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Original Article

Analysis of the potential utilization of Semantok reservoir for the fulfillment of raw water and irrigation water

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Abstract

Each reservoir's need for water is increasing, including the Semantok Reservoir. It is intended to provide 312 l/sec of raw water needs and irrigation water for 1,900 acres. To assess whether irrigation water requirements are met, it is important to simulate using the Standard Operating Rule (SOR) technique and the QM For Windows V5 linear program. This simulation model incorporates average year, dry year, wet year flow and monthly mid-month discharge input. The scenario was created using the QM For Windows V5 linear program under 25-year and 50-year circumstances. Simulations based on usual years, dry years, and wet years using the SOR technique and the QM For Windows linear software indicate 100% fulfillment in every year. The water discharge in 2048 in dry years is 0.22 m^3/sec, in normal years is 0.31 m^3/sec, and in wet years is 0.34 m^3/sec, according to the analysis of the QM For Windows V5 linear program by simulating conditions for 25 years and 50 years, while in 2073 in dry years is 0.17 m^3/sec, normal year is 0.23 m^3/sec. Wet year reaches 0.33 m^3/sec, and recommending an increase in.

Keywords: Optimization, Linear Programming, SOR, Reservoir Operations, Reservoir

1. Introduction

Water is a fundamental requirement for human survival that must be met (Isqak et al., 2012). Water demand in a region will rise in tandem with population growth as a result of regional development Sari et al., (2012). It can be surplus or inadequate since its existence in one area and at one time is not constant. A thorough and integrated approach should be used while handling water. The term "comprising" alludes to a very broad coverage (broad convergence), across barriers between resources, between locations, between many aspects, between upstream and downstream parties, between multi-disciplinary, between circumstances, and between different types of land use. Engagement with various elements, parties (stakeholders), and scientific disciplines is referred to as being integrated. Additionally, water quality conservation aims to preserve water's functionality so that the supply of raw water maintains its scientific standard (Diah & Suprapto, 2017).

The Semantok Reservoir has a storage volume of 32.6 m^3 and a 356.3 Ha inundation area. A 1900 ha irrigation area, 312 lt/sec of raw water for homes, 30 lt/sec for river maintenance, a 30% decrease in flood danger, and tourism are all proposed uses of this reservoir. The 1945 Constitution of the Republic of Indonesia, which specifies that "Earth, Water, and the natural wealth contained therein are controlled by the state and used as much as possible for the prosperity of the people," must be adhered to in order to enhance the wellbeing of the people of Nganjuk Regency.

In order to lessen floods in the Rejoso sub-district, hold a lot of water during the rainy season, and distribute it during the dry season to avoid drought in rice fields, the Semantok Reservoir was built. By doing this, it will enhance agricultural output or the intensity of the harvest, increasing farmer income. In addition, to utilise raw water of 312 lt/s and produce irrigation water for a 1,900-ha area, it requires further research based on earlier studies to be carried out.

Reservoir operation essentially seeks to achieve balance between input discharge (inflow), output discharge (outflow), and changes in storage (Isqak et al., 2012). In order to maintain equilibrium between the supply of raw water and irrigation water, the Semantok Reservoir operates according to a set timetable. This simulation is also used to assess the outcomes of the operating pattern in the reservoir in order to determine if the operation was successful or failed (Epti & Puji, 2020). This work models reservoir operations utilizing the Standard Operating Rule (SOR) method employing basic water balance equations adapted to the operating designation of the Semantok Reservoir and the QM for Windows V5 application. Every half month, the Standard Operating Rule (SOR) simulation examination of storage reliability determines the inflow and outflow (Epti & Puji, 2020). The calculations made by the QM for the Windows V5 application yield information on the appropriate area for each type of plant in each alternative planting pattern (Risfiyanto et al., 2017).

You will understand the distinctions between the Standard Operating Rule (SOR) method and the QM for Windows V5 model after calculations to determine the simulation model for the utilization of the Semantok Reservoir in existing conditions, 25-year projected conditions, and 50-year conditions with inflow discharge in wet years, normal years, and dry years.

2. Materials and Method

Materials

a) Study Location

One of the regencies of East Java Province, Nganjuk Regency is situated in the western portion of the province. Its precise coordinates are 7°20 to 7°50 South Latitude and 111°5 to 111°13 East Longitude. Its 122,433.1 Ha of land area is broken up into 284 settlements and 20 sub-districts. In the Kedungpingit Hamlet, Sambikerep Village, Rejoso District, Nganjuk Regency, East Java Province, work is now being done on the Semantok Reservoir. Geographically, this reservoir’s intended site is between 111°53'25.68"E 7°29'41.90" South Latitude, with a distance of ± 16.70 km north of Nganjuk City, in the Semantok River Basin. A four-wheeled vehicle can go down an asphalt road with a road width of 4 meters to get to the destination. A distance of 3,100 meters will separate the Semantok Reservoir from the right and left hills of the Semantok River. The Semantok Reservoir provides benefits such as a 30% reduction in flooding, irrigation water for 1,900 ha, raw water at 312 ltr/sec, tourism, and maintaining rivers downstream of the reservoir at 30 lt/sec.

b) Research Data

Supporting information utilized in the analysis of the Semantok Reservoir's potential usage as a source of irrigation and raw water includes Data on rainfall collected between 2010 and 2021 at 4 rain stations (Kedungpingit, Matokan, Gondang, and Rejoso), Climate data from the Nganjuk Geophysical Station from 2010 to 2021 statistics on measured river discharge gathered between 2010 and 2021 at Margo Mulyo Dam and Rejoso Dam, data on water quality from 2018 to 2022, Amount of irrigated land, Population statistics from 2017 to 2021, Sedimentation data from 2020, and Other Supporting statistics.

