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RESEARCH ARTICLE

Clean Water Supply in Tasikmalaya Municipality, Opportunities and Challenges

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Abstract

Currently, there are three sub-districts in Tasikmalaya City that are still vulnerable to clean water, namely Kawalu, Tamansari, and Cibeureum sub-districts. PDAM Tirta Sukapura, owned by the Tasikmalaya Regency Government, has not been able to meet clean water needs, so the Tasikmalaya Municipality Government plans to build a new PDAM as an alternative. PDAM is a regional company with the main task of providing services and providing drinking/clean water to the community. The Ciwulan river in Cibeuti Village is a source of water that will be used as a collection point. Rain data was taken from 2 stations, namely Gunung Satria and Cikunten II stations, for ten years. The evapotranspiration value was calculated using the Penman-Monteith method. The calculation of the discharge in the intake area, namely Ciwulan-Cibeuti with a watershed area of 405 km^2, used the NRECA method using parameters taken from the calibrated Ciwulan-Sukaraja station. The calibration parameters are PSUB = 0.86; GWF = 0.22, reduction coefficient = 0.80; and NSE = 0.764. The determination of the dependable flow is calculated using the Weibull method. The magnitude of the Q90 dependable flow is 4.3 m^3/s. The projected population for the next 15 years is estimated at 307,857 people, so the amount of water needed is around 0.535 m^3/s. Opportunities for business entities to participate in building PDAM are wide open, with the certainty of return plus profits or independent management by business entities within a certain period of time. The challenge for the government and business entities is to provide reasonable prices to customers and new networks.

Keywords: **C**iwulan-Cibeuti, Dependable flow, NRECA Calibration.

1. Introduction

The establishment of Tasikmalaya City is inseparable from the history of the establishment of Tasikmalaya Regency as its parent regency. In 1976 its status was increased to an Administrative Municipality. The milestone of the birth of the City of Tasikmalaya occurred on October 17, 2001, through Law Number 10 of 2001 concerning the Establishment of the Tasikmalaya Municipality. The Tasikmalaya Municipality has ten sub-districts and 69 urban villages with a population of 716,160 people (Pemerintah Kota Tasikmalaya, 2019).

Sources of drinking water supply generally come from surface water such as rivers, reservoirs, and lakes. As a result of anthropogenic activities, there is an uncontrolled decrease in water quality and a decrease in quantity due to drought (Shaheed & Mohtar, 2015). Water is one of the natural resources which is very vital not only for life but also for the development of the nation (Sukereman et al., 2015).

Clean water is currently a vital need for the community. Currently, three sub-districts in Tasikmalaya Municipality are still vulnerable to clean water, namely Kawalu, Tamansari, and Cibeureum sub-districts. Until now, the need for clean water is supplied by the PDAM Tirta Sukapura. PDAM Tirta Sukapura is one of the regional-owned enterprises owned by the Tasikmalaya Regency Government whose task is to provide drinking/clean water for the people of Tasikmalaya Regency and Tasikmalaya Municipality. PDAM Tirta Sukapura is owned by the Tasikmalaya Regency Government. Until now, PDAM Tirta Sukapura has not fully served the needs of the people of the Tasikmalaya Municipality, so the Tasikmalaya Municipality Government plans to build its PDAM, primarily to help do the people in the three sub-districts. The development of this PDAM is an opportunity and a challenge for the Tasikmalaya Municipality Government and business entities/investors to participate in the development.

The river used as the source of extraction is the Ciwulan river, which is located in Cibeuti Urban village, Kawalu sub-district. This river is the boundary between Tasikmalaya Municipality and Tasikmalaya Regency. The Ciwulan river has an automatic water level measuring station, namely the Ciwulan-Sukaraja station and its tributary, the Cikunir river, namely the Asta station. Figure 1 shows the location of the study area and the location of the Gunung Satria and Cikunten 2 rain stations.

2. Methodology

2.1. Rainfall

The hydrological cycle is an important process because it maintains the availability of surface water for living things. Evapotranspiration is part of the hydrological cycle playing an important role in the domestic water supply (Farah et al., 2017). The impact of climate change results hydrological processes, including increased rainfall, especially when extreme events occur (Othman et al., 2016). The Ciwulan river is managed by the Ciwulan-Cilaki River Basin Technical Service Unit. The government has widely used the Ciwulan River for public welfare, such as providing raw water for the community and irrigation. Inappropriate agricultural practices can lead to over-exploitation of water leading to water scarcity (Nair et al., 2020).

