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RESEARCH ARTICLE

Calibration of the Water Balance Model for the Upper Cimanuk Catchment Area for Raw Water Supply

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Abstract

The main task of PDAM Tirta Intan Garut Regency is to manage raw water into clean water for customers. The management of raw water supply in Bayongbong District for the community still relies on springs with a gravity system, deep well pumps and rivers. The flow of the Cimanuk River in Bayongbong District can be used to provide raw water. Four rainfall stations are used. Average rainfall is calculated using the Thiessen method. The raw water collection point does not have a automatic water level recorder (AWLR), so it is necessary to create a model to obtain the discharge at the collection point. The model used is the water balance model from F.J. Mock. Calibration of model parameters was carried out on observed discharge at Cimanuk-Bayongbong AWLR and Cimanuk-Bojongloa AWLR. To test the reliability of the model, NSE and RMSE values were used. The NSE and RMSE values in the Cimanuk-Bayongbong catchment area are 0.515 and 3.615 and Cimanuk-Bojongloa are 0.593 and 4.813. The results of the model parameter calibration are used to calculate the discharge at the collection point. The calibration result at the collection site are exposed surface 50%, infiltration coefficient 0.5: recession coefficient 0.35: catchment area characteristic factor 10%; and soil moisture capacity 200 mm. The dependable flow is calculated based on Q90% probability, water availability in July, August, September and October is 0.078 m^3/s; 0.025 m^3/s; 0.035 m^3/s; and 0.025 m^3/s. Water availability in that month is smaller than the discharge requirement for the next five and ten years, namely ranging from 0.134 m^3/s to 0.168 m^3/s and 0.145 m^3/s to 0,182 m^3/s.

Keywords: Dependable flow, F.J. Mock model, Raw water, Water balance,

1. Introduction

In May 2024, Indonesia will host the 10th Word Water Forum, which is the largest international meeting discussing the water resources sector. The theme of the 10th World Water Forum is Water for Shared Prosperity. This meeting raised six main sub-themes, one of which was water for humans and nature.

Garut Regency has an area of 3,065.19 km^2, geographically located between 6^0 57'34" – 7^0 44'57" South Latitude and 107^0 24'03"-108^0 24'34' East Longitude (BPS Kabupaten Garut, 2023). The area of this district is surrounded by mountains, except for the southern part which is partly coastal and lowland. The current population is 2,683,665 people. One of the sub-districts is Bayongbong District.

Currently the population of Bayongbong District is 107,246 people, the population growth rate is 1.59% (BPS Kab Garut, 2024) with the livelihood of some of the people being farming. The Cimanuk weir in Bayongbong District is used to irrigate an agricultural area of 874 hectares. Until now, the existence of the Cimanuk River has been widely used, especially for agriculture, while for raw water supply, especially in Bayongbong District, it has not been widely used. An important parameter in meeting the need for irrigation and raw water is flow (Permana, 2022) In accordance with the sub-theme of the 10th Word Water Forum, namely water for humans and nature, PDAM Tirta Intan has been given the mandate to manage the clean water system to serve the interests of the community. Until now, raw water management for the community still relies on springs with a gravity system, pumps, deep wells and rivers other than the Cimanuk River. Clean water sources generally come from surface water (Permana et al., 2022). The use of groundwater must be balanced with conservation efforts to prevent environmental disasters (Barkah et al., 2021). There is quite a lot of water available for supplying raw water, but water collection must be coordinated with BBWS Cimanuk-Cisanggarung as the person in charge.

In 2016 and 2022 the Cimanuk River experienced flooding, especially in Garut city. The occurrence of floods indicates that the condition of the catchment area has been damaged and has an impact on future water availability. (Harmiyati and Fuaji, 2023) The upstream Cimanuk River catchment area from Cikajang District to Bayongbong District has two automatic water level recorder (AWLR), namely the Cimanuk-Bayongbong AWLR with a catchment area of 157.41 km^2 and the Cimanuk-Bojongloa AWLR with a catchment area of 281.89 km^2. The location for taking Cimanuk River water for raw water needs is located after the Cimanuk-Bojongloa AWLR with a distance of 1.5 km from the Cimanuk-Bojongloa AWLR and 3 km from the Cimanuk-Bayongbong AWLR. To find out the discharge at the collection location, calculations need to be carried out using a model.

The model that is often used to relate rainfall and runoff is the F.J. Mock water balance model. The water balance is the amount of available water minus the amount of water needed for various sectors, so that the water surplus and deficit will be known (Chandrasasi et al., 2020) The concept of hydrology explains the relationship between inflow and outflow within an area for a certain period of time (Pratama et al., 2021). To maintain model reliability, calibration of model parameters is required. Calibration of F.J. Mock model parameters so that the simulated discharge is close to the observed discharge. Calibration was carried out on observed discharge at Cimanuk-

Bayongbong AWLR and Cimanuk-Bojongloa AWLR. The resulting calibration parameter values are used to predict discharge at water extraction locations for community services. The dependable flow at the water intake location is Q90%. The research aims to determine the magnitude calibration parameters of the F.J. Mock model and simulated discharge at the collection location.