Method

The information for this study came from four rain stations: Kedungpingit, Matokan, Gondang, and Rejoso. The four rain stations would be subjected to the Consistency Test, Absence of Trend Test, Stationarity Test, and Persistence Test. In order to calculate the amount of rainfall in the Semantok watershed, which has a catchment (DTA) area of 54.04

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km^2, it is crucial to study the average rainfall using the Average Method. It used the Penman method to determine the evapotranspiration value in the interim. The No Trend Test, Stationarity Test, and Persistence Test were used to assess AWLR discharge between 2010 and 2021. A conversion to flow study using a mock model is also necessary to verify that the water availability analysis is intended to assess water potential. The Semantok River contains water due to inflow from the Semantok Reservoir. With results under 10%, data can be used to evaluate the forecasting error model, and the output of the mock technique is then calibrated using the mean absolute error method. The discharge grouping describes data on the volume of incoming discharge in rainy years, normal years, and dry years between 2010 and 2021. The Standard Operating Rule (SOR) technique would ascertain the simulated irrigation water and raw water requirements in rainy, dry, and normal years. Additionally, QM For Windows 5 would simulate the raw and irrigation water requirements in 2048 and 2073 under rainy year, dry year, and normal year conditions.

Rainfall and Evapotranspiration

Water availability is uneven at all times and in every region because the hydrological cycle, strongly tied to local meteorological conditions, determines where and when water is present (UU RI No 7 Tahun 2019). For the purpose of obtaining high-quality hydrological data, it is necessary to understand and predict the sources of error and uncertainty in monitoring and measuring (Pusta Penelitian dan Pengembanganan Sumber Daya Air, 2014). Additionally, evapotranspiration combines transpiration and evaporation events (Sudinda, 2021). Compared to other methods, the modified Penman method calculates evapotranspiration using more detailed climate data (Sudinda, 2021). The steps for checking rainfall data in order to prevent inaccuracies are as follows:

a) Consistency Test

Since it would be impossible to eliminate mistakes entirely, the rain station data that would be used in the Consistency Test analysis should have very small errors (Paraga et al., 2020). The dual mass curve (DMC), one of the helpful approaches for comparative analysis, is distinguished by low data needs and great transferability, making it more helpful in assessing hydrological benefits than water balance equations and hydrological models (Gao et al., 2017).

b) Absence of Trend Test

This test is run to see if there is any pattern or variance in the data. A trend can be defined as a relationship between time and a hydrological variable's variance. It is not advised to analyze the data if there is a trend (Suhartanto et al., 2018). In this study, the Rank Correlation Test with the Spearman Method was used to test for the lack of a trend, and the results showed that H0 is accepted and H1 is refused (the data have no trend) (Juma'a at al., 2021).

c) Stationarity Test

The Stationarity Test was used to determine whether the average values and variance of the periodic series were stable (Ardiansyah et al., 2018). The results of both tests should demonstrate stable data, which is anticipated from this stationarity test (Suhartanto at al., 2019). The F-test and T-test were carried out to complement this test.

d) Persistence

Each value in a sequential series must be independent to be considered persistent (Juma'a et al., 2021).

Arithmetic Methods

The findings of measuring the depth of rain recorded at each rain station in a watershed will typically differ if the stations are spaced apart (Wijaya et al., 2021). The easiest approach for determining the average rainfall in a region is the arithmetic/algebraic average method (Lashari et al., 2017). When employed in flat terrain and watersheds with a large number of

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rain gauge evenly distributed in representative sites, arithmetic approaches in regional rainfall analysis are extremely suitable (Lashari et al., 2017).

a) Mean Absolute Error (MAE)

By quantifying the inaccuracy from a forecasting model, the Mean Absolute inaccuracy (MAE) is used to assess forecasting models (Adiyatma, 2018). The results of the Mean Absolute Error calculation display the average absolute error between the actual and predicted values (Adiyatma, 2018).

b) Fj. Mock

To determine the size of the watershed's primary outflow, the F.J. Mock method is used (Sudinda, 2021). The Mock technique additionally accounts for the volume of incoming anddeparting water as well as soil water storage (Widyaningsih et al., 2021). The calculations were done using 15 days of regional average data. The Mean Absolute Error method, a measurement used to evaluate forecasting models by determining the error from a forecasting model, was then used to calibrate the findings generated using the Mock method (Adiyatma, 2018).

