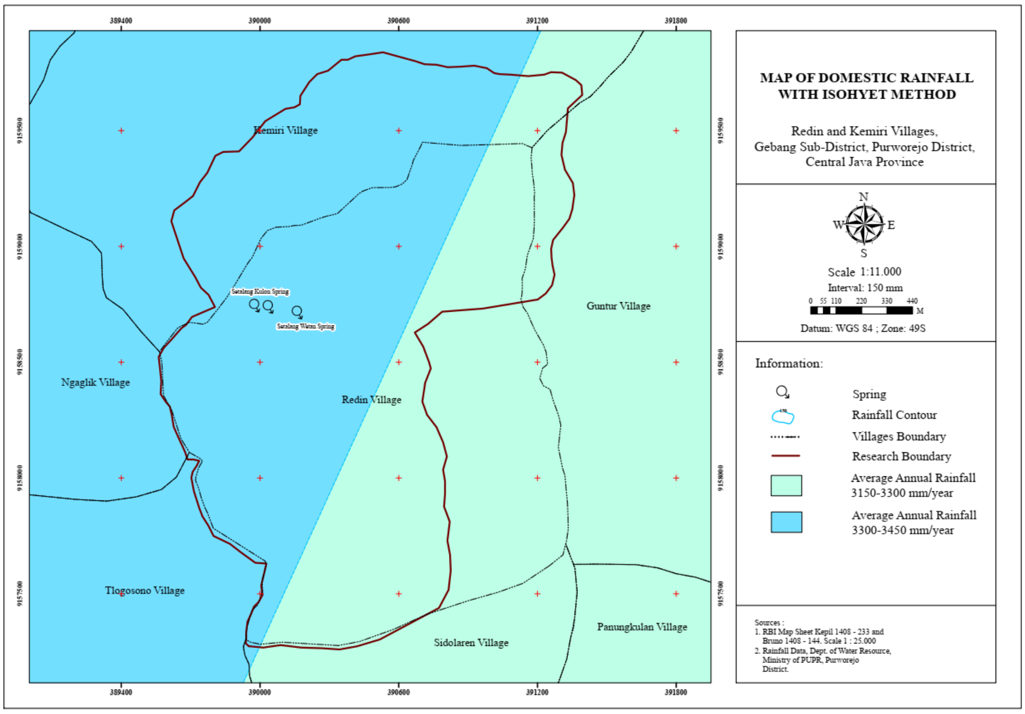

Figure 2. Map of Domestic Rainfall with Isohyet Method

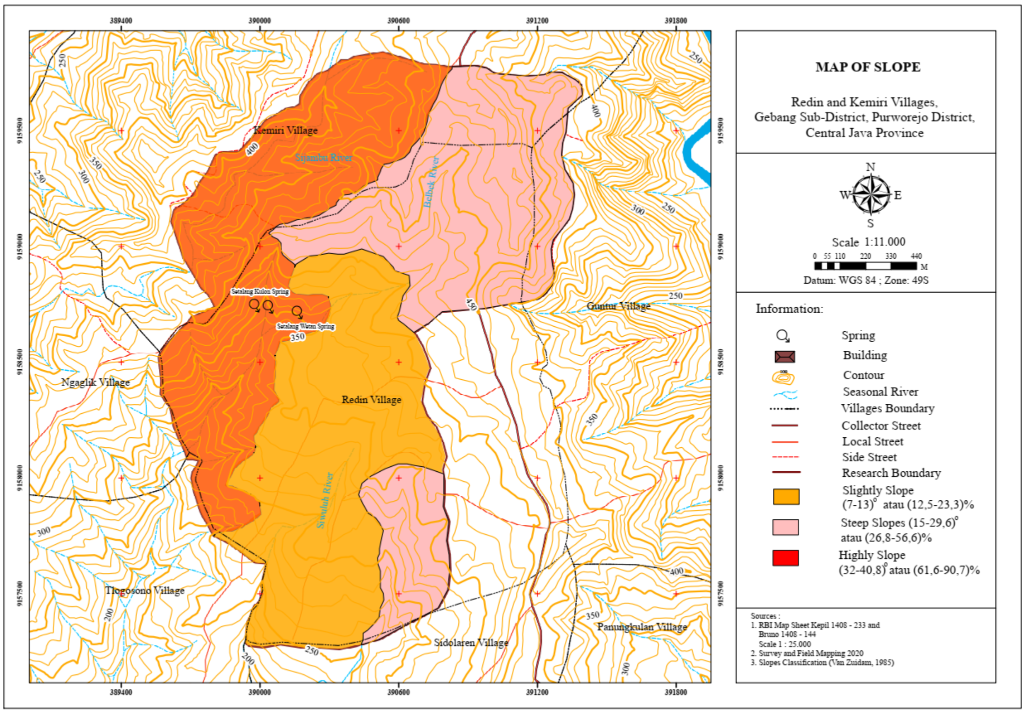

Figure 3. Map of Slope

Tabel 4. Slope

Spatial Classification	Score	Large of Area (Ha)	Pecentage (%)
<5%	5	0	0
5-20%	4	0	0
20-40%	3	18,9946	13,45
40-60%	2	42,2472	29,93
>60%	1	79,9200	56,62

Another parameter that affects the recharge area is soil. Soil greatly influences the infiltration process or the level of water infiltration into the soil, which, when compared with the intensity of rainfall, the results will be relatively the same (Guvil et al., 2018). Soil with a sandy texture will find it easier to enter water into the soil than clay textured soil because sand has larger pores between grains than clay. The research area has a sandy clay soil texture scattered throughout the study area, so the score obtained for soil texture is 3. The following is the distribution of soil texture which can be seen in Table 5 and Figure 4.

Tabel 5. Soil Texture

Spatial Classification	Score	Large of Area (Ha)	Pecentage (%)
Sand	5	0	0
Loamy Sand	4	0	0
Sandy Loam	3	141,1618	100
Fine Sandy Loam	2	0	0
Clay	1	0	0

Land use also affects areas that can absorb water into the ground. Settlement areas have little infiltration capacity compared to areas without cover. A house equipped with a road cover can block the entry of water into the ground resulting in a slight infiltration. Population growth can lead to an increase in the amount of land needed for settlements. A large number of existing settlements will reduce the number of areas capable of absorbing high amounts of water. Changing an undeveloped area to a builtup area will increase runoff (Nurrochman et al., 2018). Vegetation also affects the infiltration rate. The better the vegetation on a land cover, the better the infiltration rate that occurs. According to research conducted by Iqbal et al. (2014), there is a decrease in water availability due to changes in land use. The following is the distribution of land use in the study area, which is shown in Table 6 and Figure 5.