The hydrological cycle is related to water resources, and is a basic concept of water balance. Changes in land use and land cover have a significant impact on rainfall, temperature and will change the water balance of a catchment area (Saddique et al., 2020). The hydrological approach method in a region to describe the water balance of input (rain) and output (evapotranspiration, infiltration) parameters is the concept of water balance (Muhardiono and Arthamefia, 2024).

2. Method

Monthly discharge is calculated using monthly rainfall, evapotranspiration, soil moisture and groundwater storage data. Differences in rainfall and evapotranspiration will result in direct runoff, base flow, and heavy rain runoff. Parameters used in the F.J. Mock method is an exposed surface based on a land use map. Population growth will have an impact on increasing residential area and reducing green open space (Farid et al., 2022). Uncontrolled land demand will cause catchment area to be disturbed (Herman et al., 2020). Changes in land cover and climate have the potential to increase flooding and erosion (Ardiansyah et al., 2021). Such as dense forests, eroded land, and agricultural land. Soil moisture capacity (SMC) is the water content capacity of the surface soil layer. SMC depends on the porosity of the soil layer in the catchment area. The infiltration coefficient is determined based on soil porosity conditions and the slope of the catchment area, with a value range between 0 and 1. The groundwater flow recession factor is influenced by the geological conditions of the catchment area, while the recession factor is determined by trial and error. The model parameters calibrated are exposed surface, infiltration coefficient, recession factor, and catchment area hydrological characteristic factors. Calibration is carried out by adjusting parameter values that influence the hydrological conditions of catchment area (Parahita et al., 2022).

Water flowing in rivers according to F.J. Mock method is the sum of direct flow , underground flow and ground flow. So the monthly modeling discharge (m^3/sec) is the river flow times the area of the catchment area divided by the time of 1 month (seconds).

2.1 Rainfall

The flow of the Cimanuk River is widely used by the community, especially to irrigate agricultural areas, such as the Copong weir, the Jatigede dam in Sumedang Regency, while in Majalengka Regency there is the Rentang weir to Indramayu Regency, all under the authority of BBWS Cimanuk-Cisanggarung. Rainfall used for 15 years from 2008 to 2022. The Cimanuk-Bayongbong catchment area consists of three rainfall stations, namely the Pamegatan rainfall station, Cikajang District, the Pangauban rainfall station, Cisurupan District, and the Bayongbong rainfall station, Bayongbong District. Rainfall data was obtained from Water Resources Office of West Java Provincial, and Public Works and Spatial Planning Office of Garut Regency. Figure 1 is the distribution of rainfall station in the Cimanuk-Bayongbong catchment area.

Meanwhile, the rainfall station in the Cimanuk-Bojongloa catchment area consists of 4 rainfall stations. Three rainfall stations in the Cimanuk-Bayongbong catchment area and the Kapakan rainfall station in Pasirwangi District. Figure 2 shows the distribution of rainfall station in the Cimanuk-Bojongloa catchment area.