c) Raw Water Needs

Population predictions are analyses that take the pace of population increase into account and predict how many people will live in a certain area in the upcoming year (Epti & Puji, 2021). Semantok Reservoir needed 1900 liters/second of raw water. estimating it for up to 25 and 50 years with the goal of determining whether or not the need for raw water was met. Field data indicate that the Semantok Reservoir should only be used for daily needs like bathing, washing, and other essentials, not for drinking. Drinking water management is required while this is going on due to the Semantok Reservoir's class II water quality.

d) Simulation of Reservoir Release Settings

The reservoir operation pattern is a benchmark operational time during which the produced water discharge must adhere to the rules in order to keep the reservoir elevation consistent with the design. Finding changes in the strength of the reservoir storage is the purpose of a simulation of a reservoir's functioning (Suryanto & Muqtadir, 2019). This simulation is used to assess operating patterns in reservoirs and determine if operations were successful or unsuccessful. Through a simulation-based analysis of the reservoir's performance, the operation is assessed (Epti & Puji, 2020). The Standard Operating Rule (SOR) technique was employed in this investigation. In order to calculate the best actual release (R) from a reservoir, six variables were considered in this study: water storage (S), minimum water storage (DS), inflow (I), total release of irrigation water and I water (TR), evaporation from reservoir water storage (E), and runoff from spillways (SP) (Hadthya, 2020). In order to meet the stipulated optimal water use criteria, the simulation is in theory run with a trial for the reservoir release value, which is the outflow (Hadthya, 2020).

e) Optimizing Reservoir Water Utilization

With the goal of determining how large the results of optimization are with current ones, optimization modeling is used to solve problems in the usage of existing water resources. Furthermore, by taking into consideration the current restrictions, this optimization has the value of a function that allows it to maximize a number of existing variables (Ahadunnisa et al., 2021). It is possible to use optimization studies to determine how to regulate cropping patterns and allocate water efficiently (Hermanto et al., 2020). One technique for creating reservoir operation guidelines is an optimization model (Adatika et al., 2021). With the assistance of POM-QM for Windows 5, linear programs can be used to optimize reservoir volume in order to meet the needs for irrigation and raw water (Fachrurozi et al., 2017). Based on the irrigation water requirements of the reservoir and the planting intensity, the ideal area

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will be identified using linear programming and the QM for Windows 5 auxiliary software [25]. Following are the steps involved in putting linear programming into practice:

a) The optimization model should be used;
b) Identify the adjustments that will be optimized (in this study, the available discharge will be optimized to meet irrigation water and raw water needs in normal years, dry years, and wet years);
c) Create mathematical models for the examination of optimization.

3. Results and Discussion

Water Availability Analysis

Based on the consistency test, lack of trend test, stationarity test, and persistence tests, there is a change in the rainfall data since all rain stations had their figures corrected because in the absence of trend test, the graph does not show 45°. The 15 daily regional average rainfall was then derived from the rainfall measured at the 4 rain stations using the average method. The absence of trend, stationarity, and persistence tests were performed on the AWLR discharge data available from 2010 to 2021 to assess the data's accuracy, with 100% of the findings passing the feeding test. The AWLR data can be used for more research, it can be said. Use mock model analysis to gather information on the water availability in the Semantok River, which will subsequently become the Semantok Reservoir inflow.

The Mean Absolute Error (MAE) method must be utilized to test since the findings of the Mock model analysis are used for further analysis. Based on the calculations, it appears that the analysis of forecasting rain data into discharge is successful, with the smallest results in period I being 2.12% in 2013 and for period II being 5.05 in 2017, the largest value in period I being 9.57% in 2019 and period II, the largest value in 2011 being 9.81%. This is indicated by the fact that all calibration analyses between rain discharge data and river discharge data are below 10%. The final rain data is a discharge calculated using the mock method, and since all calibration values are below 10%, which is calculated using the mean absolute error method, the data can be used. If averaged from 2010 to 2021 for period I, it is 7.38%, and for period II, it is 8.60%.

Debit Data Grouping

The purpose of the discharge grouping is to depict the amount of discharge inflow data from 2010 to 2021 into rainy year, normal year, and dry year circumstances with probability values equal to or exceeding, respectively, 35%, 50%, and 65% (Pusat Pendidikan dan Pelatihan SDA dan Konstruksi, 2017). The Semantok Reservoir Optimization and SOR technique calculations will use this grouping debit as the inflow discharge.

