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Water Balance Analysis of Dolok Reservoir using Mock Method

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Abstract— *Based on the study of Pola PSDA WS Jratunseluna (2015), there was a shortage of water in both raw and irrigation water in several areas in WS Jratunseluna. The Dolok reservoir in Demak Regency is planned to suffice irrigation water needs covering 1296 ha and raw water to serve Demak Regency. This reservoir is part of the urban water system component, which is a source of water storage. This study aims to analyze the water balance in the Dolok Reservoir, adopting the Mock Method. Daily rainfall data and climatological data for 13 years (2003 - 2015) are required to calculate reservoir inflow due to limited discharge data. Data on irrigation water demand were obtained from the Planting Pattern Scheme in Dolok Irrigation Area. Data on raw water demand was obtained from population data. The water balance was calculated by comparing water availability with water demand. The water balance condition in the Dolok Reservoir watershed before the reservoir was built suffered a deficit in 2018 in some periods. To build reservoirs, it can suffice the needs of raw water and irrigation water needs in 2018 and 2025 in the Demak Regency*.

Keywords— *reservoir inflow, dependable discharge, mock method, water balance.*

I. Introduction

The Dolok watershed is part of the Dolok-Penggaron System, which is located in the Jratunseluna River Region. The current condition of the Dolok River has undergone siltation considering its capacity has decreased due to riverbank erosion caused by land-use changes in the upstream of Dolok watershed; this caused flooding that inundated the surrounding settlements. Another problem is the lack of water availability in the dry season because of increasingly scarce water sources due to deforestation and uncontrolled water use. One of the efforts to overcome the problem of flooding, and the lack of available water is to build a reservoir. Reservoirs as water buildings for flood control and fulfillment of irrigation water requirements and raw water are expected to accommodate water flow from the river; thus, it can contain water during the rainy season and provide water during the dry season. The reservoir is part of urban water infrastructure components, which typically includes water collection and storage facilities at source sites, water transport via aqueducts (canals, tunnels, or pipelines) from source sites to water treatment facilities; water treatment, storage, and distribution systems; wastewater collection (sewer) systems and treatment; and urban drainage works (Loucks & Beek, 2017). One of the reservoirs planned to be built to handle flooding in the Dolok-Penggaron River System and the lack of water availability in the Dolok watershed is the Dolok Reservoir. The plan to utilize the Dolok Reservoir with a storage capacity of 34.09 million cubic meters is to meet the irrigation water needs of the Dolok irrigation area and raw water in the Demak Regency. Based on these problems, it is necessary to analyze the water supply available in the Dolok Reservoir; thus, it can meet water needs in the future.

II. Purpose

This study aims to determine water availability, water needs, and water balance in the Dolok Reservoir.

III. Methods

A. Research Site

The object of this research is Dolok Reservoir in the Dolok watershed. The Dolok watershed adjacents to the Java Sea in the north, to the Jragung watershed in the south, to the Babon watershed in the west, and the Setu watershed in the east, as shown in Fig. 1. The Dolok watershed has an area of 89.1 km^2. The upstream of the Dolok river is in a mountainous area located in the middle of the hilly area of Central Java province, extending from west to east, located between Mount Ungaran and Mount Merbabu. Land use in this watershed is a forest area and moor. The inundation area of the Dolok Reservoir is entirely in PT Perhutani's management land and not inhabited by residents. Administratively it is in the Banyumeneng Village, Mranggen District, Demak Regency. The population in 2014 amounted to 175604 people with a livelihood mostly as farmers and factory workers (BPS Kabupaten Demak, 2015).