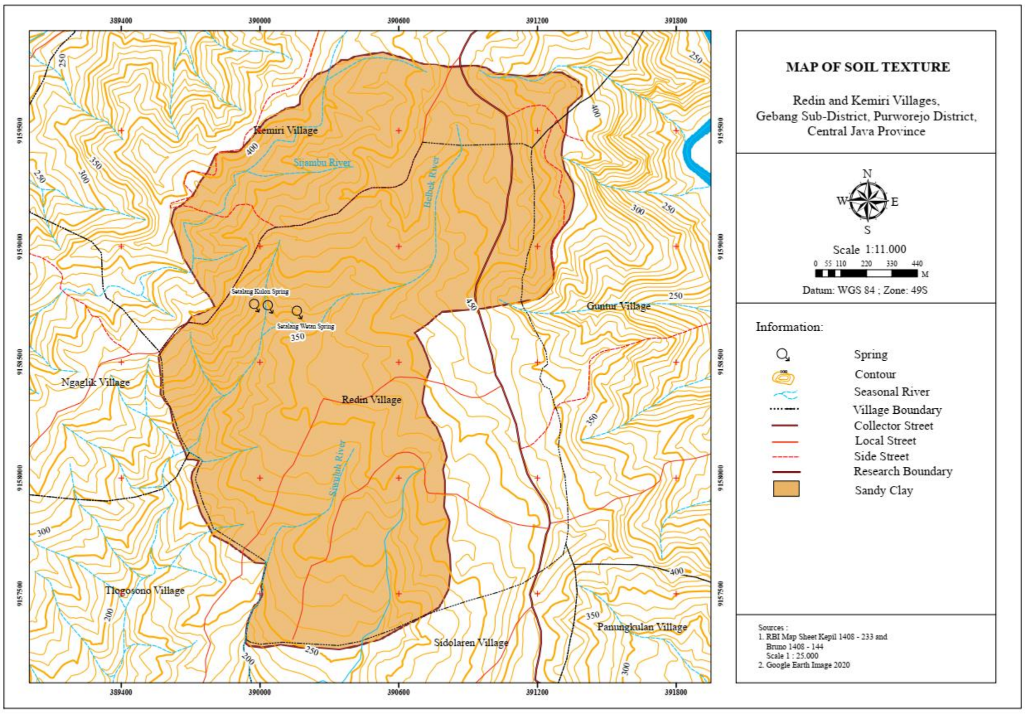

Figure 4. Map of Soil Texture

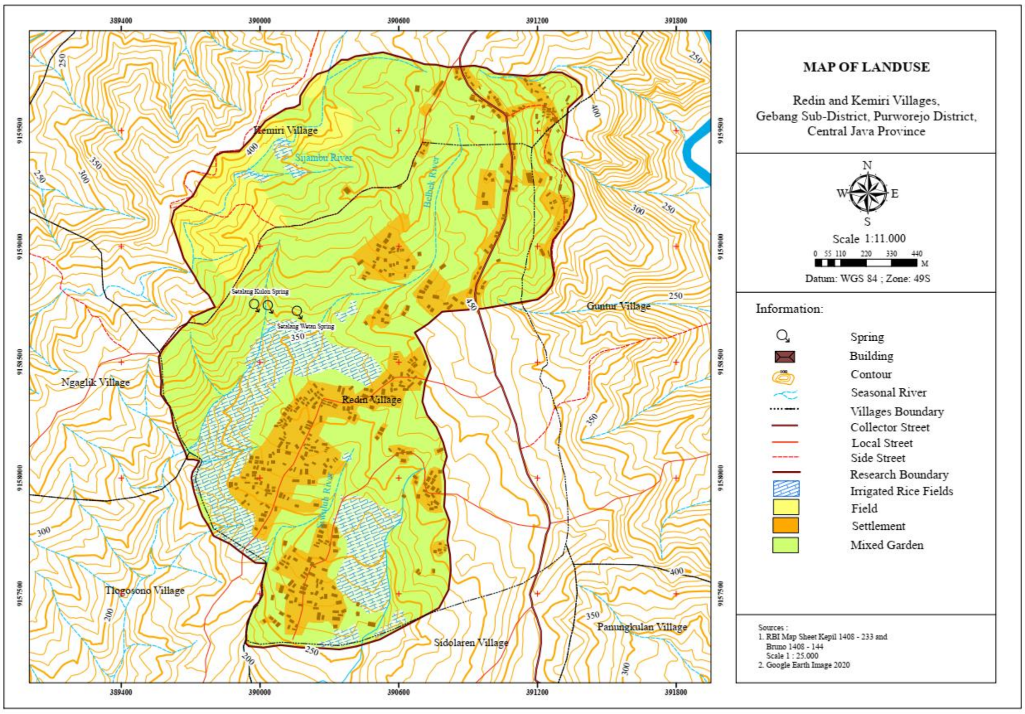

Figure 5. Map of Landuse

Tabel 6. Landuse

Spatial Classification	Score	Large of Area (Ha)	Pecentage (%)
Forest	5	0	0
Shrub	4	0	0
Field, Mixed Garden,	3	81,7271	57,90
Ricefield-Pond-Swamp	2	25,2226	17,86
Settlement	1	34,2121	24,24