Table 1
Grouping of semi-monthly debits

No	Month	at	Condition (m^3/sec)		
			Dry	Normal	Wet
1	Jan	I	1.79	2.16	2.44
		II	0.72	0.90	1.38
2	Feb	I	2.01	2.06	2.33
		II	1.35	1.55	2.19
3	Mar	I	1.82	2.08	2.21
		II	0.92	1.50	1.83
4	Apr	I	1.82	2.13	2.20
		II	0.98	1.32	1.56
5	May	I	1.26	1.40	1.79
		II	0.58	0.91	1.07
6	Jun	I	0.84	1.03	1.30
		II	0.42	0.61	1.05
7	Jul	I	0.50	0.67	0.78
		II	0.24	0.35	0.59
8	Aug	I	0.30	0.40	0.47
		II	0.14	0.21	0.36
9	Sep	I	0.18	0.24	0.37
		II	0.09	0.13	0.23
10	Oct	I	0.11	0.17	0.38
		II	0.05	0.07	0.13
11	Nov	I	0.06	0.10	0.57
		II	0.09	0.14	1.45
12	Dec	I	0.51	0.68	1.21
		II	0.14	0.99	1.10

Table 1 demonstrates that the dry season's height falls between August and November in both dry and normal years as well as rainy years, but the inflow discharge is constant year after year to meet the demand for raw water and irrigation water. Utilizing QM It is possible to determine whether this demand is satisfied for Windows 5 by analyzing the SOR approach and linear programming method.

Raw Water Needs

An analysis of projected population growth indicates that the three sub-districts that the Semantok Reservoir would serve will be home to 259,710 people in 2048 and 343,804 people in 2073. The total amount of raw water needed is 120 liters per person per day for the urban population and 60 liters per person per day for the rural population, according to geometric population estimates (BSN, 2002). As a result, it is determined that the raw water requirements for 2048 and 2073, respectively, are 0.19 m^3/s and 0.25 m^3/s.

Irrigation Water Needs

The irrigation it provides for 1900 ha of land, including the DI. Rejoso Kiri (205 ha), DI. Rejoso Kanan (264 ha), DI. Margomulyo (154 ha), DI. Jati (227 ha), DI. Jatirejo (303 ha), DI. Janeng (226 ha), DI. Ngomben (122 ha), and Suplesi DI. Widas Utara (399 ha), is one benefit of the Semantok Reservoir. In the Semantok irrigation basin, the average annual crop intensity is expected to rise from 186.3% to 300%. The total amount of irrigation water needed is shown in Table 2.

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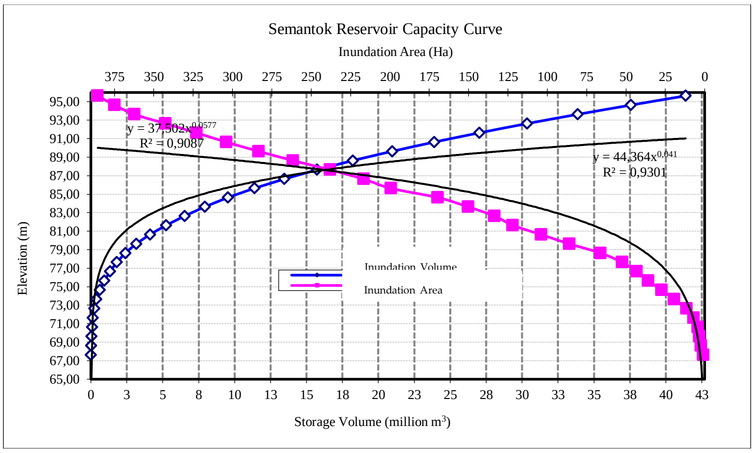
Table 2
Total Irrigation Water Needs for Semantok Reservoir

Month	Day	Need m^3/sec	Month	Day	Need m^3/sec
January	15	4.59	July	15	6.36
	16	6.45		16	4.08
February	15	5.52	August	15	3.94
	13	5.33		16	4.34
March	15	5.02	September	15	6.11
	16	5.85		15	6.55
April	15	12.99	October	15	5.50
	15	12.78		16	2.38
May	15	10.74	November	15	2.80
	16	11.50		15	9.30
June	15	10.69	December	15	10.92
	15	8.96		16	10.53

Characteristics of the Semantok Reservoir

The link between elevation, inundation area, and storage volume can be used to determine storage characteristics, which are crucial to the operation of the Semantok Reservoir. Figure 1 depicts the storage characteristic curve for the Semantok Reservoir.

Figure 1
Semantok Reservoir Storage Capacity Curve



Semantok Reservoir Water Quality

The Semantok Reservoir's water quality was sampled annually, and from 2018 to 2022, water quality samples were routinely analyzed. There were tests each semester. Other factors under investigation were pH, temperature, TSS, TDS, BODs, COD, DO, Copper (Cu), Colbalt (Co), Iron (Fe), Manganese (Mn), Zinc (Zn), H2S, pecal coliform, and total coliform. The water quality status is the average level of water quality that indicates whether the situation is clean or polluted (Triwanda et al., 2023). Since surface water status is in the class II category, the Semantok Reservoir may be used to provide the raw water needs of the Rejoso, Gondang, and Nganjuk Sub-districts.