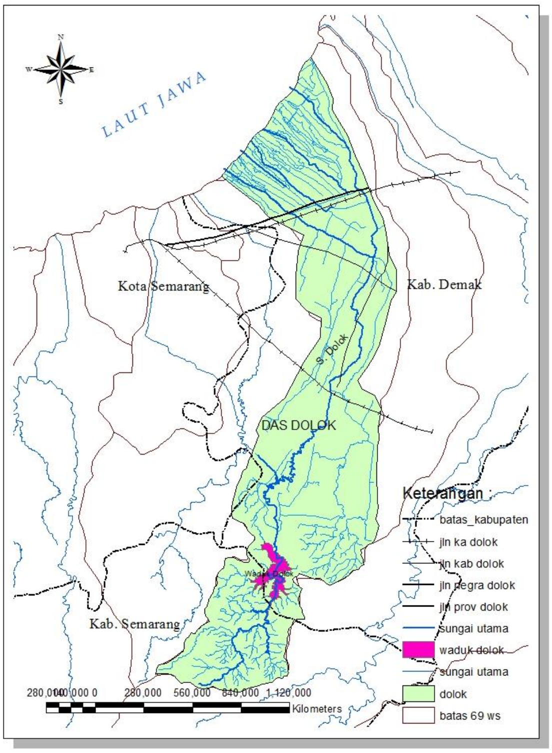
The planned construction of the Dolok Reservoir is near the Barang Weir, in the Girikusumo area, Banyumeneng Village, Mranggen District, Demak Regency. The location of the planned construction of the Dolok Dam is located on the Dolok River approximately 1 km before the Barang Weir. This Barang Weir will later function to distribute the Dolok Reservoir for irrigation and raw water purposes. Besides that, the Dolok River supplies water discharge to Pucanggading Weir through Kebonbatur Supplementary Channels.

B. Tool and Materials

This research requires supporting data to perform an analysis of the water balance of the Dolok Reservoir. The data used is secondary data obtained from an organization or institution in the form already prepared. In this study, secondary data was obtained from BBWS Pemali Juana. Secondary data required include:

1. Rainfall data, obtained from the recording of stations around the research location, namely the Banyumeneng Rain Station and Bawen Rain Station. The duration of rainfall data needed in this study is 13 years, from 2003 to

2015. This data is employed for dependable discharge analysis.



Source: BBWS Pemali Juana, 2015

Fig 1. Research site

2. Climatology data
   The climatology data used is data recorded at the Jragung Climatology Station. Climatology data consists of evaporation data, mean temperature, relative humidity, number of rainy days, solar radiation, and wind speed. This data is used for the analysis of evapotranspiration.
3. Irrigation Data
   Irrigation data in the form of a map of the Dolok Irrigation Area with an area of 1296 ha was obtained from BBWS Pemali Juana. Dolok Irrigation Area cropping pattern data is needed to determine the current cropping pattern of irrigation areas, particularly rice-pulses. These data are used to determine the irrigation water needs of Dolok Irrigation Area.
4. Reservoir technical data
   The reservoir's technical data is used to analyze reservoir capacity; thus, water availability in the Dolok Reservoir can be identified.
5. Map of the Dolok watershed
   The Dolok watershed map was obtained from the map of Rupa Bumi Indonesia with a scale of 1: 25000.
6. Population Data
   Population data were obtained from the Central Bureau of Statistics's latest year to determine the Demak Regency population. This data is used for the analysis of raw water requirements.

C. *Stage of Research*

This research was achieved through several stages, starting from preparation, data analysis, and conclusions. The details are described as follows.

D. *Data Analysis*

1. Inflow Data Analysis

a. Average watershed rainfall

Analysis of the watershed's average rainfall from the Banyumeneng rain station and the Bawen rain station was performed by the Thiessen polygon method. The data used is daily rainfall data and then processed into biweekly data. Using the Thiessen polygon method, we comprehend the weight of each watershed's influence to obtain the average rainfall of the watershed.

b. Evapotranspiration

The data used in calculating evapotranspiration are climatological, include air temperature (°C), relative humidity (%), wind speed (m/s), solar radiation (%). Calculation of evapotranspiration uses the following Penman formula (Limantara, 2010):

$$ET_O = C \times ET_{O'} \quad (3.1)$$

$$ETo^* = w(0.75Rs - Rn) + [(1 - w) \times f(U) \times (\varepsilon\gamma - \varepsilon d)] \quad (3.2)$$

with:

ETo	=	potential evaporation (mm/day)
C	=	correction factor
ETo*	=	evaporation (mm/day)
W	=	factors related to temperature and regional elevation
Rs	=	shortwave radiation (mm/day)
Rn	=	longwave clean radiation (mm/day)
F(U)	=	function of wind speed at altitude 2,00 m
(εY-εd)	=	the difference in vapor pressure is saturated with the actual vapor pressure

c. Discharge analysis

Discharge analysis is used to get a dependable discharge or water availability. In this study, discharge analysis was based on rainfall, rainy days, and evapotranspiration data using the Mock Method. The FJ Mock method is one method to describe natural phenomena in the form of water flow available in a river's flow, which we identify as discharge (Bakhtiar, 2008). Discharge analysis with the Mock Method in general through several stages. Limited evapotranspiration calculations, water balance calculations, runoff and groundwater storage calculations, and discharge calculations (Departemen Pekerjaan Umum, 1986). The calculation steps of the Mock method to obtain the simulation discharge are as follows:

1) Prepare input data, namely data on rainfall area (P), number of rainy days (h), potential evapotranspiration (Eto), and several other parameters. The parameters used in this study were determined as follows: groundwater flow recession factor (k) of 0.75, dry season infiltration coefficient (ik) number of 0.2, and rainy season infiltration coefficient number (ih) of 0.3.
2) Determining limited evapotranspiration (Et) with equations

$$Et = Eto - \Delta E \quad (3.3)$$

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3) Determining the amount of rain at ground level (Ds) with the equation Ds = P-Et (3.4)
4) Determining the soil moisture capacity (SMC), which is equal to 200 mm
5) Determining water surplus (WS)
6) Determining the infiltration value (I)
7) Determining the underground water content (Vn), with the equation $Vn = k*V_{n-1} + ½ (1+k)*In$ (3.5)
8) Determining changes in underground water content (DVn), with the equation $DVn = V_n - V_{n-1}$ (3.6)
9) Determine base flow (BF) and direct flow (DR), with the equation BF = I – DVn (3.7) dan DR = WS – I (3.8)
10) Determining the available debits in the river by multiplying Flow (R = BF + DR) with the watershed area.

The results of the calculation of simulation discharge with the Mock Method are then calibrated with observational discharge. Calibration aims that the output of the model produced approaches the output of the observation. In this study, calibration was performed using graphical methods and statistical tests by calculating the coefficient of determination (R^2) and the Nash-Sutcliffe Coefficient of Efficiency (NSE) using (3.9) and (3.10). If the simulation discharge has the same tendency as the observation discharge, the model can be used. R^2 and NSE's criteria can be viewed in table 1 (Hidayat, Sudira, Susanto, & Jayadi, 2016; Priyanto, 2016; Suprayogi, Handayani, Darmayanti, & Trimaijon, 2013).

TABLE 1. Criteria for R^2 and NSE Value

Statistical Test	Value	Criteria
Coefficient of determination (R^2)	$R^2 \geq 0.60$	Good
	$R^2 < 0.60$	Bad
Nash-Sutcliffe Coefficient of Efficiency (NSE)	$NSE \geq 0.75$	Good
	$0.36 \leq NSE < 0.75$	Satisfactorily
	$NSE < 0.36$	Poor

Source: Hidayat, 2016

$$R^2 = \frac{\left[\sum_{i=1}^{n}(Q_{obs,i} - \bar{Q}_{obs,i})(Q_{sim,i} - \bar{Q}_{sim,i})\right]^2}{\sum(Q_{obs,i} - \bar{Q}_{obs,i})^2 \sum(Q_{sim,i} - \bar{Q}_{sim,i})^2} \quad (3.9)$$

$$NSE = 1 - \frac{\sum_{i=1}^{n}(Q_{obs,i} - Q_{sim,i})^2}{\sum_{i=1}^{n}(Q_{obs,i} - \bar{Q}_{obs,i})^2} \quad (3.10)$$

With: R^2 = Coefficient of determination, NSE = Nash-Sutcliffe Coefficient of Efficiency, Q_{obs}= observation discharge (m^3/s), Q_{sim}= simulation discharge (m^3/s), $\bar{Q}_{obs}$ = average observation discharge (m^3/s), $\bar{Q}_{sim}$ = average simulation discharge (m^3/s).

After obtaining the simulation discharge, then the dependable discharge is calculated. Dependable discharge is a discharge that is available throughout the year, with the magnitude of certain failures' risk. In this study, the dependable discharge was calculated based on the annual average discharge. The average discharge calculates each year, then sorted from the largest value to the smallest value. The percentage of reliability is obtained from the value of m / n expressed in percent (%), where m is the sequence number, and n is the amount of data. In this case, the dependable discharge used is a discharge with 80% reliability.