Based on the scoring carried out on the four parameters above, there were three variations in the recharge area scores' value. These scores are the values 11, 12, and 13, which are included in the classification of medium-class affix areas. A score of 11 indicates that the area has a steep and rather steep slope and land use in the form of settlements and rice fields. For a score of 12, it has the characteristics of very steep slopes and mixed gardens. Then for a score of 13 it has regional characteristics in the form of land use in the form of settlements and rice fields and a steep and rather steep slope. The scoring results are visualized in the form of a map which can be seen in Figure 6. Medium class scoring shows that the recharge area still needs to be managed to maintain its sustainability. This sustainability is manifested in the quantity and quality of springs that can meet the community's water needs. The quantity of water or the availability of water shows an indicator of the water carrying capacity. The carrying capacity of water includes aspects of fulfilling water needs and its availability (Santoso, 2015).

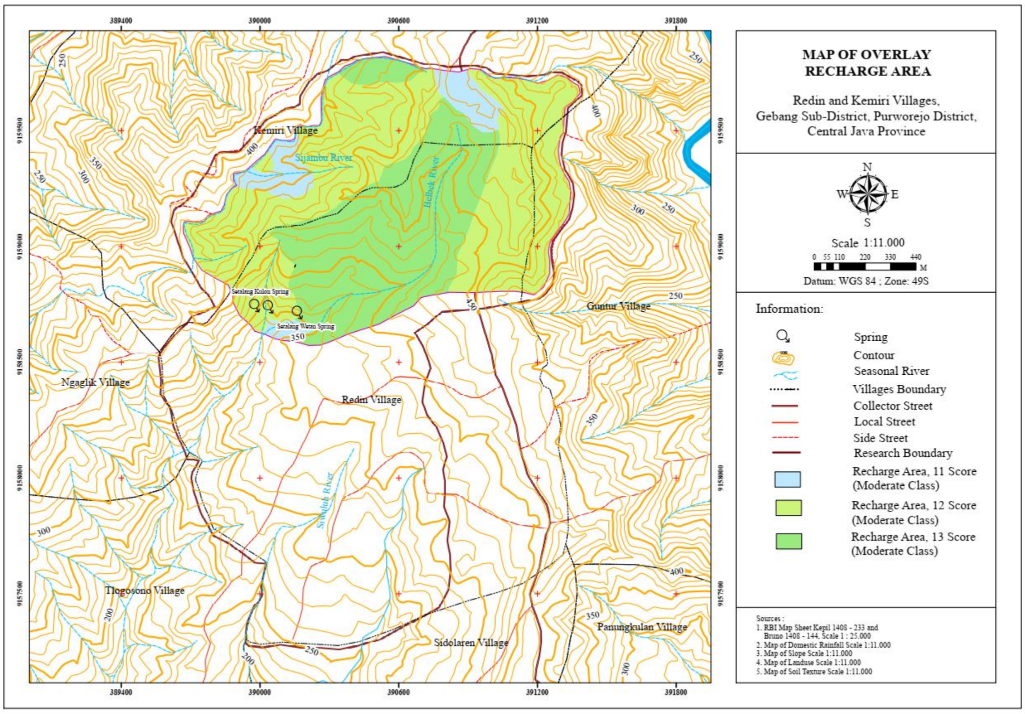

Figure 6. Map of Overlay Recharge Area

3.3 Conservation Directions

The use of springs by local people still uses simple technology. The three springs in the research location do not yet have a spring catcher so that the water that comes out is naturally stored in the basin around the spring (Figure 7). This can lead to the entry of pollutants in the form of litter and/or animal waste into the water body, which can interfere with water quality. The supporting infrastructure for springs found in the study area is reservoirs for springs that are scattered at several points. The container is still made and in dimensions that are not too big. The water distribution system is carried out using a pump system by flowing it through pipes to the spring users. The pump system is used because the spring users' elevation is higher than the point where the springs are located. Spring support infrastructure plays an important role in spring conservation so that water use can be maximized.