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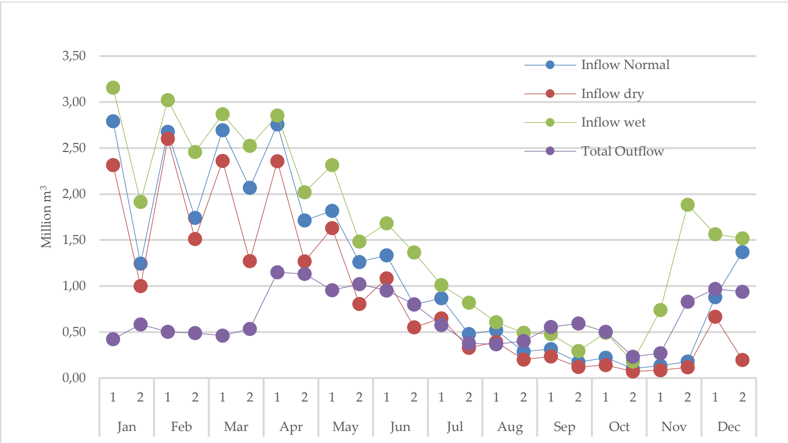
Only uses that require the same level of water quality as the aforementioned uses—such as irrigation of crops, infrastructure and facilities for water recreation—can make use of raw water. There won't be a decrease in water quality between 2018 and 2022. Population increase is the main cause of the deterioration in water quality because of the rising need for food and irrigation water for agricultural land (Sari et al., 2013. The Semantok Reservoir's usage for irrigation, planting, and/or other purposes that call for the same water quality as those uses is deemed appropriate if the water quality drops to classes III and IV (Denindya et al., 2023).

Standard Operating Rule (SOR) Method Simulation

According to simulations using the Standard Operating Rule (SOR) method, the need for irrigation water and raw water is satisfied each month. Runoff occurs through the spillway from January in the second period to May in the first period in wet years. In dry years, the Semantok Reservoir is able to satisfy the need for irrigation and raw water.

Figure 2

Comparison of inflow and outflow simulations of the SOR method



According to Figure 2, which compares total outflow and inflow in normal, dry, and wet years, there is a shortage in September and the demand for outflow in September rises, making it impossible for inflow in dry and normal years to meet the total outflow. However, based on simulations using the SOR method, the total is met since it can be met from the previous month because the inflow to the Semantok Reservoir with outflow according to needs has been met and the excess inflow is Thus, it can be said that the Semantok Reservoir can provide 100% of the raw water and irrigation needs for every year.

Linear Program Calculation

The primary goal of a linear program computation is to maximize or minimize numerical values. In order to model the optimization of the Semantok Reservoir in dry years, normal years, and wet years for irrigation water and raw water needs up to 2048 and up to 2073, a linear program will be calculated using the QM For Windows 5 tool. The following variables, restrictions, and objectives are provided for all simulations:

a) Maximize

Z = XAi + XAb

b) Variable

XAi = Irrigation water requirements

XAb= Raw water requirements in 2048/2073

c) Goals

1) Irrigation water needs are achieved
2) Raw water needs will be reached in 2048

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3) Raw water requirements will be reached in 2073

d) Constraints

1) Mainstay debit (January 1 to December 2)
2) Effective storage area (Constrain 25)
3) Maximum irrigation area (Constraint 26)
4) Raw water need (Constraint 27)

The optimization model, which was developed using linear programming and the QM for Windows 5 auxiliary application, will be used to decide whether or not it will be realized between the years 2048 and 2073. These are the outcomes that the model produced.

Table 3

Optimization Model in Linear Programs for 2048 in Dry Years

	XAi	XAb		RHS	Equation form
Maximize	1	1			Max XAi + Xab
Januariy1	4.59	0.23	<=	1.79	4.59XAi +.23XAb <= 1.79
January 2	6.45	0.23	<=	0.72	6.45XAi + .23XAb <= .72
February 1	5.52	0.23	<=	2.01	5.52XAi + .225443XAb <= 2.01
February 2	0.23	0.23	<=	1.35	.23XAi + .23XAb <= 1.35
March 1	5.02	0.23	<=	1.82	5.016XAi + .23XAb <= 1.82
March 2	5.85	0.23	<=	0.92	5.852XAi + .23XAb <= .92
April 1	12.99	0.23	<=	1.82	12.99XAi + .23XAb <= 1.82
April 2	12.78	0.23	<=	0.98	12.7775XAi + .23XAb <= .98
May 1	10.74	0.23	<=	1.26	10.7445XAi + .23XAb <= 1.26
May 2	11.5	0.23	<=	0.58	11.5045XAi + .23XAb <= .58
June 1	10.69	0.23	<=	0.84	10.6875XAi + .23XAb <= .84
June 2	8.96	0.23	<=	0.42	8.9585XAi + .225443XAb <= .42
July 1	6.36	0.23	<=	0.5	6.3555XAi + .225443XAb <= .5
July 2	4.08	0.23	<=	0.24	4.0755XAi + .225443XAb <= .24
August 1	3.94	0.23	<=	0.3	3.9425XAi + .225443XAb <= .3
August 2	4.34	0.23	<=	0.14	4.3415XAi + .225443XAb <= .14
September 1	6.11	0.23	<=	0.18	6.1085XAi + .225443XAb <= .18
September 2	6.55	0.23	<=	0.09	6.5455XAi + .225443XAb <= .09
October 1	5.5	0.23	<=	0.11	5.5005XAi + .225443XAb <= .11
October 2	2.38	0.23	<=	0.05	2.3845XAi + .225443XAb <= .05
November 1	2.8	0.23	<=	0.06	2.8025XAi + .225443XAb <= .06
November 2	9.3	0.23	<=	0.09	9.3005XAi + .225443XAb <= .09
December 1	10.92	0.23	<=	0.51	10.9155XAi + .225443XAb <= .51
December 2	10.53	0.23	<=	0.14	10.5317XAi + .225443XAb <= .14
Constraint 25	1	1	<=	293.9	XAi + XAb <= 293.94
Constraint 26	1	0	<=	1900	XAi <= 1900
Constraint 27	0	1	<=	0.31	XAb <= .312

