Water balance analysis of springs in Banjarasri Village, Kalibawang Sub-District, Kulonprogo District

L.W. Santosa and A. Harsanti

1Department Environmental Geography Faculty of Geography, Universitas Gadjah Mada

wahyus1972@gmail.com

Abstract. Water is essential for all living things and has an important role in human life. A spring is groundwater that comes to the ground surface naturally and centrally and forms a water flow. Springs is important and vital for some region in providing water sources. One of the regions using springs as the main water resource is Banjarasri Village. The usage of spring should be recked to avoid lack of water in the future. The objectives of the study were (1) to calculate the availability of springwater in Banjarasri Village, Kalibawang Sub-District, Kulonprogo Regency (2) to calculate the water demand based on domestic use and livestock utilization in Banjarasri Village, and (3) calculate the water balance of spring. The method used is a survey and field measurements to counting the availability of springwater, interviews to determine the amount of water demand, and the water balance method to analyze the amount of water availability and demand. The availability of total water in the dry season is 138,544 m$^3$/year, while the rainy season is 227,888 m$^3$/year. The total water needed is 91,200 m$^3$/year consisting of domestic water needs and livestock water needs. The results of the water balance calculation show the total water availability can meet the water needs of the population in one village, but the uneven distribution causes some hamlets to have deficit water. The dry season surplus is 47,343 m$^3$/year, while the rainy season surplus is 137,220 m$^3$/year.

1. Introduction
Water is essential for life on Earth, and the largest source of fresh water are lies under earth’s surface. Water is a dynamic resource, which has a high variability of space and time. Based on Undang-Undang No. 7 Tahun 2004 about Water Resources, water resources are defined as any kind of water, water sources, and water resources that are located above and below the earth's surface, which includes groundwater, surface water, and rainwater.

Groundwater is one of the water resources that have good quality supported by abundant availability at certain locations [1]. The groundwater utilization is not only formed as wells but also formed as springs. Spring is a discharge of groundwater that appearing to the ground surface naturally and centrally as a current of flowing water [2]. Springs cannot be found in all of earth's surface, it's only forms in current potential area. The potential area of springs is different from each other, depending on the recharge area and the magnitude of recharge which will affect the magnitude of
springs discharge [3]. Groundwater has the best quality compared to rainwater or surface water, which is influenced by the type of lithology [3,4].

Springs come from groundwater. Groundwater is filled by surface water or rainwater, which the area that filling aquifer referred to a recharge area while the area for groundwater withdrawal is called a discharge area. Discharge of springs varies that depends on the condition of the recharge area and amount of the recharge [2]. Springs discharge is also influenced by the character of aquifers, topography, amount of rainfall, and geological structure. The condition of the recharge area greatly influences groundwater and spring conditions because it affects the amount of rainwater that will infiltrate [5]. The flow of spring are always fluctuating due to variations in the level of recharge based on geological and hydrological conditions.

Banjarasri is a village in Kalibawang sub-district, Kulonprogo Regency were almost all population use springs as the main water source to meet their needs. According to the data [6] wells and springs are the most widely used water sources, both used as drinking water and for domestic uses. Kalibawang Subdistrict is one of the areas that encounter drought in almost every year, and also includes Banjarasri Village which cause a reducing discharge of spring.

Banjarasri is located on slopes of Perbukitan Menoreh with a varies of topography, ranging from flat to steep but dominated by a gently sloping and strongly sloping. The topographical conditions causing bad distribution access for clean water, especially in Banjarasri that has not been provided by PDAM (local water company). All residents fulfill their clean water demand by utilizing spring water or wells, with most of them using spring water as a water source. There are 20 springs in Banjarasri that have different characteristics and get different management, depending on the policies of each hamlet. Generally, the springs always flow every year in different amount of discharge between the rainy season and the dry season. The condition of spring discharge in the dry season tends to be lower than rainy season, but it can still meet the needs with limited conditions. Springs located in Banjarasri are shown by Figure 1.

Figure 1. Springs Located in Banjarasri
The problem that arose in the study area was the water drought in the dry season at several areas in Banjarasri. The drought indicates that Banjarasri can have a water deficit in the dry season, while in the rainy season the water will be more abundant. According on those issue, this study focused on water balance analysis of springs. The objective of this study were to knowing the characteristics and potential of springs in Banjarasri, Kalibawang, Kulonprogo; counting the water needs based on domestic purpose and animal husbandry in Banjarasri; and calculating the water balance of springs for the needs of domestic uses and animal husbandry in the village of Banjarasri.

2. Methods
The data used in this study are consist of primary data and secondary data. The primary data used are spring distribution, spring discharge, quality of spring water, and data of the amount of water needed by the population of Banjarasri Village. This data obtained from the field observations and interviews. The secondary data needed is institutional data obtained from the local government in Banjarasri and other related agencies. Data obtained from the local government of Banjarasri are the distribution of springs, population data, and livestock data. Other data needed is data related to Kalibawang Subdistrict administration boundary from the official website of Daerah Istimewa Yogyakarta government.