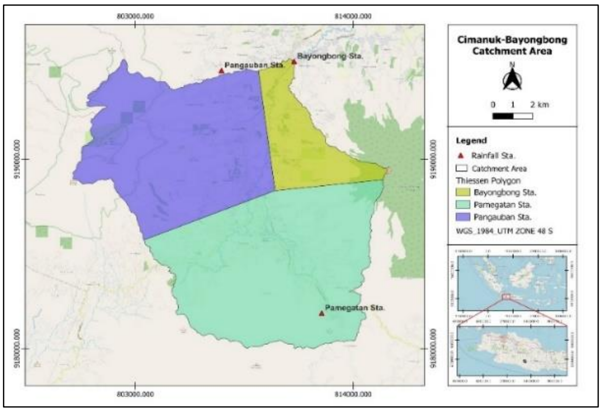

Fig 1. Cimanuk-Bayongbong catchment area

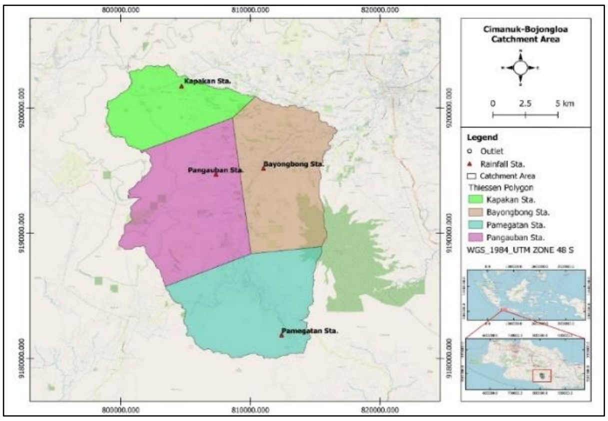

Fig 2. Cimanuk-Bojongloa catchment area

2.2 Evapotranspiration

Evapotranspiration is the amount of water needed for the plant growth process and evaporation from soil/water as a place for plant growth (Badan Standardisasi Nasional, 2012). The evapotranspiration calculation uses the Penman-Monteith method referring to SNI 7745:2012. Monthly evapotranspiration is evapotranspiration multiplied by the number of days in a month (mm/month). Data for calculating evapotranspiration, namely air temperature, humidity, duration of sunlight and wind speed were obtained from the BRIN Garut.

2.3 Model reliability

The flow in rivers in in a catchment area depends on rainfall and climate (Alaniri and Suryadi, 2023). The initial parameters for calculating discharge are determined by trial and error, namely exposed surface, infiltration coefficient, recession coefficient, hydrological characteristics of the catchment area, and soil moisture capacity (SMC). The final model parameters are parameter values that show a strong relationship between the simulated discharge and the observed discharge. The Nash-Sutcliffe method is used to calculate deviations (Sebayang et al., 2023). To test the reliability of this model, the Nash-Sutcliffe (NSE), and Root Mean Square Error (RMSE), and correlation coefficients are used. A model will be reliable if the NSE value is close to 1 and the RMSE value is close to 0 or the discharge from the simulation results is close to the observation results. The NSE and RMSE values are calculated using equation (1) and equation (2).

$$NSE = 1 - \frac{\sum_{t=1}^{T}(Q_0^t - Q_m^t)^2}{\sum_{t=1}^{T}(Q_0^t - \overline{Q}_0)^2} \qquad (1)$$

NSE : nash-sutcliffe coefficient.
Q_0^t : observed discharge at time t.

Q_m^t : discharge from simulation results at time t.
$\overline{Q_0}$: average discharge from observations

The root mean square error is defined as the measure of the differences between values that are predicted by a model and value that are actually observed. Here, N is the number of observations.

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(Q_o - Q_m)^2}{n}} \quad (2)$$

where:
RMSE : root mean square method
Q_o : observation discharge
Q_m : simulated discharge
n : number of data

2.4 Dependable flow

Dependable flow is a certain amount of debit whose occurrence is linked to a certain probability or return period (SNI 6738:2015, 2015). The dependable flow is the amount of flow to meet water needs which has taken into account the risk of failure (Sebayang and Fahmia, 2021). The dependable flow is obtained from the discharge duration curve method using the Weibull probability formula such as equation (3).

$$P(X \geq x) = \frac{m}{n+1} 100\% \quad (3)$$

where:

$P(X \geq x)$: probability of occurrence of a discharge variable equal to or greater than x m^3/s
m : data rank
n : number of data
x : dependable flow P (X ≥ Q 90%) = 0.9
X : discharge data series

2.5 Population projection

Population growth continues to increase from year to year, so it is necessary to predict the population in Bayongbong District for the next few years according to dependable flow. The population projection uses equation (4).

$$P_n = P_o(1+r)^n \quad (4)$$

where:

P_n : population after the next n years
P_0 : population in the initial year
r : population growth rate
n : time period

3. Result and discussion

3.1 Areal rainfall

Average rainfall (mm) was used using the Thiessen method. This method is used because the rainfall station in the catchment area are not evenly distributed, this method is done by taking into account the area of influence of each rainfall station. The weight factor for each rainfall station is the area of influence of the rainfall station divided by the total area of the catchment area. The Cimanuk-Bayongbong catchment area, respectively, the weight factor for the Pamegatan rainfall station, Pangauban station, Bayongbong station, is 0.475; 0.404; 0.121. Meanwhile, for the Cimanuk-Bojongloa catchment area, each weight factor is 0.265; 0.314; 0.261; and the Kapakan station is 0.160. Table 1 and Table 2 show the amount of average rainfall in the Cimanuk-Bayongbong catchment area, and the Cimanuk-Bojongloa catchment area.