Based on Table 3, after calculating the variables to meet the raw water needs of 0.31 m^3/sec, the irrigation needs of an area of 1900 ha, and the effective storage area of the Semantok Reservoir of 293.9 ha by choosing the maximum objective function to obtain the maximum discharge profit value in 2048/2073 so that the Reservoir is utilized Table 4 displays the maximum performance with running results.

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Table 4
Optimization Results in Linear Programs for 2048 in Dry Years

	XAi	XAb		RHS	Dual
Maximize	1	1			
January 1	4.59	0.23	<=	1.79	0
January 2	6.45	0.23	<=	0.72	0
February 1	5.52	0.23	<=	2.01	0
February 2	0.23	0.23	<=	1.35	0
March 1	5.02	0.23	<=	1.82	0
March 2	5.85	0.23	<=	0.92	0
April 1	12.99	0.23	<=	1.82	0
April 2	12.78	0.23	<=	0.98	0
May 1	10.74	0.23	<=	1.26	0
May 2	11.5	0.23	<=	0.58	0
June 1	10.69	0.23	<=	0.84	0
June 2	8.96	0.23	<=	0.42	0
July 1	6.36	0.23	<=	0.5	0
July 2	4.08	0.23	<=	0.24	0
August 1	3.94	0.23	<=	0.3	0
August 2	4.34	0.23	<=	0.14	0
September 1	6.11	0.23	<=	0.18	0
September 2	6.55	0.23	<=	0.09	0
October 1	5.5	0.23	<=	0.11	0
October 2	2.38	0.23	<=	0.05	4.44
November 1	2.8	0.23	<=	0.06	0
November 2	9.3	0.23	<=	0.09	0
December 1	10.92	0.23	<=	0.51	0
December 2	10.53	0.23	<=	0.14	0
Constraint 25	1	1	<=	293.94	0
Constraint 26	1	0	<=	1900	0
Constraint 27	0	1	<=	0.31	0
Solution	0	0.22		0.22	

According to Table 4's results, there will be no shortage in 2048 due to 100% fulfillment of demand. This may be inferred from the usage results obtained up until that time. In September there was a scarcity using the SOR approach, but not the QM. The debit for Windows applications was 4.44 m^3/sec. There was a shortage in October because the Semantok Reservoir's inflow was very low from July Period II's inflow value of 0.24 m^3/sec to October Period's various values, causing the QM to drop. The Windows 5 application suggests an inflow value of 4.44 m^3/sec for October period II, but it can be reached because there was an excess discharge of 0.22 m^3/sec the month before, demonstrating that it can be fulfilled.

If it will be realized or not for the years 2048 and 2073 will be determined based on the optimization model that had been determined by utilizing Linear Programming with the QM for Windows 5 auxiliary application. These are the outcomes that the model produced:

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Table 5
Optimization Model Results in Linear Programs

No	Years	Condition	A	B	C	D
			m^3/sec	m^3/sec	m^3/sec	m^3/sec
1	2048	Dry	0.22	0	0.22	0
2		Normal	0.31	0	0.31	0
3		Wet	0.34	0.02	0.31	0.97
4	2073	Dry	0.17	0	0.17	0
5		Normal	0.23	0	0.23	0
6		Wet	0.33	0.02	0.31	0.87

Information Table 5.
A: Benefits of water discharge in 2048
B: Excess water discharge in irrigation water needs
C: Excess water discharge in raw water needs
D: Raw water needs which can be achieved

According to the overall analysis, each of them will have a different surplus discharge in 2048 and 2073 regardless of whether the year is normal, dry, or wet. Table 5's chart A shows the value of the excess discharge. Using the QM to deduce conclusions from an analysis of linear programming for the Windows 5 program the requirement for raw water must be taken into consideration. Based on usable age data, this estimate suggests raising the demand for raw water at the Semantok Reservoir, which was formerly 312 ltr/sec, may be satisfied until 2073. The reservoir is up to 30 years old, and considerable action must be taken to address the Semantok sub-watershed's high levels of silt if irrigation water and raw water needs are to be met through 2073.