The characteristics of springs are examined through the results of measurements of the quantity and quality of springs. The quantity of springs is known by calculating springs discharge. The characterization of springs is based on the classification of springs according to the amount of discharge, springs occurrence, and the flow. The quality of springs based on quality is reviewed based on several parameters such as temperature, pH, electrical conductivity. Potential spring is calculated based on data quality and quantity of spring by the scoring method that considers several parameters.

Water demands that will be measured are domestic and livestock uses because most of springs in Banjarasri are widely used for these needs. Analysis of water demand is done by descriptive analysis, which explains the total water demand in Banjarasri by calculating the number of domestic uses and livestock uses. The total water demand value indicates the amount of water that must be available to meet daily needs.

Water balance analysis is shown by the water balance method, which comparing the availability of water with water demand. The method used is the modified water balance in accordance with Indonesian National Standard Agency [7]. The water balance of springs is presented in the form of a table with 3 main rows, namely as an active column, passive column, and the balance column. The active column used to indicate the amount of water availability, i.e. the amount of spring discharge in Banjarasri. The passive column used to indicate various types and amounts of water demand which include domestic uses and livestock uses. The balance column provides reserves from the difference between the amount of water availability and demand.

3. Result and Discussion
The result of the research were presented on the parameters of water balance calculation, such as water availability of springs, water demand, and calculation of water balance

3.1. Water Availability of Springs
Banjarasri has 20 springs which are spread in several hamlets, such as Dukuh, Kalijeruk, Kembangsari, Kalisoka, Ngelebeng, Paras, Semak, Sumbersari, Tirip, and Tosari which are used as the main water source. The springs distributed using PVC hose or pipe from the spring to the houses, depending on the elevation of the spring. The spring in high elevation distributed by the force of gravity to reach the lower area. Low elevation springs are pumped to get to the houses.

Most of the springs in Banjarasri is a depression spring. Depression springs occur because the saturation zones appear to the ground surface which generally occurs on buckling slopes. The springs are the Kaliwates spring, Kalikendil, Kalilangon, Kembangsari, Tosari, Sawit, Semak, Winong, Mbladeran, Kalilangan, Kaliwedok, Njurugan, Kalibendo, Kalijeruk, Kalipojok, and Kalideso. Quality and quantity of these springs are easily influenced by the surrounding environment and easily
contaminated by human activities [7]. Spring of Mbalong and Pancuran Gondang occur due to contact between impermeable rocks and permeable rocks, which referred to contact springs. These conditions are known based on geological maps that show the location of springs at the confluence of two formations. Tuksongo and Sumbersari springs are structural springs that occur due to cracks in impermeable rocks, so that groundwater can pass through the rocks and appear as springs. Generally, these springs are formed naturally on compact rocks, which have low permeability [8].

The twenty springs in Banjarasri are perennial springs, which flow throughout the year and not affected by rainfall. Springs discharge are always fluctuates. Spring discharge is influenced by conditions in the recharge area and the amount of water infiltrated [9]. Factors that influence springs are rainfall, surface hydrological characteristics, topography, aquifer formation, and geological structure [10]. Springs discharge is classified by modified Meizner classification. The majority of spring water discharge classified into class V, which is the worst class in the classification. Banjarasri is formed by formation of the Kebobutak, Sentolo, and Kolovium. There were formed in the tertiary period (at late Oligocene) to the quarter (at the Pliocene). According to [11], years of formation will affect the capability of aquifers, that older rock has less discharge than the younger. Based on this theory, it is reasonable if the springs discharge in Banjarasri are relatively small because of the old formation.

Spring water availability is the amount of water available and can be used for all purposes in a location continuously over a certain period of time [12]. Water availability is calculated based on the calculated discharge spring in each hamlet. Spring discharge increases during the rainy season because of the rainwater which can increase groundwater discharge. The average discharge springs in Banjarasri in the dry season is 13,854 m³/year, while in the rainy season is 22,788 m³/year.

### Table 1. Water Availability in Banjarasri

| No | Name of Hamlets | Discharge of Dry Season | Discharge of Rainy Season |
|----|-----------------|-------------------------|---------------------------|
|    |                 | litre/second            | m³/year                   | litre/second            | m³/year                   |
| 1  | Nglebeng        | 0.36                    | 11,324.40                 | 0.62                    | 19,407.20                |
| 2  | Kembangsari     | 0.14                    | 4,386.38                  | 1.18                    | 37,177.23                |
| 3  | Tosari          | 2.10                    | 66,334.91                 | 2.44                    | 77,002.72                |
| 4  | Semak           | 0.06                    | 1,805.67                  | 0.06                    | 1,930.78                 |
| 5  | Tirip           | 0.36                    | 11,431.12                 | 1.11                    | 34,964.09                |
| 6  | Kalisoka        | 0.09                    | 2,767.80                  | 0.14                    | 4,290.48                 |
| 7  | Paras           | 0.23                    | 7,278.94                  | 0.29                    | 9,209.71                 |
| 8  | Dukuh           | 0.35                    | 10,889.50                 | 0.31                    | 9,848.84                 |
| 9  | Kalijeruk       | 0.54                    | 17,155.46                 | 0.52                    | 16,259.02                |
| 10 | Sumbersari      | 0.16                    | 5,169.73                  | 0.56                    | 17,798.13                |