2. Outflow Data Analysis

Outflow discharge of the reservoir is analyzed based on the water balance principle. Water entering the reservoir (inflow) is equal to the amount of water that emerges in the reservoir (outflow). Reservoir outflow is adjusted to the amount needed for irrigation water and raw water needs.

a. Irrigation water needs in Dolok are obtained from the planting pattern data of Dolok Irrigation Area in 2017/2018
b. Raw water requirements were analyzed based on projections of the population of the Demak Regency.

In this study, the population data were obtained from the Central Bureau of Statistics for 5 (five) years, from 2013 to 2017. The population data was projected for the next ten years using arithmetic and geometric methods that were then averaged to produce data population projection. The formula used is as follows :

The basic formula for arithmetic methods are:

$$P_n = P_O + nr \quad (3.11)$$

$$r = \frac{(P_O - P_t)}{t} \quad (3.12)$$

The basic formula for geometric methods is:

$$P_n = P_O(1 + r)^n \quad (3.13)$$

with: Pn = Number of future population, Po = Total population at the end of the data year, Pt = Population at the beginning of the data year, t = the difference between the initial year of data and the final year of data, n = period reviewed, r = arithmetic / geometric growth rate.

Based on the projections of the population then water requirements are calculated utilizing the criteria for determining domestic water requirements as in table 2 (Triatmodjo, 2015).

TABLE 2. Criteria for Determining Domestic Water Needs

Population	Domestic (liter/capita/ day)	Non-Domestic (liter/capita/ day)	Domestic Water Loss (liter/capita/day)
> 1.000.000	150	60	50
500.000 – 1.000.000	135	40	45
100.000 – 500.000	120	30	40
20.000 – 100.000	105	20	30
< 20.000	82.5	10	24

Source : (Triatmodjo, 2015)

The water requirements calculated in this study consist of domestic water requirements (Qd) and non-domestic water requirements (Qnd). The following formula is used to determine the number of domestic water needs (Prijanto & Ismoyo, 2010) :

Qd = Pn*Un (3.14)

with :

Qd = domestic water needs (litre/s), Pn = total population in the year concerned (people), Un = value of per capita water needs per day (liter/capita/day).

Non-domestic water needs include water supply for commercial bodies, government, and social offices. Non-domestic water needs are based on the provisions contained in table 2. The total raw water requirements are calculated by summing domestic (Qd) water needs with non-domestic water needs (Qnd).

3. Analysis of Water Balance

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The water balance concept shows the balance between the amount of water entering into, available at, and emerging of a sub-system (Prijanto & Ismoyo, 2010). The water balance in the reservoir is obtained by comparing water availability and water requirements in the current and projected conditions. The calculation results show that the value of reservoir water needs can be met during the reservoir's life. The equation that applies to the calculation of the water balance is as follows :

$$I - O = \Delta S \quad (3.15)$$

with : I = inflow (m^3/s), O = outflow (m^3/s), ΔS = changes in the volume of water in the reservoir (m^3/s)

IV. RESULTS AND ANALYSIS

A. *Analysis of Watershed Rainfall*

Rainfall data used to analyze regional rainfall in this study were daily rainfall data at the Banyumeneng Rain Station and Bawen Rain Station for 13 years (2003 - 2015). Annual rainfall at Banyumeneng Rain Station is recorded between 1167 mm – 3276 mm, with an average of 2075.7 mm. While annual rainfall at Bawen Rain Station is recorded between 723 mm – 3741 mm, with an average of 1663.2 mm, the method used is polygon Thiessen, by connecting the two rain stations on the rain station map then the axis lines are perpendicular to the connecting line to form the polygon Thiessen. The influence of the Banyumeneng rainfall station was 0.825, and the Bawen rain station was 0.175. The analysis of rainfall in the Dolok Reservoir watershed area two weeks (mm) can be observed in table 3.