Comparison of SOR and QM Methods For Windows 5

Based on the analysis that has been carried out, the differences between the two methods can be as follows:

1) With the QM For Windows V5 linear software, you can project the future based on whether or not the plan is carried out, however with the SOR method analysis, you can only project the reservoir;
2) The SOR approach has the advantage of having more supporting data than the linear QM For Windows V5 application, allowing for greater accuracy;
3) It is possible to see when month the discharge can overflow the spillway and what height the reservoir water level is in the findings produced by the SOR approach, which are more specific.
4) Based on the analysis results from both methods, there is a water shortage in QM For Windows V5, it can be shown how big the discharge shortage must be achieved;
5) Both the SOR and QM For Windows V5 approaches are used in simulation calculations for the Semantok Reservoir, but the QM For Windows V5 linear program calculations allow you to determine the amount of the excess discharge;
6) The QM For Windows V5 linear program calculations' final results include recommendations for the amount of raw water needed to grow the service area to its ideal size.

4. Conclusion

Both simulation methods have been calculated in order to determine the simulation of Semantok Reservoir utilization. Although the SOR approach is unable to replicate QM projection conditions for 25 and 50 years, these two methods continuously yield 100%

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outcomes. According to the results of the Windows 5 linear program, which models predictions for 25 years and 50 years, water discharge will benefit in dry years by 0.22 m^3/sec in 2048, normal years by 0.31 m^3/sec in 2051, and wet years by 0.34 m^3/sec in 2073. Additionally, the QM For Windows 5 linear program analysis suggests that the increased raw water demand for the Semantok Reservoir, which was previously 312 lt/sec, may be met until 2073 providing that the increase occurs during wet years. The Semantok sub-watershed has a very high silt content, so the reservoir needs to be extensively treated in order to meet irrigation water and raw water needs until 2073; according to statistics on the reservoir's functional life, which is up to 30 years in that year.

5. References

Adiyatma, S. (2018). Data Asimilasi Menggunakan Metode Kalman Filter Untuk Mengevaluasi North-American Multi Model Ensemble (NMME) di Indonesia.

Adatika, L., Suripin, S., & Darsono, S. (2021). Optimasi Operasi Waduk Dolok dengan Program Dinamik. Briliant Jurnal Riset dan Konseptual, 6(1), 205. https://doi.org/10.28926/briliant.v6i1.595

Ahadunnisa, R., Anwar, N., & Margini, N. F. (2015). Studi Optimasi Pemanfaatan Waduk Way Apu di Provinsi Maluku untuk Jaringan irigasi, Kebutuhan air Baku, dan Potensi PLTA. *Jurnal Hidroteknik*, *1*(2), 51-58.

Ardiansah, I., Putri, S. H., & Rahmah, D. M. (2018). Penentuan Panjang Rekaman Data Curah Hujan Untuk Menggambarkan Kondisi Iklim di Kecamatan Jatinangor. *Agritech: Jurnal Fakultas Pertanian Universitas Muhammadiyah Purwokerto*, *20*(1), 19-22.

Bestari, A. S., Marrushartati, N. A., Sumirman, E., & Imaaduddiin, H. (2017). Optimasi Pemanfaatan Air Sungai Keser Untuk Daerah Irigasi Ngasinan Menggunakan Program Linier.

BSN. (2002). Standar Nasional Indonesia No. 19-6728.1-2002 Penyusunan Neraca Sumber Daya - Bagian 1: Sumber Daya Air Spasial. Badan Standardisasi Nasional, ICS 13.060, 10.

Denindya, Z. A. P., Haribowo, R., & Rubiantoro, P. (2023). Analisis Status Kualitas Air Metode STORET Saluran Irigasi di. *Jurnal Tresda*, *3*(2), 178–185.

Epti, N. I., & Puji, U. (2020). Simulasi Pola Operasi Embung Serbaguna Tambaksari Kabupaten Cilacap dengan Metode Standard Operating Rule (SOP). *Jurnal Civil Engineering*, 14.

Fachrurrozi, M. (2017). Studi Optimasi Pemanfaatan Waduk Bagong Untuk Jaringan Irigasi, Kebutuhan Air Baku, Dan Potensi PLTA. Institut Teknologi Sepuluh November.

Gao, P., et al. (2017). Use of double mass curves in hydrologic benefit evaluations. *Hydrological Processes*, *31*(26), 4639–4646. https://doi.org/10.1002/hyp.11377

Hadthya, R., Jayadi, R., & Pratiwi, E. P. A. (2020). Optimasi Pemanfaatan Air Waduk Tukul Menggunakan Model Simulasi Operasi Waduk Multi Kriteria. Prosiding Webinar Nasional Teknik Sipil 2020, 193–200.

Hermanto, K., Utami, S. F., & Suarantalla, R. (2020). Optimasi Alokasi Air Irigasi Menggunakan Program Linier (Studi Kasus Bendungan Batu Bulan Kecamatan Moyo Hulu). *Barekeng Jurnal Ilmu Matematika dan Terapan*, *14*(3), 447–460.