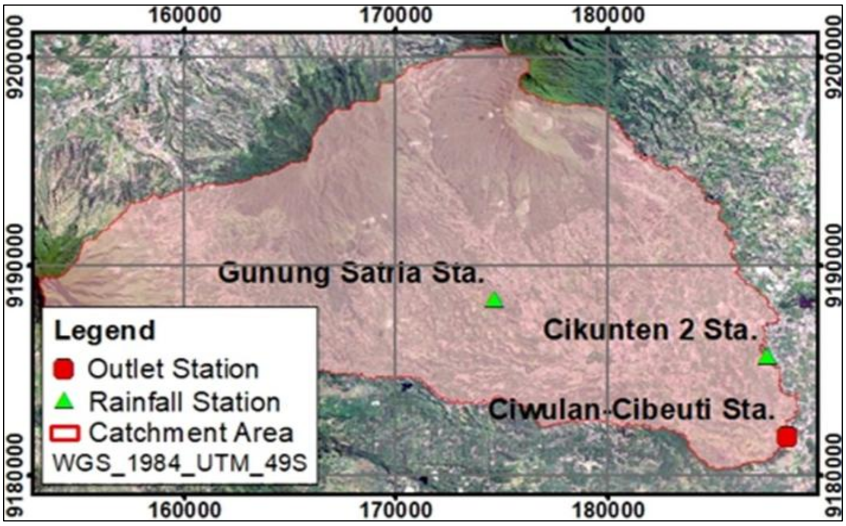

Fig 1. Location of the Ciwulan-Cibeuti study area

The upstream of the Ciwulan river are located on Mount Karacak with an altitude of 1838 m above mean sea level and Mount Cikuray in Garut Regency with a height of 2821 m and empties into the Indian Ocean. Currently, the condition of the central watershed has changed land use. The need for wildland causes the physical and environmental carrying capacity of the watershed to decrease (Herman et al., 2020).

The place for taking Ciwulan river water is an outlet and is used as a downstream catchmen area (watershed). The area of the watershed, climatological conditions and soil characteristics are important parameters in determining river discharge. The area of the watershed with outlets in Cibeuti Urban village is 405 km^2. Figure 2 shows the outlet of the Ciwulan-Cibeuti watershed.


Fig 2. Outlet of the Ciwulan-Cibeuti watershed

The rainfall stations calculated in this study consist of two rainfall stations measured by manual measuring instruments, namely the Gunung Satria rainfall station in Cigalontang district at an elevation of 548 m, and the Cikunten 2 rainfall station in Singaparna district at the height of 548 m. 417 m. The rainfall data taken into account in this study is ten years, from 2011 to 2020. The dominant land uses in the Ciwulan-Cibeuti watershed are rice fields, dryland forests, and plantation forests. Figure 2 shows outlet of the Ciwulan-Cibeuti watershed. The calculation of the area's average rainfall is done by using the Thiessen method.

2.2 Evapotranspiration

Important climatic variables are temperature and rainfall, as well as the impact of drought on agriculture as a source of livelihood in the region (Schilling et al., 2020). Four climatological parameters such as temperature, duration of sunshine, relative humidity, and wind speed are needed to calculate the evapotranspiration value calculation of evapotranspiration using the Penman-Monteith method. The data source for the four parameters was taken from the Tasikmalaya Municipality in Figures book.

$$ET_o = \frac{0.408\Delta R_n + \gamma\frac{900}{(T+273)}U_2(e_s - e_a)}{\Delta + \gamma(1+0.34U_2)} \quad (1)$$

ETo = reference plant evapotranspiration, (mm/day)
R_n = net solar radiation above ground level, (MJ/m2/day)
T = average air temperature, (^{o} C)
U_2 = wind speed at a height of 2 m above ground level, (m/s)
e_s = saturated water vapor pressure, (kPa)
e_a = actual water vapor pressure, (kPa)
Δ = slope of the curve of water vapor pressure with respect to temperature, (kPa/^{o} C)
γ = psychrommetric constant, (kPa/0 C)

2.3 Hydrological Modeling

Land use conditions in the upper Ciwulan river and rainfall are important parameters in determining river discharge (Permana et al., 2019). The Ciwulan River, which will be used as a water collection point, does not have a water level measuring instrument, so to get the discharge value, hydrological modeling must be done.