TABLE 3. Watershed rainfall of Dolok Reservoir (mm)

January		February		March		April	
I	II	I	II	I	II	I	II
138	166	135	97.4	130	120	137.1	126
May		June		July		August	
I	II	I	II	I	II	I	II
70.8	49.4	45	48.8	37	14.7	12.6	18.3
September		October		November		December	
I	II	I	II	I	II	I	II
25.4	36.8	51.95	94	124	109	155	170

B. *Evapotranspiration Analysis*

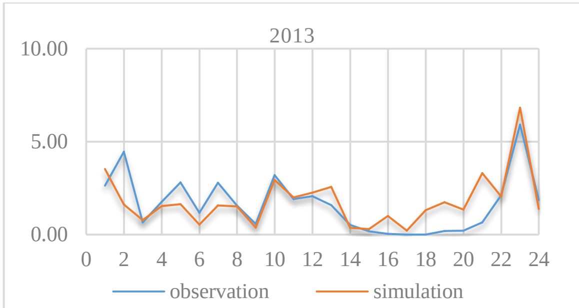
Calculation of evapotranspiration uses the modified Penman method. The data used is Climatology Station Jragung Station, which includes data on air temperature, relative air humidity, solar radiation data, and wind speed data. Climatological data are available for 13 years, from 2003 to 2015. The evapotranspiration analysis results show a semi-monthly average evapotranspiration rate ranging from 56.54 mm/2 weeks to 87.64 mm/2 weeks. Recapitulation of potential evapotranspiration (Eto) from 2003 to 2015 can be seen in table 4.

C. *Inflow analysis of Dolok Reservoir Watershed*

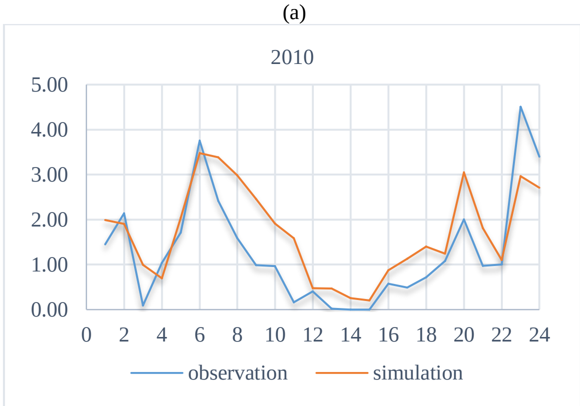
Calculation of the Dolok Reservoir inflow is carried out using the Mock Method. This method is a hydrological model with the working water balance principle for flow with rain as the input data model. The results of semi-monthly debit recapitulation with the Mock Method can be seen in table 8 in the appendix.

TABLE 4. Average Potential Evapotranspiration of Dolok Reservoir Watershed (mm)

January		February		March		April	
I	II	I	II	I	II	I	II
66.37	70.79	64.41	64.41	66.92	71.38	56.54	56.54
May		June		July		August	
I	II	I	II	I	II	I	II
64.55	68.85	63.23	63.23	63.38	67.6	77.82	83.01
September		October		November		December	
I	II	I	II	I	II	I	II
87.33	87.33	82.16	87.64	75.43	75.43		67.25



(a)



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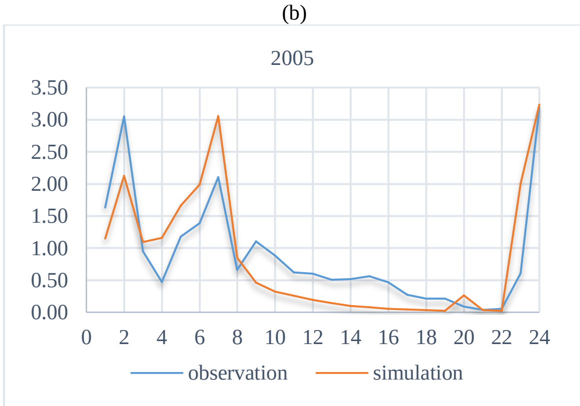

(c)

Fig. 2. Model Calibration

The simulation discharge calculation results are calibrated with observational discharge in the AWLR Barang Weir station, located downstream of the Dolok Reservoir watershed. The available discharge observations are 2005, 2010, and 2013. The results of discharge calibration can be seen in Fig.2. Based on Fig.2, it can be observed that the calculation discharge and observation discharge have almost the same tendency. Besides being presented with graphics, Calibration

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is also done using statistical tests by calculating the coefficient of determination (R2) and the Nash-Sutcliffe Efficiency Coefficient (NSE). R2 value obtained is 0.6 (good), and NSE is 0.54 (satisfactorily), which shows that the model can be used in the Dolok Reservoir watershed.

Furthermore, the calculation of dependable discharge is calculated based on the annual average discharge. The average annual discharge is sorted from the largest to the smallest value. Based on calculations that approach, the value of 80% is 76.92%, specifically in 2007. Thus the biweekly discharge with 80% reliability is the discharge in 2007, as observed in table 5.

