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ANALYSIS OF WATER AVAILABILITY IN THE KAMPUNG BANJAR RESERVOIR AND KEBUN RAYA RESERVOIR IN BANJARBARU CITY FOR MEETING WATER NEEDS

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ABSTRACT

The Kampung Banjar Reservoir and Kebun Raya Reservoir were built to address the disrupted water catchment areas caused by land clearing for the development of the South Kalimantan Province Government office area in Banjarbaru. These two reservoirs are planned to function as water catchment areas, water tourism destinations, and raw water sources within the office areas. The water availability in the reservoirs is expected to remain stable. Therefore, a study on the water availability analysis of both reservoirs is necessary to ensure that the stored water can be utilized optimally and sustainably, particularly for tourism purposes. The research methodology includes data collection, data analysis, results, and discussion. The analysis phase involves evapotranspiration analysis, water availability analysis using the F. J. Mock method, and dependable flow analysis. Based on the flow simulation calculations using the F. J. Mock method, a 90% dependable flow was selected for raw water rEquationuirements. The largest dependable flow occurs in December, with a flow value of 0.1557 m³/second for the Kampung Banjar Reservoir and 0.2028 m³/second for the Kebun Raya.

Keywords: *Water Availability, Dependable Flow, Kampung Banjar Reservoir, Kebun Raya Reservoir.*

1. INTRODUCTION

Water is the source of life that has affected the sustainability of all living things. The benefits of water are not only for consumption needs, but also needed in irrigation, recreation, agricultural purposes, industry, and various other activities. One way to optimize the use of water resources is by building reservoirs. The construction of reservoirs is one of the effective ways to maintain and increase water availability. The reservoir has a function to accommodate excess rainwater that can be used to meet water needs during the dry season. In addition, the reservoir can also be used for recreational activities, drinking water needs, irrigation, and so on.

Banjarbaru City covers an area of 305.24 km², which is five times larger than Banjarmasin City (BAPPEDA Kota Banjarbaru, 2024). This is one of the reasons why Banjarbaru City was chosen as the capital of South Kalimantan Province. The relocation of the provincial capital to Banjarbaru began with the construction of the South

Kalimantan Provincial Secretariat Office in 2009, marking the start of the development of the provincial government's office center. Along with the construction of office buildings and road openings in Banjarbaru City, new challenges arose, including the management of water resources for the availability of water in the city's office area. To address this issue, the Kampung Banjar Reservoir and the Kebun Raya Reservoir were built.

The Kampung Banjar Reservoir and the Kebun Raya Reservoir are two water structures located in the South Kalimantan Provincial office area. The Kampung Banjar Reservoir was built after the Kebun Raya Reservoir and serves to address issues such as reducing the availability of water resources, flood control conservation, and providing water for irrigation and tree planting in the Kebun Raya Banua Botanical Garden. Both reservoirs are planned to function as water infiltration areas, water tourism zones, and raw water sources for various needs within the office area. Given this, the water availability in the reservoirs is expected to be sufficient to meet the rEquationuired demand. Factors such as rainfall, evaporation, and irrigation water needs can influence the water availability in the reservoirs. Therefore, it is necessary to conduct a study to analyze the water availability in both reservoirs to ensure that the stored water can be utilized optimally and sustainably. This research aims to analyze the potential storage capacity of both reservoirs based on simulations of water availability (inflow) versus water demand (outflow), particularly for non-domestic water needs, such as those for tourism purposes.

2. THEORITICAL STUDY

Reservoir

A reservoir is a water conservation structure in the form of a pond designed to collect rainwater, runoff, and other water sources to support agricultural, plantation, and livestock activities, especially during the dry season. A reservoir is a depression in a hilly area. The water in the reservoir comes from rainwater runoff that falls in the catchment area. A reservoir is a water storage structure built in a depression, typically located outside of river channels (Sastrawijaya, 2015).

The Reservoir's Storage Capacity

The reservoir's storage capacity is calculated based on the volume of available water and water demand. A simulation between these two parameters is performed using a mathematical model, such as numerical analysis, which is conducted in this study by analyzing the water balance between water availability (Inflow) at the development site and the water demand (Outflow). The rEquationuired storage capacity is determined by the difference between the Outflow volume minus the Inflow, where the maximum volume represents the rEquationuired capacity for the reservoir (Zevri, 2022).

Water Availability

Water availability is the amount of water flow that is continuously estimated to be present at a specific location (water structure) in a river with a certain volume and over a certain period of time (Triatmodjo, 2008).