Infantri ,Y.M., Wijakesuma, T. G. R., & Harmayan, K. D. (2020). Evaluasi Pola Operasi Waduk Tamblang di Kabupaten Buleleng Provinsi Bali. *Jurnal Teknik Pengairan*, *11*(2), 116–127. doi: 10.21776/ub.pengairan.2020.011.02.05

Isqak, D., Juwono, P. T., & Suprijanto, H. (2012). Analisa Pola Operasi Embung Joho untuk Pemenuhan Kebutuhan Air Bersih Desa Joho Kecamatan Pace Kabupaten Nganjuk Jawa Timur. *Jurnal Teknik Pengairan*, *2*(2), 218–225.

Juma'a, M. W., Limantara, L. M., & Wahyuni, S. (2021). Estimasi Tinggi Curah Hujan dari Data Klimatologi Menggunakan Model Artificial Neural Network (ANN) di Kabupaten Badung Bali Selatan. *Jurnal Teknologi dan Rekayasa Sumber Daya Air*, *1*(1), 126–135. doi: 10.21776/ub.jtresda.2021.001.01.11

Lashari, et al. (2017). Analisa Distribusi Curah Hujan di Area Merapi Menggunakan Metode Aritmatika Dan Poligon. Jurnal Teknik Sipil dan Perencanaan, 19(1), 39–46. doi: 10.15294/jtsp.v19i1.9497

Lestari, D. T. B., & Suprapto, H. (2019). Analisis pemanfaatan mata air sebagai sumber air baku di Kecamatan Cisarua, Kabupaten Bogor. *Jurnal Ilmiah Desain & Konstruksi*, *16*(2).

Paraga, D. B., Nurhayati, & Yulianto, E. (2020). Uji Konsistensi Data Hujan Dari Stasiun Hujan Yang Berpengaruh Di Wilayah Kota Pontianak. *JeLAST Jurnal Elektronik Laut, Sipil, Tambang*, *7*(3), 1–6. https://jurnal.untan.ac.id/index.php/JMHMS/article/view/42661

Pusat Penelitian dan Pengemangan Sumber Daya Air. (2014). Puslitbang Sumber Daya Air Model Sistem Kendall Mutu Data Hidrologi Nasional Output Kegiatan, 022.

Pusat Pendidikan dan Pelatihan SDA dan Konstruksi. (2017). Modul Operasi Waduk Pelatihan Alokasi Air, 67.

Risfiyanto, L., Anwar, N., & Margini, N. F. (2017). Studi Optimasi Pola Tanam Pada Daerah Irigasi Baru Banyuwangi Dengan Menggunakan Program Linier. *Jurnal Hidroteknik*, *2*(1), 13. doi: 10.12962/jh.v2i1.4397

Sari, I. K., Limantara, L. M., & Priyantoro, D. (2011). Analisa ketersediaan dan kebutuhan air pada DAS Sampean. *Jurnal Teknik Pengairan: Journal of Water Resources Engineering*, *2*(1), 29-41.

Sari, R. A., Prayogo, T. B., & Yuliani, E. (2013). Studi Penentuan Status Mutu Air di Sungai Brantas Bagian Hilir Untuk Keperluan Air Baku. *Jurnal Teknik Pengairan*, *4*(1), 53–60.

Sudinda, T. W. (2021). Penentuan Debit Andalan Dengan Metoda F J Mock Di Daerah Aliran Sungai Ciliwung. Jurnal Air Indonesia, 12(2), 15–24. doi: 10.29122/jai.v12i2.4362

Suhartanto, E., Cahya, E. N., & Maknun, L. (2019). Analisa Limpasan Berdasarkan Curah Hujan Menggunakan Model Artifical Neural Network (ANN) Di Sub Das Brantas Hulu. *Jurnal Teknik Pengairan*, *10*(2), 134–144. https://doi.org/10.21776/ub.pengairan.2019.010.02.07

Suryanto, A. A., & Muqtadir, A. (2019). Penerapan Metode Mean Absolute Error (MAE) Dalam Algoritma Regresi Linear Untuk Prediksi Produksi Padi. *Saintekbu*, *11*(1), 78–83. doi: 10.32764/saintekbu.v11i1.298

Triwanda, D., Sholichin, M., & Yuliani, E. (2023). Studi Analisa Kualitas Air Hulu Sungai *Brantas Ruas Kota*, *3*(2), 550–563.

Undang-Undang Republik Indonesia No 7 tahun 2019. (2019). Undang-undang (UU) Nomor 17 Tahun 2019 tentang Sumber Daya Air. Jdih Bpk Ri Database Peraturan, 011594.

Widyaningsih, K. W., Harisuseno, D., & Soetopo, W. (2021). Perbandingan Metode FJ. Mock dan NRECA untuk Transformasi Hujan Menjadi Debit pada DAS Metro Kabupaten Malang, Jawa Timur. *Jurnal Teknologi dan Rekayasa Sumber Daya Air*, *1*(1), 52–61. https: //doi.org/10.21776/ub.jtresda.2021.001.01.05

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