Underground river resources potential in Gunungkidul regency for drinking water

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Abstract. Gunungkidul has the potential for raw water from underground rivers with a discharge reaching 1,000 lps. This river is in the middle zone of Gunungkidul Regency and has not been used optimally. This study aims to analyze the condition of water supply in Gunungkidul Regency and to plan the development of water supply in Gunungkidul Regency. The methods used in this study include direct measurement, surveys, and interviews. From the analysis it was found that the available underground river discharge capacity in Gunungkidul Regency was 5,756 lps, while the water demand for each district after accumulation was 4,030 lps. The difference between the available discharge capacity and the water needs of Gunungkidul Regency is 1,726 lps. Furthermore, the discharge capacity of 5,050 lps has not been utilized in Gunungkidul Local Water Company. To reduce the difference in discharge capacity, a regional drinking water supply system originating from the Gunungkidul Regency can be made for several districts in the Special Region of Yogyakarta.

1. Introduction
In the last 20 years, the world has been hit by a catastrophic drought, a deficiency of precipitation [1]. All of continents around the world have experienced it, America [2,3,4], Europe [5,6,7,8], Asia [9,10,11], Australia [12,13], and Africa [14,15,16] due to climate change crisis. All of this natural hazard will have negative effect on people or environment which is further aggravated by growing water demand [17]. Recent years, Indonesia is also susceptible to experience drought, especially in Java island caused by global warming, environmental degradation, increased population. Water deficit has been experienced by around 77% of regencies and cities in Java in a year for one to eight months [18].

One source of water needs is surface water, such as rivers, which being used for agriculture [19], hydroelectric power plants [20], domestic use [21], etc. But, the ecological security of the River water resource is not guaranteed [22] due to the water scarcity is to a large extent because of the excessive irrigation development which breaks the balance between the water supply and demand in the river basin [23]. Otherwise, in Gunungkidul Regency there is an abundant river whose water sources are located underground, even though the surface water is dry or has little water flow. This is due to the characteristics of the karst soil which recharge in this area also occurs by direct infiltration of rainfall into the aquifer [24].

There is no research on this matter and water sources have not been used optimally. In this research, we will study how much water potential that can be optimized from several underground river water
sources. Previously, residents of Gunungkidul district used clean water from the Regional Drinking Water Company, Village Drinking Water Distribution, and wells [25].

The goal of this study is in further research, infrastructure can be designed to support domestic and non-domestic needs of residents (sanitation, fisheries, livestock, etc.). In addition, to increase the economic value of Gunungkidul Regency, some tourism can also be developed by utilizing this abundant source of raw water from the Underground River.

2. Methodology
This research method includes the stages of data collection and data analysis. The results would be used as reference for the upcoming researches. For instance, the development system of supplying water in Gunungkidul Regency.

2.1 Data collection
Data collection techniques are one way of obtaining data that functions to make a general plan. Primary data required is existing data in the study area (water discharge measurement) and the condition of the location studied through a field survey and using procedures that fit the research problem best [26].

Procedures that implemented in this research are SNI 03-2414-1991, SNI 03-2819-1992, and SNI 03-2820-1992 for open channel measurement. Meanwhile in this research, the data sets that have been collected are in the form of administrative data for the study area, a map of the study area, the minimum population of the study area for the last 5 years, water service zone, and existing data. In data collection, data can be obtained using data held by relevant government agencies, such as Local Water Company, Central Statistics Agency, Public Works Services of Cipta Karya, and Development Planning Agency at Sub-National Level in Gunungkidul Regency and DIY Province. Besides, data also can be obtained by interviewing local people.

2.2 Data analysis
The stage of analyzing data in this research is projection of inhabitants, projection of water demand, determination amongst water demand and potential water, and potential water that could be optimized from the existing water services.

Population projection is a scientific calculation of the population in the future based on the assumptions of population growth components at a certain level where the results will show a trend of changes in population composition [27]. Population projection analysis can be done using several methods, namely arithmetic, geometric and least-square methods. To determine the appropriate method in projecting population numbers, it is done by comparing the linear regression values of each method in the calculation of population growth for the previous 5 years. The regression value that is closest to 1 (one) or the biggest itself indicates that the calculation of population growth will use this method [28].