Table 1. Average rainfall in the Cimanuk-Bayongbong catchment area (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	90,6	189,7	221,6	229,6	54,3	6,9	8,6	24,6	58,5	197,6	393,2	212,0
2009	224,7	137,9	215,1	255,6	127,3	32,4	28,5	25,3	24,1	165,9	225,7	170,8
2010	281,5	378,2	220,2	171,9	275,2	151,9	141,1	88,5	278,4	221,0	295,5	238,1
2011	109,6	206,2	150,7	189,1	184,7	51,6	54,4	6,2	6,7	126,3	219,7	217,2
2012	288,8	286,0	167,1	243,6	184,2	35,7	6,9	7,4	13,8	166,8	272,0	277,6
2013	407,8	297,2	250,8	422,0	357,3	114,7	288,7	48,3	62,0	169,8	164,9	318,5
2014	173,5	208,4	496,5	372,5	134,0	198,1	222,4	100,1	42,6	62,9	325,8	629,6
2015	288,3	302,1	355,8	371,4	188,5	78,6	2,9	1,4	2,6	1,9	380,0	347,8
2016	375,2	325,8	529,7	330,2	308,0	195,8	207,1	378,3	377,7	302,7	347,0	312,3
2017	276,3	356,9	374,9	308,8	195,6	174,0	156,6	17,1	85,7	248,8	473,8	301,9
2018	306,5	425,4	398,0	352,3	194,1	101,3	4,8	12,8	22,3	21,7	289,4	332,1
2019	379,6	398,8	529,7	277,5	213,6	17,3	29,5	1,9	1,8	1,4	117,3	330,3
2020	473,1	447,0	441,6	383,4	270,6	237,4	37,7	32,6	121,2	380,6	319,8	404,5
2021	386,2	236,9	247,7	231,9	182,4	226,4	119,2	176,7	211,1	228,0	532,7	403,1
2022	355,3	422,5	239,4	373,2	212,0	259,5	145,9	138,7	284,5	257,3	319,5	370,7

Table 2. Average rainfall in the Ciamanuk-Bojongloa catchment area (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	83,6	133,0	224,2	192,4	41,3	5,3	4,8	14,5	38,2	155,6	311,8	205,8
2009	244,1	192,5	163,0	264,2	98,6	33,4	17,3	15,2	14,4	110,3	166,7	147,4
2010	199,9	256,1	162,0	134,7	183,5	100,9	132,1	119,6	236,6	147,1	206,4	196,0
2011	88,8	179,1	151,0	179,9	149,1	36,7	44,7	3,4	3,7	98,3	207,1	189,6
2012	266,8	272,1	140,3	211,5	168,3	30,7	4,6	10,8	8,7	131,8	237,5	279,1
2013	349,4	286,5	260,0	419,5	326,1	162,1	255,8	36,5	39,8	129,2	158,9	308,5
2014	174,4	191,0	489,7	347,9	136,2	173,7	208,9	84,0	26,0	42,5	267,0	409,2
2015	294,3	330,7	329,5	329,0	169,5	64,6	1,6	0,8	1,7	1,1	298,9	329,3
2016	344,2	317,5	485,8	291,6	276,8	170,1	179,3	302,7	369,9	343,3	325,2	312,8
2017	241,5	348,6	386,4	313,1	178,7	151,2	128,2	10,3	83,6	200,6	470,4	292,7
2018	269,7	412,7	385,7	290,4	156,0	87,8	2,7	7,2	15,9	19,0	250,8	295,7
2019	334,8	418,4	424,9	302,7	166,4	11,2	16,4	1,1	1,1	1,1	94,3	299,9
2020	457,2	410,1	364,4	333,6	240,0	176,9	27,1	31,0	84,7	298,4	266,2	355,3
2021	323,4	192,3	268,4	168,4	161,3	208,1	92,4	136,0	177,0	215,0	551,1	390,4
2022	309,4	356,3	250,2	345,0	202,9	210,2	133,5	119,2	237,8	280,9	301,5	349,8

3.2 Monthly evapotranspiration

Evapotranspiration is calculated to determine limited evapotranspiration (mm). Monthly evapotranspiration can be seen in Table 3. Water that evaporates in catchment area due to evapotranspiration can affect the flow in rivers. Based on calculations, the estimated water loss every month over a 15 year period is 143 mm.

3.3 Calibration of the F.J. Mock model

If the simulated discharge is not close to the observed discharge based on the NSE and RMSE value criteria, then the model needs to be calibrated. Calibration of model parameters for monthly discharge was carried out for 15 years, namely from 2008 to 2022, which was carried out at Cimanuk-Bayongbong AWLR and Cimanuk-Bojongloa AWLR. Model parameters calibrated on the F.J. Mock model in the Cimanuk-Bayongbong catchment area is exposed surface with a value of 50%, an infiltration coefficient of 0.5; recession coefficient of 0.3; the catchment area characteristic factor is 10%, and the soil moisture capacity is 200 mm. Meanwhile, the calibration results of model parameters in the Cimanuk-Bojongloa catchment area for exposed surface are 50%, an infiltration coefficient of 0.5; recession coefficient of 0.4; the catchment area characteristic factor is 10%, and the SMC is 200 mm.