The hydrological model used in this study is the National Rural Electric Cooperative Association (NRECA) model. Figure 3 shows the discharge simulation scheme of the NRECA model.

The calibration of the model parameters, namely the surface soil characteristics at a depth of 0 – 2 m (PSUB) and the surface soil characteristics at a depth of 2 – 10 m (GWF), was carried out on the discharge data at the Ciwulan-Sukaraja station for three years, from 2015 to 2017 with a watershed area of 524 km2. Ciwulan-Sukaraja Station is approximately 6.6 km from the water collection point. To assess the predictions of the hydrological model, the Nash-Sutcliffe (NSE) efficiency test was used is shown in equation (2). The prediction of the hydrological model will be of good value if the NSE value is close to 1. Figure 4 shows the location of Ciwulan-Sukaraja AWLR station.

$$NSE = 1 - \frac{\sum_{t=1}^{T}(Q_0^t - Q_m^t)^2}{\sum_{t=1}^{T}(Q_0^t - \overline{Q_0})^2} \quad (2)$$

NSE = Nash-Sutcliffe
Q_0^t = observed discharge at time t
Q_m^t = modeled discharge at time t
$\overline{Q_0}$ = the mean of observed discharges

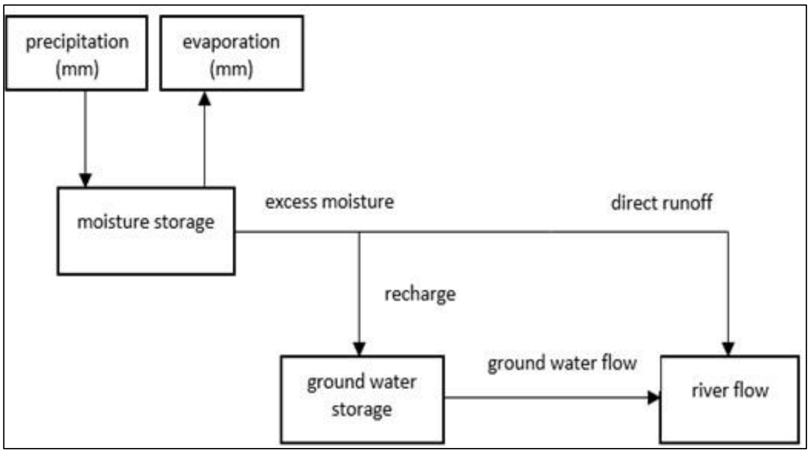

Fig. 3. Schematic of the NRECA mode

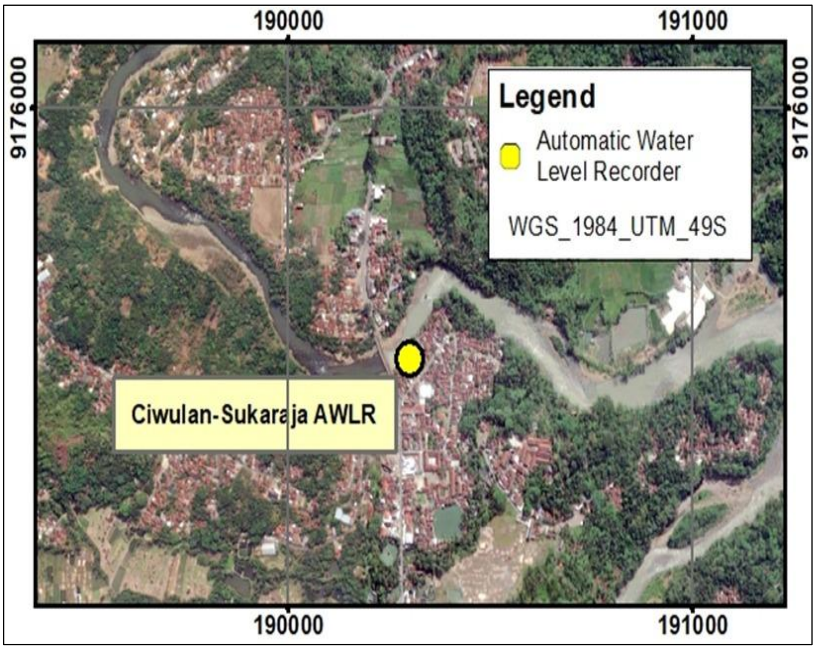

Fig 4. Ciwulan-Sukaraja AWLR station.