Land use in the recharge area becomes an important role because it affects the amount of water that will be infiltrated into the soil. Changes in land use into settlements need to be controlled so that the composition of areas capable of absorbing water is maintained not to affect the water discharge that comes out of the springs. Prastiwi et al (2019) stated that conservation recommendations for recharge areas could follow the zoning results of recharge areas based on the Zoning of the Imbuhan Areas according to the Minister of Public Works Regulation No. 2 of 2013. Based on the following explanation, the proposed conservation direction of the medium class recharge area is constructing a gulud terrace in the recharge area. As well as the construction of supporting infrastructure for springs such as catching tanks and water reservoirs.

Figure 7. Condition of Spring in Research Area

The spring catcher is made so that the spring is protected from pollutants that can interfere with water quality. The design for catching tubs and storage tanks for springs is carried out under the Technical Guidelines for the Implementation of Simple Drinking Water Infrastructure provided by the Directorate of Human Settlements (2007). The dimensions of the tub are calculated and adjusted to the number of residents who use the water and the amount of water discharge that comes out of the spring (liters/second). Obtained a reservoir with a volume of 10 m2 so that the dimensions of the tub designed are 250 x 200 x 100 cm for length x width x height. The reservoir and spring catcher can be seen in Figure 8 and Figure 9.

Mixed gardens dominate the land use contained in the recharge area. The garden is still not well managed, so that technical conservation is needed for the surrounding area. Gulud terrace is one of the conservation directions that can be applied. Gulud terrace has the advantage that it does not change the geometry of the slope. The mound terraces are carried out by making same direction mound as the contour, with a maximum distance of 4x4 meters per mound (PermenHut No. P.4 Year 2011). Existing mound will be made a hole/excavation which will be filled with woody plants. The recommended wood plant is teak. Teak is a local endemic plant that can be found in the research area. In addition, around the mounds can also be planted with grass. This grass plant can be elephant grass. The grass around the mounds can function to prevent erosion and runoff. Making gulud terraces can follow the guidelines in

Permenhut P.04 / Menhut-II / 2011. The following is an illustration of the gulud terrace which can be seen in Figure 10.