The Analysis of Water Availability

The analysis of water availability is calculated using the F.J. Mock method. The Mock model, developed by F.J. Mock, is used to calculate the flow rate in a watershed based on the concept of water balance. Rainwater that falls on a region does not always directly flow into the river or infiltrate into the ground, but also undergoes evapotranspiration processes, where part of the water is lost to evapotranspiration depending on the vegetation covering the catchment area. The calculation based on the F.J. Mock model uses the following formula (Nurrochmad et al., 1998).

$AET = CF\ x\ PET$ ..... (Equation. 1)

$ER = P - AET$ ..... (Equation. 2)

$WS = ER - SM$ ..... (Equation. 3)

$I = WIC\ x\ WS$ ..... (Equation. 4)

$GWS = 0{,}5\ (1 + k) + k.IGWS$ ..... (Equation. 5)

$BF = I - (GWS - IGWS)$ ..... (Equation. 6)

$DRO = WS - I$ ..... (Equation. 7)

$QRO = DRO + BF$ ..... (Equation. 8)

$Q = \frac{A\ x\ Rtot\ x\ 1000}{H\ x\ 25\ x\ 3600}$ ..... (Equation. 9)

Explanation:

AET = Actual Evapotranspiration (mm/month)

PET = Potential Evapotranspiration (mm/month)
CF = Crop Coefficient
ER = Excess Rainwater (mm/month)
P = Precipitation (mm/month)
WS = Excess Water (mm/month)
SM = Soil Moisture Change (mm/month)
I = Infiltration (mm/month)
WIC = Wet Season Infiltration Coefficient
DIC = Dry Season Infiltration Coefficient
GWS = *Ground Water Storage* (mm/month)
IGWS = *Initial Ground Water Storage* (mm/month)
k = Groundwater Recession Factor
BF = *Baseflow* (mm/month)
DRO = *Direct Runoff* (mm/month)
QRO = *Total Runoff* (mm/month)
Q = Calculated Runoff Flow (m^3/s)
Rtot = *Total Runoff* (mm/month)
A = Area (km^2)
H = Number of Days in One Month of Calculation

The constraint parameters are used to limit the values of parameters during the calculation in the calibration stage of the F.J. Mock model. The constraint parameters are obtained through trial and error or by testing with the parameters in Table 1 below.

Table 1 Constraint Parameters of the F.J. Mock Model

No.	Symbol	Value
1	*DIC*	0,0001 – 0,9999
2	*WIC*	0,0001 – 0,9999
3	*ISM*	≥ 0,0001
4	*SMC*	50 – 250
5	*IGWS*	≥ 0,0001
6	*k*	0,0001 – 0,9999

(Reference: Nurrochmad et al., 1998)

Analysis of Dependable Discharge

The dependable discharge refers to the minimum river discharge that is relied upon to meet a specific value with a certain probability, which can be used for various purposes (Triatmodjo, 2008). The probability for this dependable discharge varies; for irrigation purposes, a probability of 80% is commonly used, while for drinking water and industrial needs, a higher probability is rEquationuired, typically between 90% and 95% (Soemarto, 1999). The dependable values chosen to optimize water usage in various projects can be seen in Table 2 below.

Table 2 Presentage of Dependable Value

Use	Dependable Value
Irrigation needs	80%
Raw water needs	90%

(Reference: Triatmodjo, 2008)

The calculation of the probability of dependable discharge can be performed using the Weibull method with the following formula.

$$P = \frac{r}{(N+1)} \; x \; 100\% \quad \text{.....} \quad \text{(Equation. 10)}$$

Explanation:

P = probability percentage (%)

r = rank or order of occurrence or discharge

N = number of data points or observations of discharge data

3. METHOD

Research Location

The research was conducted at both reservoirs, which are administratively located within the South Kalimantan Provincial Government Office Center area, Cempaka District, Banjarbaru City, namely the Kampung Banjar Reservoir and the Kebun Raya Reservoir, as shown in Figure 1 below.

Figure 1 Research Location Map

Research Procedure

The stages involved are the collection of secondary data such as rainfall data from 2001 to 2023, climatological data from 2001 to 2023, and river discharge data from the Riam Kiwa River for the year 2001. After the data is obtained, an analysis process is conducted, including cumulative rainfall analysis, evapotranspiration analysis, water availability analysis using the F. J. Mock method, and dependable discharge analysis by determining the 90% discharge for raw water needs.

4. RESULT AND DISCUSSION

Calibration Stages of F. J. Mock Method

Water availability at the Kampung Banjar Reservoir and the Kebun Raya Reservoir can be calculated using the F.J. Mock method. Several data points are required to calculate using this F.J. Mock method, including the following:

1. Potential evapotranspiration data
2. Rainfall data
3. Measured discharge data

In the calibration calculation process, measured discharge data from the Riam Kiwa River in 2001 is needed, with a watershed area of 382 km². The calibration graph can be seen in the following Figure 2 below.