2.4 Population

Availability of raw water is the main requirement for agriculture and household needs (Permana, 2018). Another parameter related to the PDAM development plan is the population in the three sub-districts. The population in the three sub-districts is 242,450 people, with an average population growth rate of 1.605% (Tasikmalaya Municipality in Figures 2021). In meeting future water needs, it is necessary to project the population in three sub-districts critical to project population numbers in three sub-districts.

The projected population is calculated using the geometric method. Population projections are carried out for the next 15 years. This projection is taken by taking into account the government's readiness to build PDAM. The geometric method is shown in equation (3).

$$P_n = P_0(1 + r)^n \quad (3)$$

where P_n is the population in the nth year, P_0 is the population in the initial year, and r is the total population growth (%).

Many residents in Kawalu and Tamansari sub-districts have opened home industry businesses, so the need for water for the industry is urgent. Industrial water requirements for production activities, including raw materials, workers, and other forms of support for the industry (Chandrasasi et al., 2020).

3. Result and Discussion

3.1 Average Rainfall and Evapotranspiration

Calculating the average rain area using the Thiessen method with the area of influence Cikunten 2 station is 18.13%, and Gunung Satria is 81.87%. The results of the calculation of the average regional rain are shown in table 1.

Evapotranspiration is a combination of evaporation from the soil surface and transpiration from plants. The results of the calculation of monthly evapotranspiration based on equation (1) using the Penman-Monteith method are shown in table 2.

3.2 Calibration and Dependable Flow

The location where the water is taken does not have a water level measuring device, so it cannot directly calculate the amount of flow. The calculation of the amount of flow at the site is done by modeling. Therefore calibration is ried out on the Ciwulan-Sukaraja station to obtain calibration parameters. The calibration parameters are used to calculate the flow rate at the collection location.

The resulting calibration parameters include: initial groundwater reservoir (GW = 20 mm), deep surface soil characteristics (GWF = 0.22), and surface soil characteristics (PSUB = 0.86). Figure 5 shows the results of the time series calibration from 2015 to 2017. The NSE value is 0.764.

The flow duration curve calibration shows the probability that the discharge will be equal to or exceeded from the observed and modeled discharges. Dependable flow is the amount of available discharge to meet water demand by considering the risk of failure (Sebayang & Fahmia, 2021). Figure 6. shows the calibration of the flow duration curve.

The initial moisture storage value was tested, where the difference in values for January and December did not exceed 200 mm. The calibration of the initial moisture storage is shown in Figure 7.

