

Analysis of Water Availability for Domestic Needs in Denpasar City

Wiyanti*, T B Kusmiyarti, N M Trigunasih and N Juwita

Center for Spatial Data Infrastructure Development (PPIDS) Universitas Udayana, Bali, Indonesia

wiyanti1259@yahoo.com

Abstract. This research aims to know the power carrying capacity of water for domestic needs in Denpasar City, Indonesia. Primary data collection techniques and field research using interviews to the people who directly need water for domestic purposes. Determination of the respondents was conducted by the method of purposive random sampling. The number of respondents that were used in this study was 100 respondents. The percentage of the number of communities that the fulfilment of the needs of the water comes from the PDAM as much as 38%, the well bore as much as 44% and 18% of the community's daily water needs fulfilment comes from the well dig. Most of the drinking water needs of the community in the Denpasar city, use bottled water. Water potential of Denpasar city run off coefficient calculation is 52.35 million m³/year. Water needs for domestic purposes of Denpasar city of 65,469,173 m³/year. A comparison between the availability of water by domestic needs is 0.9, which means the Denpasar city was included in the area that has water deficit.

Keywords: Water availability, Domestic needs, Denpasar

1. Introduction

The high rate of population growth, especially in urban areas will have an impact on the increase of water needs. The main human living needs come from the availability of adequate water. Fulfilling the need for water is one of them is taken from available water. Water conditions on the other hand are increasingly alarming, due to factors such as overcrowding, overfishing, damaged water catchment areas due to land conversion and environmental destructive activities. Water use utilization activities need to pay attention to the carrying capacity.

Water that is used continuously and excessively to meet the needs of the community will cause a decrease in quantity, so it is necessary to do water management steps to be used in a long time. Data / information on the need and potential of water resources is needed for the analysis of the fulfilment of domestic needs in Denpasar City. The purpose of this research is to analyses the potential of water availability for domestic water needs in Denpasar City.

Denpasar city, is the capital city and the centre of economic and service activities in Bali Province. It has a unique culture and its economic development relies on tourism and services. Since late 1970s, its urban population and economic development have grown fast resulting in fast growing settlements and rapid need for infrastructure and facilities [1]. This condition makes the population needs for water increased due to increasing of population and infrastructure and facilities.



2. Methodology

2.1. Area of Study

Area of study is located in Denpasar City, Bali Province, Indonesia. Geographically the research area is located between 08°36'56" – 08°42'23" south latitude and 115°10'23"–115°16'27" east longitude. The research location showed in Figure 1.

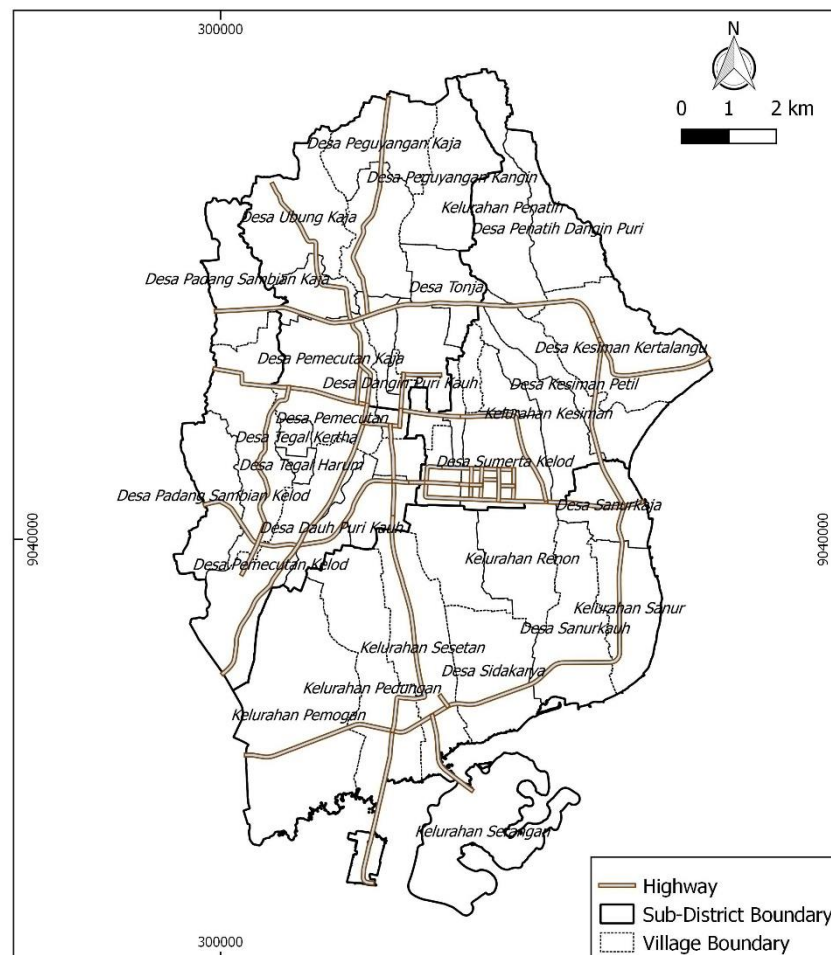


Figure 1. Research Location

2.2. Tools and Material

Materials for this study includes

- Population data of Denpasar City of 2016 from Bali Provincial Statistics Bureau 2015,
- Water potential data from Public Works Agency (PU)) and the Office of Energy and Mineral Resources (ESDM) and
- Data on the production and distribution of water from the regional drinking water company (PDAM) of Denpasar City.