Table 3. Monthly evapotranspirasi (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	148,4	145,6	112,4	128,3	135,3	99,2	128,6	141,0	133,4	137,2	123,9	147,2
2009	130,3	136,6	125,2	132,5	123,5	110,2	126,3	132,6	135,3	134,6	102,8	124,4
2010	135,4	133,0	142,8	142,6	109,6	107,4	104,1	121,4	112,5	122,3	125,9	117,5
2011	131,7	137,3	127,0	132,5	121,4	127,0	124,2	135,8	132,1	131,8	114,6	131,9
2012	127,6	153,8	141,7	128,8	129,1	132,9	138,1	142,9	133,7	135,2	112,4	124,1
2013	135,1	154,6	150,7	135,4	124,5	106,9	118,1	161,2	164,1	160,5	148,4	132,2
2014	137,2	126,5	168,9	169,9	146,0	129,6	132,5	144,8	154,1	183,8	113,7	140,3
2015	153,6	167,3	161,1	150,4	152,5	146,4	146,0	167,5	161,9	180,4	163,6	146,7
2016	164,1	157,4	155,2	153,5	137,6	141,0	146,6	164,9	148,3	139,2	133,3	133,8
2017	105,4	144,7	160,1	154,0	153,6	124,8	147,2	167,2	165,1	148,7	137,1	177,6
2018	150,4	162,9	173,4	164,9	157,8	128,9	137,7	140,2	147,0	146,1	137,3	142,2
2019	163,1	163,7	154,5	154,0	160,9	144,5	143,5	140,3	156,3	151,4	148,7	157,6
2020	163,1	162,7	159,9	160,5	152,0	141,8	135,9	162,3	158,2	143,5	144,8	144,5
2021	156,6	161,4	160,0	155,8	144,9	144,2	144,3	145,8	158,6	153,0	151,4	149,9
2022	148,0	161,5	149,7	158,4	158,4	140,9	146,3	148,6	153,9	144,5	146,2	144,8

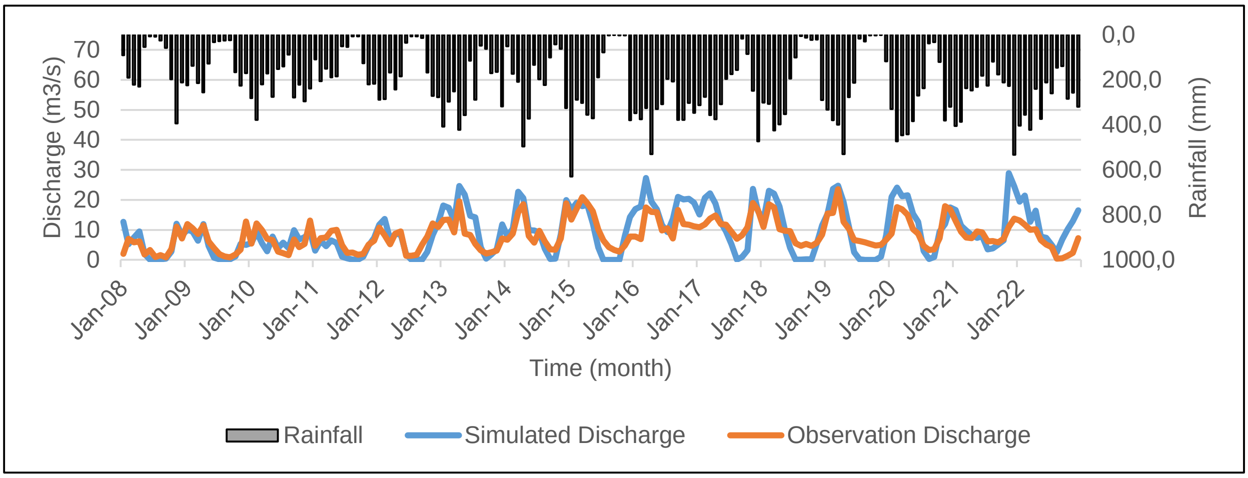

Fig 3. Time series calibration (Cimanuk-Bayongbong catchment area)

The parameter values resulting from calibration are the best values obtained to determine the final simulated discharge. The NSE value calculated using equation (1) and RMSE calculated using equation (2) for the Cimanuk-Bayongbong catchment area, the NSE value is 0.515; and RMSE is 3.615, while the correlation coefficient is 0.800; and for the Cimanuk-Bojongloa catchment area the NSE value is 0.593; and RMSE is 4.813, while the correlation coefficient is 0.778. The RMSE value ranges from 0 to infinity. The smaller the RMSE value from 3.615 and 4.813, the closer the simulation discharge is to the observation discharge. Based on the final parameter values in the Cimanuk-Bayongbong catchment area and the Cimanuk-Bojongloa catchment area, the parameter values at the collection site are 50% exposed surface; infiltration coefficient 0.5; recession coefficient 0.35; catchment area characteristic factor 10%; and soil moisture capacity 200 mm.