### 3.2. Water Demand

Domestic use is water used to meet household needs including drinking water, bathing, watering plants, washing clothes, and toilets [13]. Domestic use in Banjarasri are calculated based on the amount of water used daily. Utilization of water is counted by the number of water needs per person multiplied by the number of inhabitants per village. The average amount of water use in Banjarasri is 97.13 Liters per day per person. Compared with the standard number of water needs according to the Indonesian National Standard [6], the amount of water demand in Banjarasri Village is included in the middle category between the rural population (60 Liter/day/capita) and the urban population (120 Liter/day/capita). The average amount of water demand per hamlet is 10,460 Liters/day.

Livestock water use are the amount of water demand by farmers to meet the water uses for livestock, both for drinking, eating, and cleaning the cage [13]. Livestock raised in Banjarasri are big
livestock such as cattle and buffalo, medium livestock such as sheep and goats, poultry, and pigs. Animals that need the most water are the big livestock, which is around 14.9 liters/day, pigs around 6 liters/day, medium livestock around 1.58 liters/day, and poultry around 0.95 liters/day. The average number of farm water requirements in Banjarasri is 512.7 m$^3$/year.

Total water demand are the amount of water needed by residents to meet their daily needs, including domestics uses and livestock uses. The total water demand in Banjarasri is shown in Figure 2. The total amount of water demand by residents in Banjarasri is 91,200 m$^3$/year with an average per hamlet requiring 9,120 m$^3$/year of water. The hamlet that needs the most water is Tosari, which is 23,353 m$^3$/year. Nglebeg requires water 15,497 m$^3$/year, Kembangsa 4,573 m$^3$/year, Semak 3,996 m$^3$/year, Tirip 8,531 m$^3$/year, Kalisoka 3,334 m$^3$/year, Paras 9,919 m$^3$/year, Dukuh 6,890 m$^3$/year, and Kalijeruk 13,087 m$^3$/year. Springs is dominated for domestic use and a small portion is used for livestock uses.

![Figure 2. Graphic of Water Needed in Banjarasri](image)

### 3.3. Water Balance of Springs

Water balance of spring made based on the availability of spring water discharge and water demand based on the needs of residents of the spring. The total spring resource balance in Banjarasri shows a surplus in both dry and rainy seasons. The surplus in the dry season is 47,343 m$^3$/year while the rainy season is 137,220 m$^3$/year. The amount of surplus in the rainy season is larger than dry season due to the addition of rainwater, while the dry season only relies on groundwater storage. Surplus or water deficit is a dynamic condition and influenced by the population and number of livestock that always changes every year, as well as the amount of annual rainfall in Banjarasri. Water Balance of Spring in Banjarasri shown on Table 2.

| No | Spring Water Balance | Unit | Dry Season | Rainy Season |
|----|----------------------|------|------------|--------------|
| 1  | Water Availability   | m$^3$/year | 138,543.90 | 227,888.20   |
| 2  | Water Demand         | m$^3$/year | 91,200.38  | 90,668.15    |
| 3  | Balance              | m$^3$/year | 47,343.52  | 137,220.06   |

In general, throughout the year Banjarasri had a surplus of water. Some hamlets have a surplus in the dry season, but some others have a deficit. This condition is influenced by the characteristics of springs in each hamlet that varies based on the number of recharges and its condition. Pancuran Gondang springs are springs with the largest discharge, which influenced by the amount of water
recharge both in the dry season and the rainy season. It is different from Kalideso spring that has a small discharge because the amount of recharge is small too. There are other several hamlets that have deficits water shows that the distribution of spring water in Banjarasri has not yet been integrated.

4. Conclusion
Banjarasri has 20 springs that spread in several hamlets with varied characteristics. The total discharge of Banjarasri in the dry season is 138,544 m$^3$/year, while the rainy season is 227,888 m$^3$/year.

The average water demand in Banjarasri is 97.13 liters/person/day, which the total domestic uses is 86,586 m$^3$/year. The amount of water uses for big livestock is 1,666 m$^3$/year, medium livestock is 365 m$^3$/year, poultry is 834 m$^3$/year, and pig is 1,747 m$^3$/year. The total livestock water uses is 4,614 m$^3$/year. Total water demand in Banjarasri is 91,200 m$^3$/year with an average per hamlet requiring 9,120 m$^3$/year of water.

Water balance of spring is made based on the amount of spring water available and the amount of spring water needed. The results obtained are surpluses in both seasons. The dry season surplus is 47,343 m$^3$/year, while the rainy season surplus is 137,220 m$^3$/year. The availability of spring water is sufficient for the villager, but it has not been evenly distributed, so it causing deficits in several hamlets.

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