TABLE 5. Dependable discharge of Dolok Reservoir watershed (m^3/s)

Jan I	Jan II	Feb I	Feb II	Mar I	Mar II	Apr I	Apr II
0.834	1.248	0.57	0.754	2.567	2.443	2.456	1.752
May I	May II	Jun I	Jun II	Jul I	Jul II	Agt I	Agt II
0.53	0.373	0.298	0.224	0.168	0.118	0.094	0.066
Sep I	Sep II	Okt I	Okt II	Nov I	Nov II	Dec I	Dec II
0.053	0.04	0.03	0.021	1.929	0.183	0.382	4.277

D. *Outflow analysis of Dolok Reservoir Watershed*

1. Analysis of Irrigation Water Needs

For analysis of outflow data, water requirements data are based on the Dolok Irrigation Area Year 2017/2018 Planting Pattern Scheme obtained from the Pusdataru Service of Central Java Province. The planting pattern in Dolok, particularly Paddy – Paddy - Palawija, is divided into two groups or rotations, i.e., Rotation I and Rotation II. Planting period Rotation I starts at the beginning of the first two weeks of November, while the Rotation II planting period starts at the beginning of the second 2 weeks of November. Table 6 shows that the maximum discharge rate for water needs is 1.381 m^3/s.

TABLE 6. Irrigation Needs of Dolok Irrigation Area (m^3/s)

Jan I	Jan II	Feb I	Feb II	Mar I	Mar II	Apr I	Apr II
0.93	0.93	0.91	0.47	0.63	1.25	1.12	0.94
Mei I	Mei II	Jun I	Jun II	Jul I	Jul II	Agt I	Agt II
0.93	0.93	0.91	0.47	0.18	0.31	0.32	0.32
Sep I	Sep II	Okt I	Okt II	Nov I	Nov II	Des I	Des II
0.32	0.32	0	0	0.67	1.38	1.2	0.95

2. Analysis of Raw Water Needs

The calculation of Raw water requirements was accomplished based on the population at the study location. It is necessary to calculate the population projections to analyze the water needs in the future. The population projection of the Demak Regency was calculated in each sub-district using population data for the last five years, from 2010 to 2014, as in table 7.

Analysis of Raw water requirements in this study includes domestic and non-domestic water requirements. From the Demak population's projection table, the number is between 100,000 - 500,000 people; therefore, the assumption of water use for per-capita domestic needs is 120 liters/day, non-domestic needs is 30 liters/day, and water loss is 40% of domestic water needs. In detail, the calculation of water requirements can be examined in table 9 in the appendix.

TABLE 7. Projection of Demak Regency Population (people)

Year	Arithmetic Method	Geometric Method	Average projection
2015	181120	180205	180662
2016	186635	184926	185781
2017	192151	189771	190961
2018	197666	194743	196205
2019	203182	199846	201514
2020	208697	205081	206889
2021	214213	210455	212334
2022	219728	215969	217848
2023	225244	221627	223435
2024	230759	227434	229096
2025	236275	233392	234833

3. Water Balance Analysis

The water balance was obtained by comparing water availability (dependable discharge) with water requirements; therefore, it can be viewed the picture of water balance in the year reviewed at the study location. From the results of calculations such as in Fig.3, it can be understood that the current condition of the Dolok Reservoir watershed is the biggest deficit in the second 2 weeks of November, while the maximum surplus condition occurs in December the second 2 weeks. The total water deficit that occurred was 22.81 million cubic meters.