Figure 3 shows the time series of calibration results. Cimanuk-Bayongbong catchment area. Meanwhile, Figure 4 is a flow duration curve and the probability of the observed discharge and simulated discharge being the same or greater.

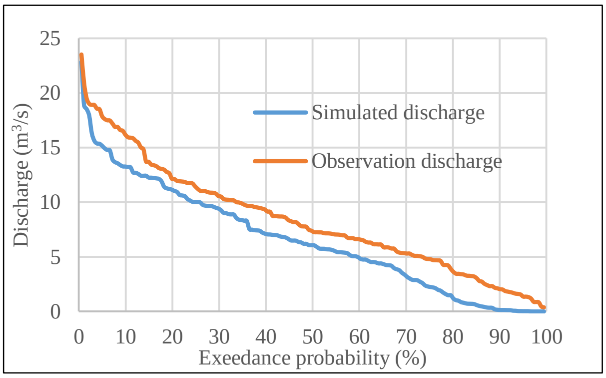

Fig 4. Duration curve calibration (Cimanuk-Bayongbong catchment area)

Figure 5 shows the time series of calibration results. Cimanuk-Bojongloa catchment area. Meanwhile, Figure 6 is a flow duration curve and the probability of the observed discharge and simulated discharge being the same or greater.

3.4 Simulated discharge

The final calibration parameters from the calculation results are used to calculate the simulated discharge (m^3/s) at the collection point. Simulated discharge results from a catchment area of 395 km^2. The amount of simulated discharge can be seen in Table 4 and the magnitude of the dependable flow for each month Q 90% can be seen in Table 5.

Discharge duration curves were created for data arranged from large to small with a Q 90% probability plot. From the monthly dependable flow to determine water availability at the collection point, water availability in July, August, September and October is 0.078 m^3/s each; 0.025 m^3/s; 0.035 m^3/s; and 0.025 m^3/s. Figure 7, Figure 8, Figure 9, and Figure 10 show the discharge duration curve.

3.5 Water needs

The standard need for clean water based on SNI 6728.1:2015 is 100 liters/person/day to 125 liters/person/day. Based on the population of Bayongbong District, the current amount of clean water needed by the people in Bayongbong District is around 10,724,600 liters/day to 13,405,750 liters/day or around 0.124 m^3/sec to 0.155 m^3/sec. The dependable flow of Q 90% based on simulation results at the collection point at a distance of approximately 3 km upstream from the collection point for the supply of clean water can be seen Table 5. Based on population growth, the predicted population of Bayongbong District for the next five years determined by equation (4) is 116,048 people. So water requirements for the next five years are estimated to be between 0.134 m^3/sec to 0.168 m^3/sec.

The projected population for the next 10 years is estimated at 125,572 people. The amount of water to meet community needs for the next 10 years is estimated at 12,557,200 liters/day to 15,696,500 liters/day or around 0.145 m^3/s to 0.182 m^3/s. Based on the dependable flow each month, the need for clean water for the next five and ten years for July, August, September and October will not be met. So PDAM Tirta Intan Garut Regency needs to look for new water sources or use a rotating system to serve the community's needs.

Table 4. Simulated discharge (m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	19,4	11,4	11,8	14,7	4,5	0,1	0,1	0,4	0,9	7,6	27,3	15,7
2009	13,5	7,1	9,6	17,0	8,5	1,6	0,4	0,4	0,4	5,9	13,0	12,5
2010	14,7	29,9	16,1	14,0	21,1	15,9	12,2	4,4	17,6	15,9	22,5	18,0
2011	7,7	10,6	7,8	10,7	12,3	3,2	0,8	0,1	0,1	3,4	9,3	11,3
2012	20,1	22,1	13,4	16,3	15,1	3,6	0,1	0,1	0,2	6,8	16,8	19,1
2013	32,1	28,2	18,5	35,1	33,9	16,0	21,5	6,7	0,9	6,0	7,3	18,7
2014	12,0	13,4	33,5	32,3	14,3	16,4	14,9	6,3	1,1	0,9	19,1	52,5
2015	31,3	26,7	27,7	30,8	20,7	7,1	0,0	0,0	0,0	0,0	18,1	25,2
2016	28,8	27,8	43,8	33,0	28,3	20,7	14,0	27,8	33,6	25,9	29,9	27,1
2017	24,6	31,1	30,8	25,7	18,9	16,0	11,0	1,2	1,3	14,1	37,8	25,6
2018	23,0	35,4	33,4	31,9	20,1	8,1	2,0	0,2	0,3	0,3	10,9	21,6
2019	28,1	33,8	45,4	28,1	17,6	4,8	0,4	0,0	0,0	0,0	2,0	15,7
2020	33,1	39,4	39,2	38,4	27,0	22,8	6,7	0,5	1,8	22,9	25,8	32,5
2021	32,3	20,7	13,9	15,6	14,6	14,3	8,4	11,0	9,7	12,2	40,4	36,2
2022	32,0	38,8	19,2	26,2	12,6	15,6	9,9	6,2	15,3	14,1	20,1	26,0