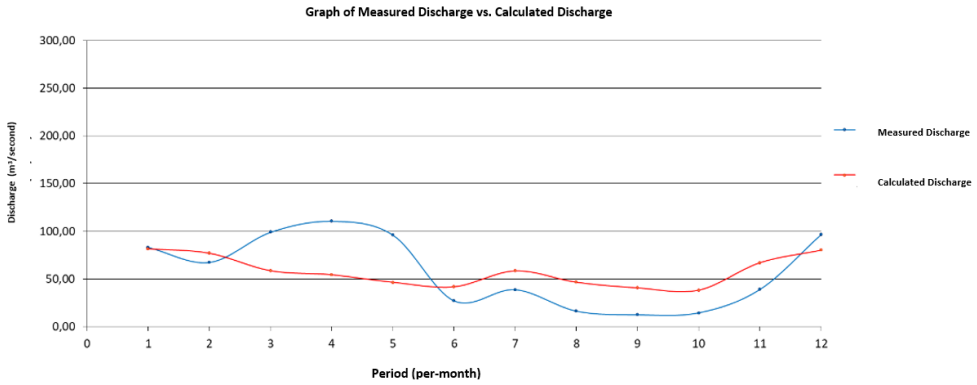

Figure 2 Calibration Graph of Measured Discharge vs. Calculated Discharge

Based on the calibration results, the calibrated parameter values are shown in Table 3, with a volume error of 0.014 and a correlation of 0.522, which means the calculation can proceed to the simulation stage by referring to the calibration requirement values.

Table 3 Parameter Calibration Results

Parameters	Calibration Results
DIC	0,0001
WIC	0,9999
ISM	250
SMC	50
IGWS	1200
k	0,6

Simulation Stage of F. J. Mock Method

The parameter values obtained from the calibration stage will be used as parameters in this simulation stage. The simulation is calculated based on the calculated discharge from 2001 to 2023, with the watershed area of the Banjar Village Reservoir and the Kebun Raya Reservoir, which can be seen in the following Table 4 below.

Table 4 Upstream Watershed Area of the Banjar Village Reservoir and Kebun Raya

Reservoir Name	Land Area (km^2)
Kampung Banjar Reservoir	1,122271
Kebun Raya Reservoir	1,462348

Recapitulation of Water Discharge Calculations using the F. J. Mock Method from 2001 to 2023 for the Kampung Banjar Reservoir and Kebun Raya Reservoir can be seen in Figure 3 and Figure 4 below.

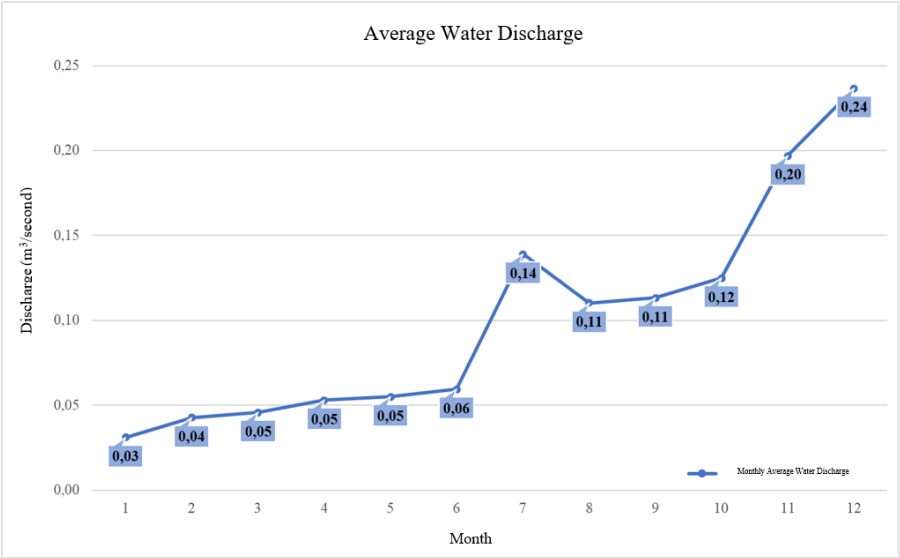

Figure 3 Graph of Monthly Average Water Discharge of the Kampung Banjar Reservoir from 2001 to 2023