Tools used in this research are:

- GPS (Global Positioning System) to determine coordinate point,
- Camera for field documentation, stationery to record the field data and
- A set of computer for the processing and presentation of data.

2.3. Data collection

Data collection method used in this research is primary data and secondary data method.

- Secondary data is obtained through literature review, reports and previous research results. The secondary data used in this study were obtained from Department of Mineral Resources (ESDM) of Bali Province, and the data of water production and water distribution of the drinking water company (PDAM) of Denpasar City.
- Primary data collection was obtained through field observation and interview. Field observation was held to re-check the calculation of water availability and to recalculate and re-check the domestic water needs for population in Denpasar City. Determination of respondents to be interviewed by purposive sampling method. Sampling by purposive method by taking samples based on the will of researchers based on certain criteria (area, population density, informal settlements).

2.4. Data Analysis

Data analysis includes the estimation of water availability and the water needs for domestic use.

2.4.1. Estimation of Water Availability. Estimation of water availability were determined using the runoff coefficient method based on landuse information and annual rainfall data as noted in Equation 1.

$$\begin{aligned} SA &= 10 \times C \times R \times A \\ C &= \sum (C_i \times A_i) / \sum A_i \\ R &= \sum (R_i \times A_i) / \sum A_i \end{aligned} \quad (1)$$

Annotation:

C : weighted runoff coefficient
 C_i : landuse i runoff coefficient
 A_i : landuse i area (ha)
 R : average annual rainfall (mm/yr)
 SA : water availability (m³/yr)
 A : area (ha)
 10 : conversion factor from ha to m³.

2.4.2. Weighted Runoff Coefficient. The value of C is the average value of the runoff coefficient based on the type of landuse. The runoff coefficient relates to the type of landuse and the ability of landuses to infiltrate the surface water. The type of landuse and the runoff coefficient value are presented in Table 1 [2].

Table 1. C Value

No	Landuse	C _i
1	Building	0.9
2	Industry	0.,9
3	Bareland	0.4
4	Housing	0.7
5	Port	0.7
6	Trade and services	0.9
7	Ricefields	0.15
8	Garden	0.25
9	Fishpond	0,05

2.4.3. Average Annual Rainfall. The average annual rainfall is calculated using Thiessen's Polygon method. The Thiessen method is based on the assumption that measured amounts at any station can be applied halfway to the next station in any direction, which means that for any point rainfall is equal to the observed rainfall at the closest gauge. The weights of the rain gauges are computed by their relative areas, which are estimated with the Thiessen polygon network. The polygons are formed by the perpendicular bisectors of the lines joining nearby stations. The area of each polygon is used to weight the rainfall amount of the station in the center of the polygon. Figure 2 shows the Thiessen's Polygon [3].

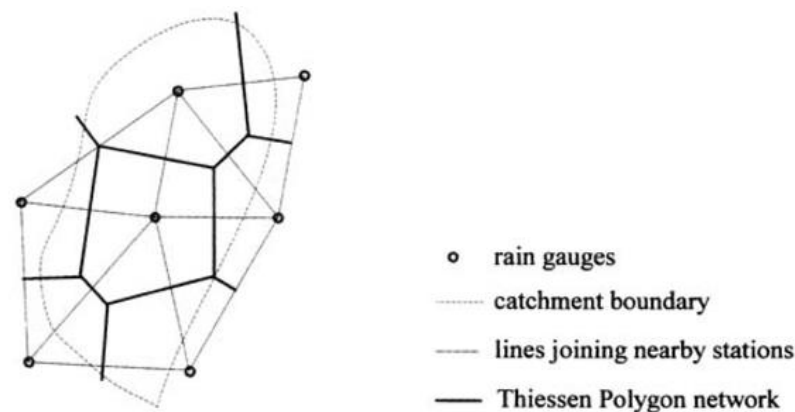


Figure 2. Thiessen Polygon Method.

2.4.4. Domestic Water Needs. The water needs are differing for each area. The higher the number of population, the higher the level of water demand. Water requirements standard based on number of population presented in Table 2 [4].