Table 5. Dependable flow (m^3/s)

Data	Prob (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	6	33,1	39,4	45,4	38,4	33,9	22,8	21,5	27,8	33,6	25,9	40,4	15,7
2	13	32,3	38,8	43,8	35,1	28,3	20,7	14,9	11,0	17,6	22,9	37,8	52,5
3	19	32,1	35,4	39,2	33,0	27,0	16,4	14,0	6,7	15,3	15,9	29,9	36,2
4	25	32,0	33,8	33,5	32,3	21,1	16,0	12,2	6,3	9,7	14,1	27,3	32,5
5	31	31,3	31,1	33,4	31,9	20,7	16,0	11,0	6,2	1,8	14,1	25,8	27,1
6	38	28,8	29,9	30,8	30,8	20,1	15,9	9,9	4,4	1,3	12,2	22,5	26,0
7	44	28,1	28,2	27,7	28,1	18,9	15,6	8,4	1,2	1,1	7,6	20,1	25,6
8	50	24,6	27,8	19,2	26,2	17,6	14,3	6,7	0,5	0,9	6,8	19,1	25,2
9	56	23,0	26,7	18,5	25,7	15,1	8,1	2,0	0,4	0,9	6,0	18,1	21,6
10	63	20,1	22,1	16,1	17,0	14,6	7,1	0,8	0,4	0,4	5,9	16,8	19,1
11	69	19,4	20,7	13,9	16,3	14,3	4,8	0,4	0,2	0,3	3,4	13,0	18,7
12	75	14,7	13,4	13,4	15,6	12,6	3,6	0,4	0,1	0,2	0,9	10,9	18,0
13	81	13,5	11,4	11,8	14,7	12,3	3,2	0,1	0,1	0,1	0,3	9,3	15,7
14	88	12,0	10,6	9,6	14,0	8,5	1,6	0,1	0,0	0,0	0,0	7,3	12,5
15	94	7,7	7,1	7,8	10,7	4,5	0,1	0,0	0,0	0,0	0,0	2,0	11,3
	Q 90	10,3	9,2	8,9	12,7	6,9	1,0	0,1	0,0	0,0	0,0	5,2	12,1

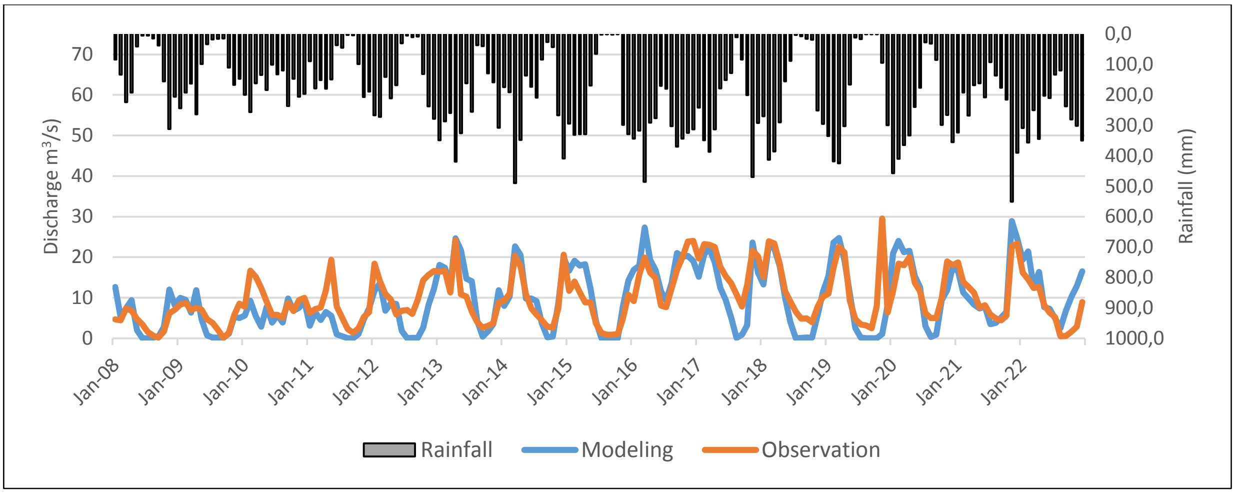

Fig 5. Time series calibration (Cimanuk-Bojongloa catchment area)