The projection of water demand is useful for planning clean water supply facilities and systems to suit the needs so that they can serve according to capacity. The factor values of peak hours, maximum daily and leakage percentages are found in Regulation of the Minister of Public Work No. 27 year 2016 about Operation of Drinking Water Supply Systems. The discharge of water usage for each person is assumed to be based on the director general of creative works year 1996. Then, comparing water needs and potential water and resulting water discharge that could be optimized from the existing water services.

3. Results and discussion

3.1 Characteristics of underground water resources
Local Water Company of Gunungkidul Regency utilizes the Underground River to meet the needs of clean water. Along with climate change and environmental damage that occurs, the presence of underground river water discharge in Gunungkidul has decreased. Lack of rainfall due to the effects of climate change results in the least amount of rainwater that infiltrates and is stored in the soil layer, even
during the long dry season the river discharge decreases by up to 50%. The existence of Underground River in Gunungkidul Regency can be seen at table 1.

Table 1. Underground river potential in Gunungkidul Regency.

| Underground River | Capacity (liters/sec) | Used/exploited (liters/sec) |
|-------------------|-----------------------|----------------------------|
| (a) Bribin¹       | 956                   | 65                         |
| (b) Ngobaran¹     | 180                   | 80                         |
| (c) Seropan²      | 2,400                 | 336                        |
| (d) Baron¹        | 1,080                 | 100                        |
| (f) Grubug²       | 680                   | -                          |
| (g) Toto²         | 260                   | -                          |
| (h) Sumurup²      | 200                   | -                          |
| **TOTAL**         | **5,756**             | **706**                   |

Source:
¹Local Water Company of Gunungkidul Tirta Handayani, 2012
²River Basin Development Agency of Serayu-Opak, 2013

The underground water source of Gunungkidul Regency is divided into 3 zones, namely the North Zone, the Central Zone and the South Zone. The North Zone has a depth of groundwater that is easily accessible so residents can dig wells there and do not need to be served by the Local Drinking Water Company. The Central Zone has a soil depth that is relatively accessible so that boreholes can still be made, although not as massive as the northern zone. As for the South Zone, there is no groundwater that can be drilled. This causes the southern zone to experience drought and for groundwater extraction it is necessary to trace to a high depth until a spring is found.

3.2 Existing condition
Local Water Company of Gunungkidul, as a drinking water provider in Gunungkidul Regency, is in 16 (sixteen) sub-districts with 49,873 house connections (Waterwork of Gunungkidul Technical data, 2019). To find out the existing number of served residents, it can be assumed that 1 house connection (SR) serves 5 people, so the following calculation will be obtained:

Number of residents served = The number of customers x 5 people
                           = 49,473 x 5
                           = 247,365 people

Percentage Served = \( \frac{\text{Number of Residents Served 2019}}{\text{Number of Existing Residents 2019}} \times 100 \% \)

\[ \frac{247,365}{742.731} \times 100\% \]

= 33.30% (has not fulfilled the vision of the Government)
3.3 Water Demand
The population is the basis for determining water needs in an area. It is well known that the population always increases every year. Which would be an important factor in domestic and industrial water demand, agricultural water demand is population growth [29,30,31].

It is determined that the planning year is 20 years, so that the population is projected until 2039. The total population in Gunungkidul Regency in 2039 is 978,532 people. The water demand is calculated based on domestic and non-domestic water demand of each district. The total of water demand is added by maintenance demand and multiplied by peak hour factor to be peak hour water demand [32,33]. The amount of peak hour water demand needed by the population of Gunungkidul Regency is 4,030 liters/second. The details of water demand of each district described on figure 2.

Figure 1. The existing water services in Gunungkidul Regency.

Figure 2. The details of water demand of each district in Gunungkidul Regency.


4 Conclusion

The potential capacity of Underground River in Gunungkidul Regency is about 5,050 liters/second. And the water demand for long term (in 2039) is about 4,030 liters/second. Which mean, there will be a water surplus in 2039 about 1,020 liters/second. Underground River in Gunungkidul Regency as potential water could supply water demand of Gunungkidul residents at many aspects, like domestic use, fisheries, tourism, and other non-domestic usage. The last 3 (three) aspects can also build economic sector growth in Gunungkidul Regency. This research would guide to the upcoming research, for instance, The Development of Water Services in Gunungkidul Regency.