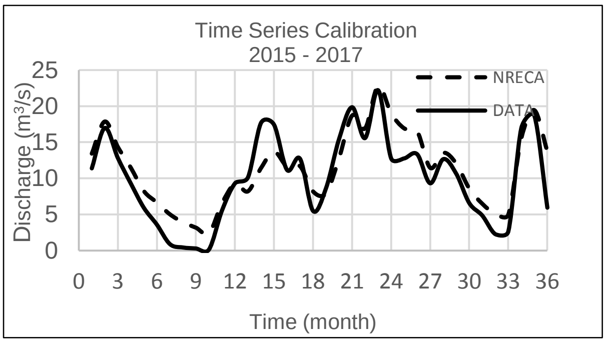

Fig 5. Times series calibration

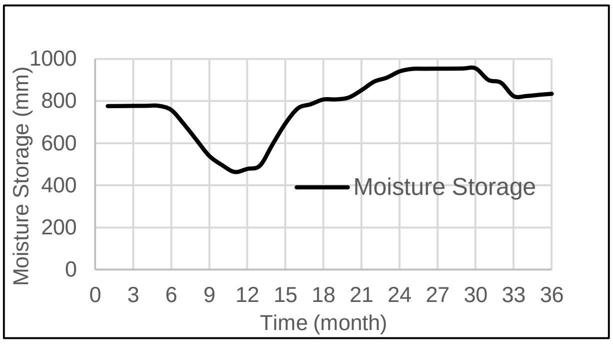

Fig 7. Initial moisture storage calibration

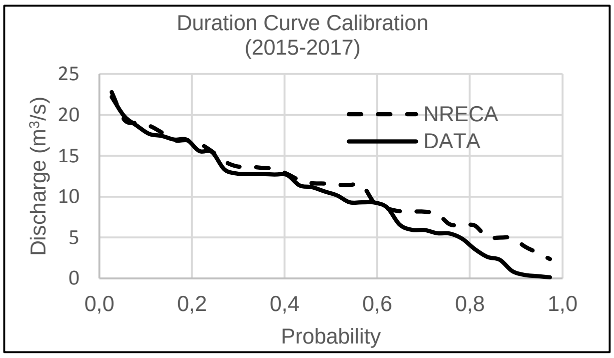

Fig 6. Flow duration curve calibration

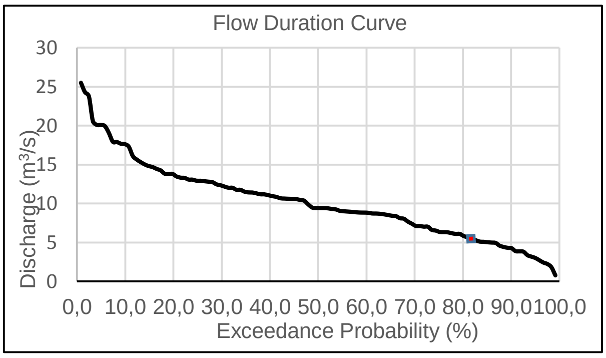

Fig 8. Flow duration curve

Table 1. Average rainfall (mm)

Month	Year									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jan	94,7	222,4	269,4	211,6	170,6	252,2	131,6	206,6	279,7	171,3
Feb	125,4	192,3	294,5	186,6	194,9	282,2	129,6	319,9	330,1	269,0
Mar	207,3	258,1	299,4	175,5	162,2	290,8	119,0	218,7	325,8	260,3
Apr	224,5	213,1	285,0	200,1	105,6	169,8	163,0	306,2	303,5	299,5
May	165,7	164,3	211,3	167,7	68,0	172,0	145,7	242,1	182,4	226,4
Jun	77,4	87,3	27,9	100,5	20,2	78,5	26,0	147,6	54,5	212,1
Jul	63,5	217,6	27,2	33,6	3,2	139,2	81,8	6,5	40,6	105,3
Aug	4,6	10,5	182,9	26,4	2,8	244,3	46,1	8,4	1,1	27,8
Sep	5,3	9,4	153,1	124,1	21,1	300,4	116,2	73,5	2,5	107,6
Oct	143,9	231,4	294,2	212,0	36,8	221,5	289,0	105,3	1,8	199,9
Nov	260,5	190,0	156,8	198,5	174,2	290,5	258,1	271,3	55,5	158,0
Dec	246,5	249,8	167,9	220,6	189,0	183,3	154,9	304,7	144,2	180,5

Table 2. Evapotranspiration (mm)

Month	Year									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jan	118,0	119,2	118,7	120,1	127,9	131,8	88,3	128,8	135,4	132,3
Feb	118,4	122,7	119,3	110,3	104,6	128,7	103,3	118,9	121,7	126,7
Mar	138,6	138,6	136,5	139,8	122,5	135,5	132,8	137,7	139,1	137,2
Apr	121,4	123,1	119,8	132,3	107,3	131,8	116,7	127,0	131,3	130,3
May	117,4	118,9	115,3	118,5	109,5	111,9	117,7	122,4	124,0	119,7
Jun	92,0	90,7	92,8	109,8	108,7	105,3	100,5	105,7	115,3	112,3
Jul	101,7	101,6	104,1	138,9	98,6	128,5	119,1	105,9	110,5	113,5
Aug	130,0	130,4	129,3	135,0	103,8	122,1	136,9	114,0	113,1	116,3
Sep	132,8	134,3	134,2	134,6	93,7	121,1	128,8	128,2	133,9	130,9
Oct	145,0	149,7	149,5	155,5	103,4	130,9	119,0	133,8	145,2	127,3
Nov	134,4	128,8	131,1	118,2	113,3	113,7	109,1	115,1	121,9	119,0
Dec	124,3	121,3	120,1	116,0	104,6	108,8	141,9	126,6	133,5	128,1