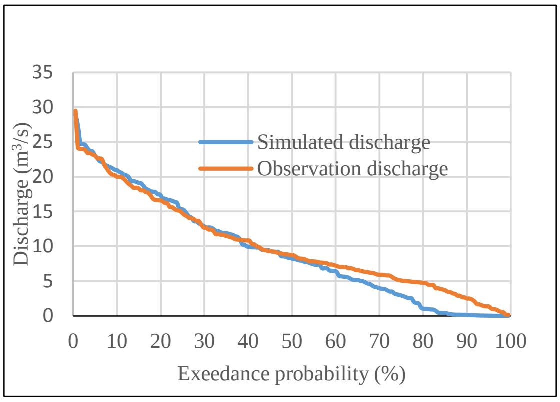

Fig 6. Duration curve calibration (Cimanuk-Bojongloa catchment area)

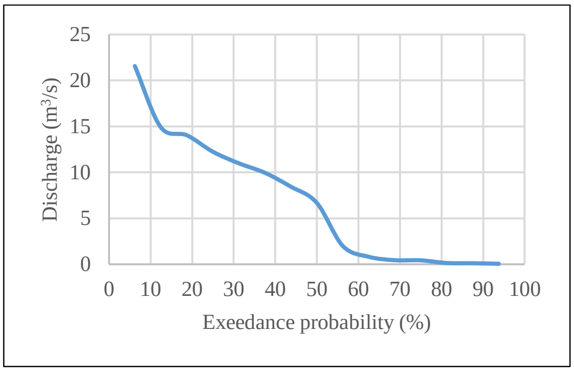

Fig 7. July duration curve

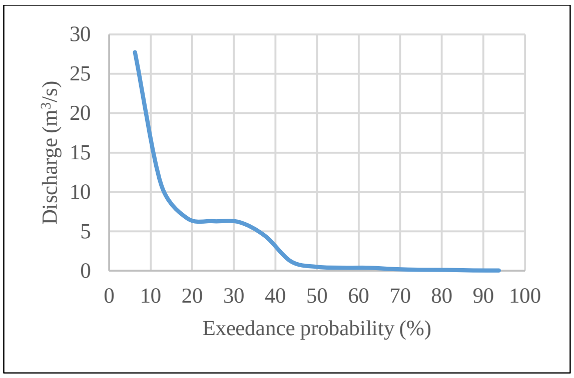

Fig 8. August duration curve

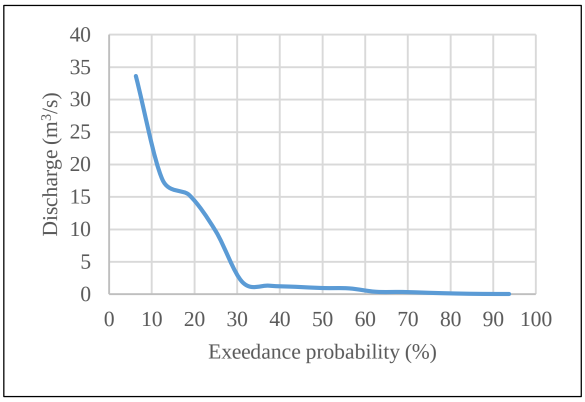

Fig 9. September duration curve

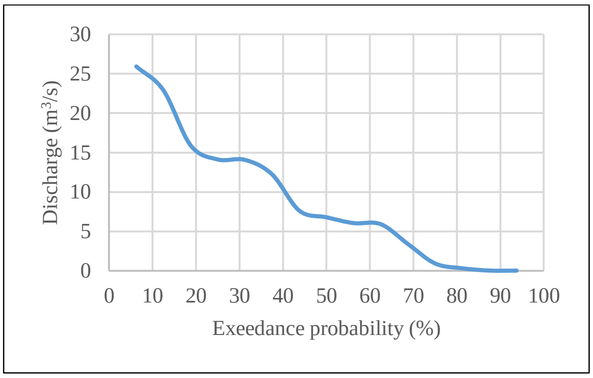

Fig 10. October duration curve

4. Conclusion

The results of model parameter calibration for the Cimanuk-Bayongbong catchment area are 50% exposed surface, infiltration coefficient 0.5; recession coefficient 0.3, and 0.4 for the Cimanuk-Bojongloa catchment area; catchment area characteristic factor 10%; and SMC 200 mm. The Cimanuk-Bayongbong catchment area value of NSE, RMSE, and correlation coefficient is 0.515; 3,615; and 0.800, while the value for the Cimanuk-Bojongloa catchment area is 0.593; 4,813; and 0.778. The model parameters at the water intake site can be used for 50% exposed surface; infiltration coefficient 0.5; recession coefficient 0.35; catchment area characteristic factor 10%; and SMC of 200 mm.

The monthly dependable flow at the collection point for water availability in July, August, September and October for the next 5 and 10 years is estimated to not be met, because the existing discharge is below the required discharge.

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