Table 2. Standard for Domestic Water Use

Category	Number of Population	Water Use (L/people/day)
Metropolitan City	> 1.000.000	150
Big City	500.000 – 1.000.000	135
Medium City	100.000 – 500.000	120
Small City	20.000 – 100.000	105
Village/ Rustic	< 20.000	82,5

3. Result and Discussion

3.1. Domestic Water Requirements

The population of Denpasar City in 2016 is 896,838 people with population growth rate of 1.27 [4]. Based on the population of Denpasar City, then Denpasar City has not been included in the category of Metropolitan City, but included in the category of Large City, where the population is less than 1 million people. If the water requirement of each individual in Denpasar City is about 200 liters per person, then the total water requirement of Denpasar City is 179,367,600 m³ / day, while for water requirement per year is 65,469,173,760 m³.

3.2. Water Potential

Water potential of Denpasar can be known from the calculation of water availability with the runoff coefficient method and water basin. The calculation of runoff coefficient method is based on runoff coefficient, annual rainfall, and the total landuse area. Total landuse area is 18,895.80 ha consist of building, industry, bare land, housing, port, trade and services, rice fields, garden and fishpond.

The rainfall intensity is calculated using Thiessen's polygon with five rainfall station i.e Sanglah, Peguyangan Kaja, Suwung Kangin, Pedungan and Sumerta. The areal rainfall in Denpasar City is 1989.51 mm/ yr. Total water potential from runoff coefficient method is 7,512,264,192.90 m³ / year. Table 2 shows the areal rainfall using Thiessen's Polygon Method and Table 3 shows the calculation of runoff coefficient method.

Table 2. Areal Rainfall using Thiessen's Polygon Method

Stasiun	x	y	R	A (Ha)	A*R
Sanglah	115.21	-8.68	1817.18	2910.76	5289374.86
Peguyangan Kaja	115.61	-9.51	1952.32	1875.25	3661088.08
Suwung Kangin	115.37	-9.64	1982.26	1894.43	3755252.81
Pedungan	116.08	-9.05	1928.96	1745.87	3367713.40
Sumerta	116.08	-9.55	1879.22	3939.10	7402435.50
Total				12365.41	23475864.65
Areal Rainfal					1989.51 mm

Table 3. Runoff Coefficient Calculation

No	Landuse	Area (ha)	Ci	Area * Ci
1	Building	3,031.26	0.9	2728.134
2	Industry	6.44	0.9	5.796
3	Bareland	83,237.57	0.4	33295.028
4	Housing	31,271.40	0.7	21889.98
5	Port	52.60	0.7	36.82
6	Trade and services	1,117.61	0.9	1005.849
7	Ricefields	40,120.04	0.15	6018.006
8	Garden	18.97	0.25	4.7425
9	Fishpond	39.91	0.05	1.9955
Total		158,895.80		64,986.351
C		2.44		
R		1898.51 mm		
SA		7,512,264,192.90 m³/yr		

3.3. Water Availability for Domestic Requirements

The carrying capacity of a region's water resources shows the comparison between the need and availability of water, or it can be defined as the maximum capacity of the region in the provision of water for a population of a certain number with its various activities. The water carrying capacity is obtained from the comparison between the availability of water (SA) and the water requirement (DA). If SA > DA then the carrying capacity is stated surplus, if SA < DA, then the water carrying capacity is expressed deficit (exceeded). Denpasar water potential based on calculation of runoff coefficient is respectively 7,512,264,192.90 m³ / year.

The water requirement for domestic needs of Denpasar City is 65,469,173,760 m³ / year. Comparison between the availability of water to the domestic needs and the people of Denpasar City based on the calculation of the water carrying capacity of 0.11, which means that the city of Denpasar is included in areas experiencing water deficit.

4. Conclusions

The water potential of Denpasar City is based on the calculation of runoff coefficient and water basin respectively for 13.75 million m³ / year and 52.35 million m³ / year. The number of domestic water needs of Denpasar City is 65.469.173 m³ / year, while for non-domestic purposes of 1.482.410,87 m³ / year. Water carrying capacity index is 0.11, which means Denpasar is included in areas with water deficit.

Acknowledgments

Writers would like to thank the Rector of Universitas Udayana, Dean of Agriculture Faculty of Universitas Udayana, Head of Center for Spatial Data Infrastructure Development (PPIDS) Universitas Udayana, fellow staf, researchers and professors at Universitas Udayana for all the support, comments and suggestions that makes this paper finished.

References

- [1] Winarso H, I Dharmapatni and M Chen 2016 Community Empowerment for Succesfull Lad Consolidation, Case Study: Banda Aceh and Denpasar, Indonesia. Paper prepared for presentation at the 2016 World Bank Conference on Land and Poverty. The World Bank - Washington DC, March 14-18, 2016
- [2] Asdak C 2010 *Hidrologi dan Pengelolaan Daerah Aliran Sungai* Cetakan Kelima (Yogyakarta: Gadjah Mada University Press).
- [3] Schumann A H 1998 Thiessen Polygon. *Encyclopedia of Earth Science* pp 648-649.
- [4] Triatmodjo B 2008 *Hidrologi Terapan* (Yogyakarta: Beta Offset).