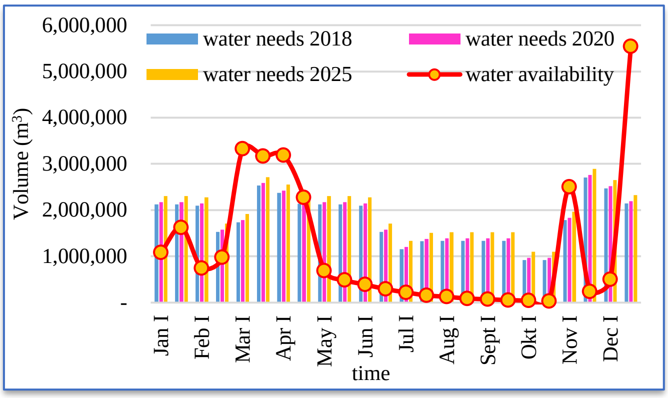

Fig. 3. Water balance of Dolok Reservoir

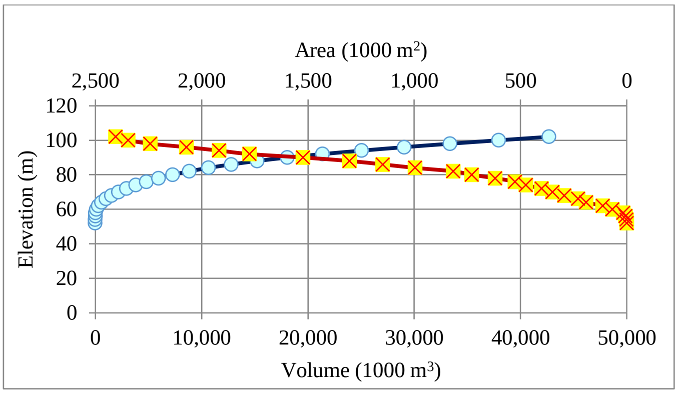

Fig. 4. Relationship between elevation - volume - area of inundation of Dolok Reservoir

With the development of the Dolok Reservoir with a storage capacity of 34.09 million cubic meters and an inundation area of 2.48 km^2 (fig.4), the total inflow in January I period of 2018 was 34090000 m^3 + 1081221.40 m^3 = 35171221.40 m^3. The total outflow was calculated considering

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the evaporation in the reservoir: the evaporation rate multiplied by the reservoir's size; thus, the evaporation amount in the reservoir equals 0.066 m x 2.48 km^2 = 165087.02 m^3. The water balance in Dolok Reservoir in January I of 2018 is I - O - E = 3511221.40 – 2124373.94 - 165087.02 = 32881760.44 m^3. The water balance calculation in 2025 was I - O - E = 3511221.40– 2305066.07 - 165087.02 = 32701068.38 m^3, which shows that with the addition of the volume of water from the Dolok Reservoir, it can suffice water needs in 2025.

The construction of the Dolok Reservoir is the base of the infrastructure component of the urban water system; hence, it is expected to be able to meet both irrigation and raw water needs for drinking water in the Demak Regency area.

V. CONCLUSION

The results of the research can be taken as follows:

1. The water availability in the Dolok Reservoir watershed based on the smallest 80% dependable discharge occurred in October; the second 2 weeks was 0.021 m^3/s. While the maximum mainstay discharge occurs in December, the second 2 weeks, which is 4.277 m^3/s.
2. The biggest irrigation needs in Dolok on November 2 of the second week were 1.38 m^3/s, while the smallest irrigation needs in the second week of July were 0.18 m^3/s.
3. Raw water requirements include domestic and non-domestic needs; in 2018 was 0.71 m^3/s, and in 2025 it will be 0.85 m^3/s.
4. The water balance condition in the Dolok Reservoir watershed before the reservoir was built suffered a deficit in 2018 in some periods, only in March, April, the first November, and the second in December, which experienced a surplus. With the effort to build reservoirs, it can meet the needs of raw water and irrigation water needs in 2018 and 2025.
5. Dolok Reservoir is part of the infrastructure component of the urban water system. Thus it is expected to meet both irrigation and raw water needs for drinking water in the Demak Regency area.

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APPENDIX

TABLE 8. Simulation discharge with the mock method (m^3/s)