References

[1] Hayes M, Svoboda M., Wall N and Widhalm M 2011 *Bull. Am. Meteorol. Soc.* 92(4) 485–488
[2] Changnon S A, Pielke R A, Changnon D, Sylves R T and Pulwarty R 2000 *Bull. Am. Meteorol. Soc.* 81(3) 437–442
[3] Cook E R, Seager R, Cane M A and Stahle D W 2007 *Earth-Science Rev.* 81(1–2) 93–134
[4] Cook B I, Ault T R and Smerdon J E 2015 *Sci. Adv.* 1(1) 1–8
[5] Voss R, May W and Roeckner E 2002 *Int. J. Climatol.* 22(7) 755–777
[6] Lehner B, Döll P, Alcamo J, Henrichs T and Kaspar F 2006 *Clim. Change* 75(3) 273–299
[7] Mishra A K, Singh V P and V R 2009 *Stoch. Environ. Res. Risk Assess.* 23(1) 41–55
[8] Vicente-Serrano S M et al. 2014 *Environ. Res. Lett.* 9(4)
[9] Zou X, Zhai P and Zhang Q 2005 *Geophys. Res. Lett.* 32(4) 1–4
[10] Mohamm A et al. 2013 *Agric. For. Meteorol.* 178–179 21–30
[11] Aadhar S and Mishra V 2017 *Sci. Data* 4 1–14
[12] Bond N R, Lake P S and Arthington A H 2008 *Hydrobiologia* 600 1–14
[13] Chiew F H S, Young W J, Cai W and Teng J 2011 *Stoch. Environ. Res. Risk Assess.* 25(4) 601–612
[14] Batterbury S and Warren A 2001 *Glob. Environ. Chang.* 11(1) 1–8
[15] Zeng N 2003 *Science* 302(5647) 999–1000
[16] Stringer L C, Dyer J C, Reed M S, Dougill A J, Twyman C and Mkambisi D 2009 *Environ. Sci. Policy* 12(7) 748–765
[17] Mishra A K and Singh V P 2010 *J. Hydrol.* 391(1–2) 202–216
[18] Maarif S 2013 *J. Sains dan Teknol. Indones.* 13(2) 65–73
[19] Al Masud M M, Gain A K and Azad A K 2020 *Land use policy* 92 104443
[20] Bongio M, Avanzi F and De Michele C 2016 *Adv. Water Resour.* 94 318–331
[21] Njuguna S M, Onyango J A, Githaiga K B, Gituru R W and Yan X 2020 *Process Saf. Environ. Prot.* 133 149–158
[22] Liu K K, Li C H, Yang X L, Hu J and Xia X H 2012 *Procedia Environ. Sci.* 13(2011) 1956–1965
[23] Chen Y, Zhang D, Sun Y, Liu X, et al. 2005 *Phys. Chem.* 30(6-7) 408-419
[24] Barrett M E and Charbeneau R J 1997 *J. Hydrol.* 196(1–4) 47–65
[25] Warih H A and Fajarwati A 2006 187–196
[26] Hox J J and Boeije H R 2004 *Encyclopedia of social measurement* pp 593–599
[27] Rezagama A 2016 *Jaringan Pemipaan Air Minum: Konsep, Teori, Aplikasi*, Edisi Pert. (Yogyakarta: Teknosain)
[28] Silva E A and Clarke K C 2002 *Comput. Environ. Urban Syst.* 26(6) 525–552
[29] Rosegrant M W and Cai X 2002 *Water Int.* 27(2) 170–182
[30] Rezagama A and Hadiwidodo M 2016 *ICSBE* 332–341
[31] Rezagama A, Sutrisno E, Susilo J, Tommy E and Ajulva N 2018 *Sustinere* 2(1) 52-64
[32] Sarminingsih A and Rezagama A 2019 *J. Phys. Conf. Ser.* 1217(1) 012134
[33] Rezagama A, Sarminingsih A, Zaman B and Handayani DS 2019 *J. Phys. Conf. Ser.* 1217(1) 0121592