Table 3. Modeling discharge (m^3/s)

Month	Year									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jan	0,78	10,86	13,47	12,81	10,37	6,33	13,07	12,19	17,29	4,60
Feb	2,24	11,31	17,93	14,26	13,81	8,82	12,75	19,95	24,30	8,05
Mar	5,66	12,93	17,90	11,54	11,08	10,57	8,84	15,65	23,75	9,39
Apr	9,24	13,32	20,08	12,93	8,85	8,97	10,46	20,57	25,50	13,29
May	8,39	11,42	17,69	11,77	6,36	9,01	9,30	19,07	20,09	12,87
Jun	5,84	8,88	12,47	8,93	5,12	6,31	6,62	16,11	14,82	13,80
Jul	4,33	12,35	9,41	6,53	3,87	6,11	5,00	11,19	11,18	9,43
Aug	3,38	7,69	10,62	5,10	3,02	9,89	3,90	8,73	8,72	7,13
Sep	2,72	6,20	9,42	4,95	2,43	14,44	3,82	7,04	7,03	6,11
Oct	3,19	8,69	13,84	7,41	1,83	13,08	12,03	5,52	5,31	8,44
Nov	8,62	9,06	10,95	9,49	5,04	17,63	15,02	12,03	4,28	8,13
Dec	10,68	11,76	10,65	11,43	7,12	14,68	10,60	15,32	4,44	8,53

Based on the values of the calibration parameters, the resulting discharge from the modeling at the water intake is in the Cibeuti urban village with an average monthly discharge of 10.22 m^3/s. The discharge modeling results are shown in table 3.

The dependable flow calculation using the flow duration curve method uses the Weibull probability formula, such as equation (4), where m is the data rank, n is the number of data, X is the discharge data series, and x is the dependable. The flow duration is shown in Figure 8.

$$P(X \geq x) = \frac{m}{n+1} 100\% \qquad (4)$$

Based on the flow duration curve in Figure 8, it is obtained that Q90% is 4.3 m^3/s (4300 l/s). Water needs for households and urban areas with a population of 500,000 – 1,000,000 people are 120-150 l/person/day (Directorate General of Human Settlements, 1996).

3.3 Population Projection

Because the population continues to increase, so that many agricultural areas are converted into settlements (Permana et al., 2019), the need for clean water infrastructure will become a community's dream. The population projections taken into account are only in three sub-districts because those three sub-districts still require clean water services. The population projection calculation uses geometric methods such as equation (3).

$P_n = P_0 (1+r)^n$ = 242450 $(1+0.01605)^{15}$ =307.857 people. By taking the water requirement of 150 l/person/day, for the next 15 years, approximately 46.178.550 l/day or 535 l/s of water will be needed.

3.4 Opportunities and Challenges

The opportunity to build a new PDAM is big enough for the Tasikmalaya Municipality Government to serve some communities in three sub-districts that are still vulnerable to clean water, thereby eliminating dependence on PDAM Tirta Sukapura. In addition, it will not use APBD funds in building new PDAM. The opportunity for business entities is quite large. It has the opportunity to participate in building PDAM because of the certainty of returns plus profits or being fully managed by the business entity within a certain period of time. The cooperation scheme is also accelerating the fulfillment of clean water for the community in three sub-districts.

Meanwhile, the challenge for the Tasikmalaya City Government is to provide clean water services to the community at a reasonable price. As a major provider of funds, the business entity aims to help and expand the clean water network at a reasonable price and provide a 24-hour service guarantee to customers. However, customers will pay a little more.

4. Conclusion

Three sub-districts in Tasikmalaya Municipality are still vulnerable to clean water, so the government plans to build its PDAM, not depending on PDAM Tirta Sukapura. The location where the water level is taken does not have a water level measuring instrument, so to determine the amount of discharge, hydrological modeling using the NRECA method is used.

The calibration of the model parameters was carried out at the Ciwulan-Sukaraja station, and the results were used to calculate the discharge in the Ciwulan-Cibeuti watershed. The dependable flow based on the flow duration curve is 4300 l/s. Based on population projections for the next 15 years, 535 l/s is required so that a maximum of only about 12.5% of the available discharge is used for clean water needs. The PDAM development plan is both an opportunity and a challenge for the government and business entities. The development does not burden the APBD and can expand the clean water network at a reasonable selling price.

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