Periode	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	rerata
Jan-1	1.11	1.55	1.15	2.88	0.83	2.23	2.88	1.99	2.09	4.13	3.53	3.52	3.20	2.39
Jan-2	0.61	2.61	2.13	3.66	1.25	3.09	2.57	1.90	1.13	4.23	1.61	5.00	2.87	2.51
Peb-1	0.87	1.02	1.10	4.10	0.57	5.67	2.54	1.00	3.11	1.55	0.78	4.08	3.84	2.33
Peb-2	0.56	0.79	1.16	2.18	0.75	3.96	2.34	0.70	0.87	1.67	1.53	1.10	2.73	1.56
Mar-1	0.90	1.96	1.66	2.24	2.57	2.39	2.97	2.04	1.71	1.37	1.64	0.77	3.43	1.97
Mar-2	0.27	0.89	1.99	0.68	2.44	2.33	0.67	3.48	2.44	1.53	0.54	0.54	3.66	1.65
Apr-1	0.96	1.06	3.06	2.98	2.46	2.06	0.57	3.39	1.73	1.39	1.57	1.66	4.99	2.14
Apr-2	0.23	0.35	0.85	1.25	1.75	2.51	3.39	2.99	1.88	1.99	1.51	3.13	4.18	2.00
Mei-1	0.17	0.26	0.46	1.76	0.53	0.69	1.17	2.46	2.37	0.49	0.38	2.47	1.68	1.15
Mei-2	0.12	0.19	0.33	0.43	0.37	0.49	1.77	1.91	0.45	0.34	2.95	0.49	0.77	0.82
Jun-1	0.10	0.15	0.26	0.34	0.30	0.39	3.98	1.59	0.36	0.27	1.99	0.39	0.62	0.83
Jun-2	0.07	0.11	0.20	0.26	0.22	0.29	0.50	0.47	0.27	0.20	2.26	6.27	0.46	0.89
Jul-1	0.05	0.08	0.15	0.19	0.17	0.22	0.38	0.47	0.20	0.15	2.56	3.52	0.35	0.65
Jul-2	0.04	0.06	0.10	0.14	0.12	0.15	0.27	0.26	0.14	0.11	0.37	1.00	0.25	0.23
Ags-1	0.03	0.05	0.08	0.11	0.09	0.12	0.21	0.20	0.11	0.09	0.30	1.49	0.20	0.24
Ags-2	0.02	0.03	0.06	0.08	0.07	0.09	0.15	0.87	0.08	0.06	1.00	0.37	0.14	0.23
Sep-1	0.02	0.03	0.05	0.06	0.05	0.31	0.12	1.13	0.82	0.05	0.21	0.39	0.11	0.26
Sep-2	0.01	0.29	0.03	0.05	0.04	0.06	0.29	1.40	0.09	0.04	1.31	0.23	0.08	0.30
Okt-1	0.01	0.04	0.03	0.03	0.03	1.04	0.09	1.25	0.07	0.03	1.74	1.91	0.06	0.49
Okt-2	0.01	0.03	0.26	0.02	0.02	0.40	0.06	3.05	1.56	0.53	1.35	4.70	0.04	0.93
Nop-1	0.01	1.37	0.04	0.02	1.93	2.12	0.49	1.81	3.55	3.04	3.30	0.63	2.02	1.56
Nop-2	1.60	1.77	0.03	0.32	0.18	1.66	0.07	1.10	2.57	2.11	2.05	0.47	2.65	1.28
Des-1	1.53	1.91	2.01	0.51	0.38	1.75	0.06	2.97	1.34	2.29	6.83	1.71	5.24	2.19
Des-2	1.08	2.88	3.24	0.50	4.28	1.85	3.27	2.71	2.66	1.56	1.38	3.82	0.85	2.31

TABLE 9. Raw water needs of Demak Regency

Description	unit	2018	2019	2020	2021	2022	2023	2024	2025
Total population	people	196,205	201,514	206,889	212,334	217,848	223,435	229,096	234,833
Underserved population	%	90	90	90	90	90	90	90	90
Total underserved population	people	176,585	181,363	186,200	191,101	196,063	201,092	206,186	211,350
water use	liter/capita/day	120	120	120	120	120	120	120	120
Domestic needs	liter/day	21,190,140	21,763,512	22,344,012	22,932,072	23,527,584	24,130,980	24,742,368	25,361,964
	m^3/s	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.29
water use	liter/capita/day	30	30	30	30	30	30	30	30
Non- domestic needs	liter/day	5,297,535	5,440,878	5,586,003	5,733,018	5,881,896	6,032,745	6,185,592	6,340,491
	m^3/s	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07
Total water needs		0.31	0.31	0.32	0.33	0.34	0.35	0.36	0.37
water losses	% domestic	40	40	40	40	40	40	40	40
	m^3/s	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12
Average water needs	m^3/s	0.40	0.42	0.43	0.44	0.45	0.46	0.47	0.48
Water needs on Maximum day	m^3/s	0.47	0.48	0.49	0.50	0.52	0.53	0.54	0.56
Water needs at peak hours	m^3/s	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.85