Spatial Analysis of Water Springs Potential in Sub Drainage Basin Hulu Jeneberang South Sulawesi Province

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Abstract. This study aims to describe the potential of water springs in the Sub Drainage Basin Hulu Jeneberang using remote sensing and Geographic Information System. There are 5 variables taken into consideration: rainfall intensity, topography, groundwater basin, fault density dan vegetation density. The results showed that there are three classes of water springs potential. Most of the area are in the moderate class, covering an area of ± 233 km² (59.44%). The high potential class are scattered around Bili-bili Dam and the upstream areas of Sub Drainage Basin Malino, Takapala, and Sub Drainage Basin Koaisi with an area of 77 km² (19.62%), while low potential class covering area of 82 km² (20.92%). In the medium class area, the water only flowing in the rainy season and soon afterwards, but not in the dry season.

Keywords: water resources, drainage basin, remote sensing, geographic information system, Jeneberang.

1. Introduction

Water is a very vital in life [1]. The population of the earth is growing so that the need for water is also increasing, while the hydrologic condition is relatively constant because it only experiences a cycle or circulation of water on earth. To meet the water needs during the dry season, a groundwater source is needed. The formation of groundwater follows the water cycle principles which is known as the hydrological cycle, a natural cycle that is sequentially continuous [2]. Springs are the discharge of groundwater that appears on the ground as a flow from a concentrated groundwater flow [3].

The origins of springs are classified into springs caused by non-gravitational forces, and springs caused by gravity. The springs that are produced by non-gravity include: volcanic springs, crevice springs, warm springs, and hot springs. Gravity springs are classified into several types, namely: depressed springs that occur when the groundwater surface is cut by topography; contact springs that occur when an aquifer lies over an impermeable layer; artesian springs emerging from confined aquifers; and turbulent springs that exist in natural channels in the Earth's crust, such as lava caves [4]. Spring water commonly used as a potential source of water which has been used as the main source of clean water, especially by the
Regional Drinking Water Company, also by bottled drinking water companies and the general community. Spring water that comes from deep groundwater, is almost not affected by the season, and the quantity or quality is the same as deep groundwater [5]. Ground water is the part of water in nature that is below the ground surface. The formation of groundwater follows a cycle of water circulation on earth called the hydrological cycle, which is a natural process that takes place in water in nature, which changes places sequentially and continuously [2]. Spring water potential varied according to rainfall intensity, topography, geological unit where there ada fault density, geohydrological situation include the groundwater basin and the vegetation density [6, 7].

2. Methods

2.1 Study Area
Study area located at the sub drainage basin Hulu Jeneberang, western slopes of Lompobattang volcanic covering an area of 392 km². The coordinates are at 119° 34’ 5” to 119° 57’ 37” East Longitude, and 5º 10’ 60” to 5º 20’40” South Latitude.

Figure 1. Study area

2.2 Research Data
Data used in this study include 1. Landsat 8 satellite image of September 2019; 2. Topographic map of South Sulawesi 1:25,000; 3. Geologic map of Gowa District; 4. Geohydrological map of Jeneberang Drainage Basin and 5. Rainfall intensity of Gowa District and location of the meteorological station data.

The satellite image was processed using Soil Adjusted Vegetation Index (SAVI), then classified into 4 classes: distant, medium, dense, and very dense. For each class, then determined 5 sampling points for field observation. Topographic map was used as a base to create elevation map. Geological map showed the drawing of the fault density. Geohydrological map was used to differentiate the area of groundwater basin and non-groundwater basin. Rainfall data and meteorological station location were combined to create the rainfall map of Jeneberang Sub-Drainage Basin area. After that, all maps were overlayed then
combined with a scoring system the spring water potential were determined. The classification and scoring system of spring water potential described in Table 1.

| Variables            | Criteria          | Class     | Score |
|----------------------|-------------------|-----------|-------|
| Rainfall [mm/year]   | ≤ 2500            | Low       | 5     |
|                      | >2500 - 3000      | Moderate  | 10    |
|                      | >3000 - 3500      | High      | 15    |
|                      | >3500             | Very high | 20    |
| Elevation [m]        | 16 - 466          | Low       | 16    |
|                      | 467 - 1010        | Medium    | 12    |
|                      | 1011 – 1692       | High      | 8     |
|                      | 1693 -2848        | Very high | 4     |
| Vegetation density   | 0,02 – 0,11       | Distant   | 1     |
|                      | -0,02 – 0,02      | Moderate  | 2     |
|                      | -0,05 – -0,02     | Dense     | 3     |
|                      | -0,13 – -0,05     | Very dense| 4     |
| Geohydrological      | Groundwater basin | High      | 4     |
|                      | Non-groundwater basin | Low | 2     |
| Fault density (%)    | 4,03              | Low       | 3     |
|                      | 5,57              | Medium    | 6     |
|                      | 9,7               | High      | 9     |
|                      | 23,57             | Very high | 12    |

After adding up the score from the parameter, then the spring water potential is classified into:

| No | Class | Class Interval | Spring potential |
|----|-------|----------------|------------------|
| 1  | I     | ≤ 28           | Low              |
| 2  | II    | 29 – 42        | Moderate         |
| 3  | III   | ≥ 43           | High             |