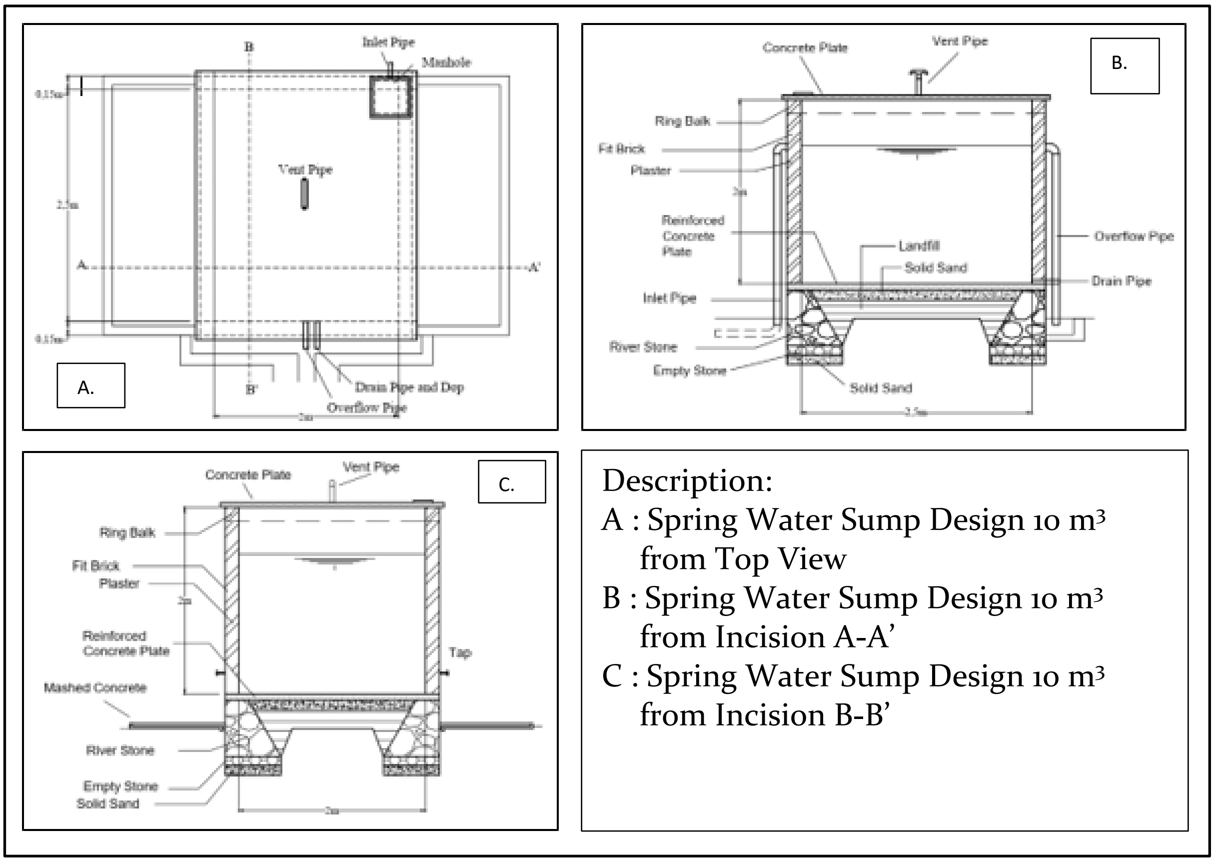

Figure 8. Design of Spring Water Sump

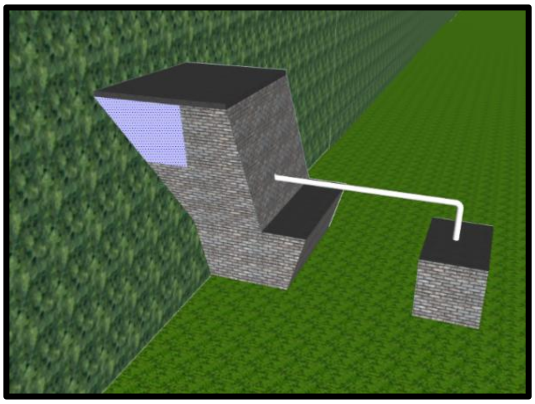

Figure 9. Design of Spring Water Catcher and Spring Water Sump

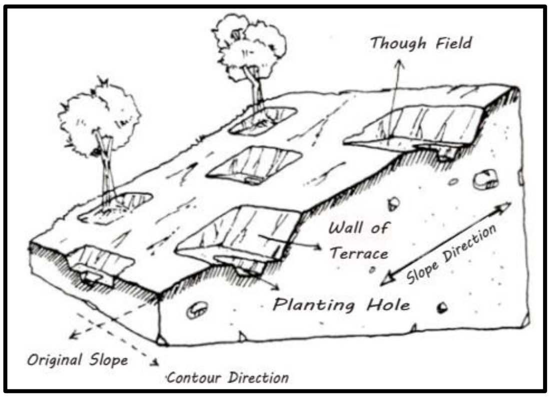

Figure 10. Design of Individual Terrace (Source: Permenhut P.04/Menhut-II/2011)

4. Conclusion

Based on the research that has been done, it was found that the recharge area of springs is included in the medium class recharge area with a value range of 11-13. Rainfall and land use have the greatest score in scoring. This score indicates that the recharge area still needs to be conserved to maintain its sustainability. The conservation direction is in the form of a technical approach, namely the hillside terrace and spring support buildings. Conservation efforts need to pay attention to the local RTRW, considering that the research area is included in a protected area and a water area. The proposed conservation directions need to consider the existing conditions of the study area.

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