3. Results and discussion

3.1. Rainfall

The annual average rainfall in the Sub Basin Hulu Jeneberang ranges from 2400 mm/year to more than 3700 mm/year. The rainfall is classified into 4 classes, namely; low, moderate, high, and very high. The rainfall map was made using isohyet method by ArcGIS 10.4. Very high class rainfall at Senre Station in the western part of the Bili Bili Dam covering an area of 12 km² (3.06%), the widest rainfall class is the high class rainfall covering 232 km² (82.40 percent) located at the western and eastern part of the study area, the moderate rainfall class located in the middle of the sub basin covering 130 km² (33.16%) whilst the low rainfall are located in the middle - southern parts of the sub basin covering area of 18 km² (4.59%). Rainfall in the Sub Basin Hulu Jeneberang is not evenly distributed because it is influenced by altitude and wind direction factor. The rainfall is higher to the North and to the West. High rainfall on the
slopes of the Lompobattang volcano. Rainfall and supported by lithological factor are main factors of spring presence in an area. Volcanic slopes are an area that has the potential for large springs, in general Strato volcanoes in Indonesia [6]. There is a strong correlation between rainfall and groundwater availability, when the rainfall is low, the availability of groundwater is also low [8].

![Rainfall map of Sub Basin Hulu Jeneberang](image)

**Figure 2.** Rainfall map of Sub Basin Hulu Jeneberang

### 3.2. Elevation

The elevation of the location are the heights above the sea-level. The elevation of the Sub Basin Hulu Jeneberang area can be differentiated into 4 classes: low (< 466 m), medium (466 – 1010 m), high (1010 – 1693 m) and very high (> 1693 m). The low elevation class covering area of 143 km$^2$ (36.48%), spread from the middle to the west of the sub basin. Medium elevation located in the middle of the sub basin covering area of 142 km$^2$ (36.22%), high elevation located at the eastern part with an area of 82 km$^2$ (21.92%) and very high elevation class located at the southeastern part of the sub basin covering small area of 25 km$^2$ (6.38%). Elevation of an area influence the spring water potential because if elevation is higher, then the rainfall is also higher [10, 11].

### 3.3. Vegetation density

Based on Soil Adjusted Vegetation Index (SAVI) analysis from Landsat 8 satellite image, there are 4 classes of vegetation density: distant, moderate, dense and very dense. The widest class is the very dense class, covering area of 171 km$^2$ (43.62%), located mostly at the upstream part of the sub basin. Area with distant vegetation mostly located at the plain with paddy field, dryland plantation (secondary crops and vegetables), covering area of 53 km$^2$ (13.52%). Other classes scattered between upstream and the plain area. In hydrologic cycle vegetation can reduce run-off and also increase infiltration so the denser vegetation in an area, the source of groundwater is also higher. Vegetation density has positive correlation with water source potential [12].
3.4. Geohydrological

The groundwater basin in Sub Basin Hulu Jeneberang area is 187 km$^2$ (47.70%), scattered in the upstream eastern part. The non-groundwater basin spread from middle part to the western part with area of 205 km$^2$ (52.30%). The groundwater basin located mainly at Lompobattang volcano Formation and Baturape Cindako Formation. Lompobattang volcano is a strato volcano which consist of interbedded fine and coarse pyroclastic material and also consist of lava. This condition provides an opportunity for precipitation to infiltrate and forming groundwater reserves.
Fault density is obtained from calculating the percentage of fault length to the width the rock formation area. The most extensive is the low fault density class of 187 km$^2$ (47.70%), spread from upstream to the West downstream. Then the area without faults 124 km$^2$ (31.63%), are spread from upstream to downstream towards South. Very high fault density with area of 21 km$^2$ located at the upstream of sub basin Malino and middle part of southern Jeneberang. The high fault density is at the Baturape-Cindako volcanic rock formation. Faults can cut the aquifer which can produce springs [7].
3.6. **Spring Water Potential**

There are three classes of potential springs in Sub Das Hulu Jeneberang, namely; low, moderate, and high. Most of the moderate potential is 233 km$^2$ (59.44%), spread almost evenly throughout the Hulu Jeneberang Sub-Basin area. Low potential class covering an area of 82 km$^2$ (20.92%), scattered in the middle of the basin, and high class covering an area of 77 km$^2$ (19.62%), scattered in the upstream part of the basin. The spring water potential of springs is determined by 5 factors: rainfall, elevation, fault density, groundwater basins, and vegetation density. In areas with high potential for springs, also have high rainfall, high elevation, groundwater basins area, high fault density and high vegetation density.

![Spring water potential map of Sub Basin Hulu Jeneberang](image)

**Figure 7.** Spring water potential map of Sub Basin Hulu Jeneberang

**Table 3.** Classification of spring water potential in Sub Basin Hulu Jeneberang

| No | Total Score | Class   | Width (km$^2$) | Percentage (%) |
|----|-------------|---------|----------------|----------------|
| 1  | ≤ 28        | Low     | 82             | 20.92          |
| 2  | 29 – 42     | Moderate| 233            | 59.44          |
| 3  | ≥ 43        | High    | 77             | 19.62          |
|    | Total       |         | 392            | 100.00         |

4. **Conclusions**

Spring water potential in Sub Basin Hulu Jeneberang is mostly in moderate class. Factors that determined the potential are interrelated to each other, but the major factor is rainfall. At the moderate potential class, the spring water flows only in rainy season and soon afterwards, but not in dry season.
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