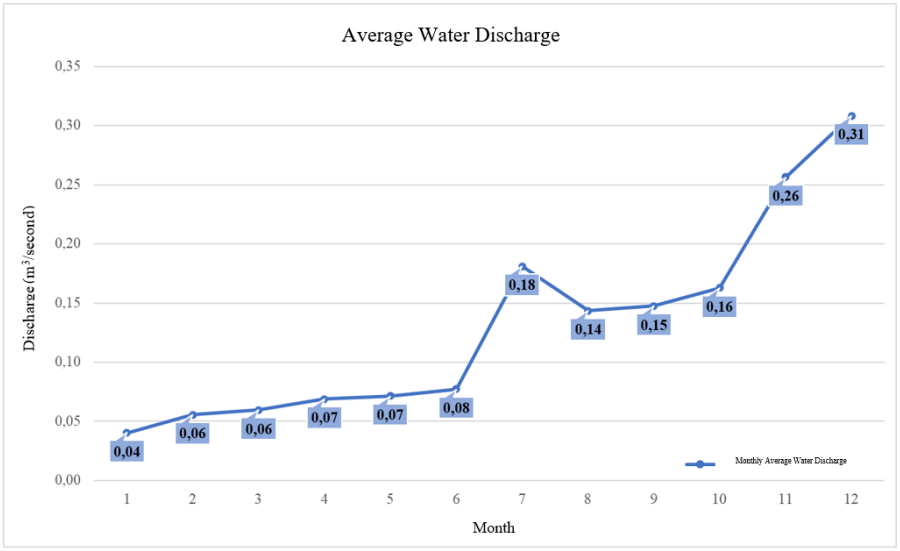

Figure 4 Graph of Monthly Average Water Discharge of the Kebun Raya Reservoir from 2001 to 2023

The monthly average discharge values are obtained by averaging the discharge data for each year in the same month. The highest discharge values occur in December for both reservoirs. The highest discharge value is 0.24 m³/second for the Kampung Banjar Reservoir, while the Kebun Raya Reservoir has a highest discharge value of 0.31 m³/second.

Analysis of Reliable Discharge

Reliable discharge is calculated by sorting the average discharge per year (2001-2023) from the highest to the lowest value, resulting in a 90% average discharge value for raw water needs. The results of the reliable discharge calculation can be seen in Figure 5 and Figure 6 below.

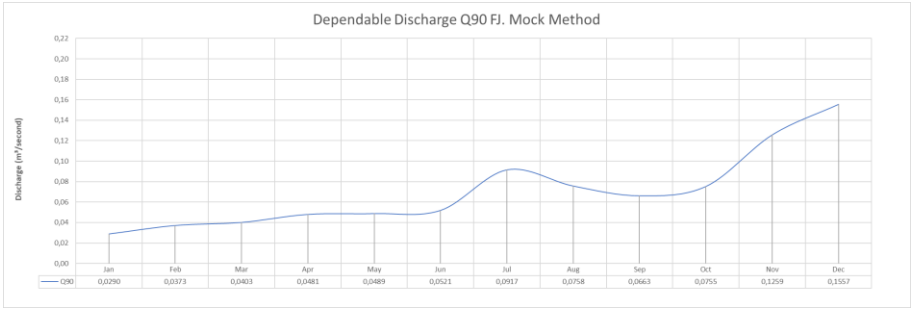

Figure 5 Graph of Reliable Discharge at 90% (m³/second) for the Kampung Banjar Reservoir

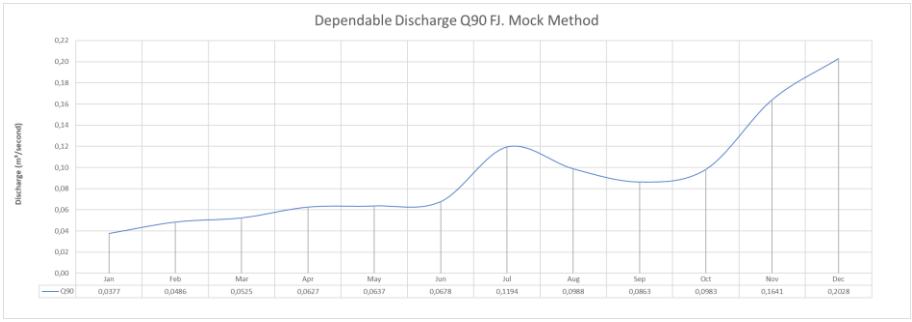

Figure 6 Graph of Reliable Discharge at 90% (m³/second) for the Kebun Raya Reservoir

In the Kampung Banjar Reservoir, the reliable discharge is highest in December with a value of 0.1557 m³/second and lowest in January with a value of 0.0290 m³/second. Meanwhile, for the Kebun Raya Reservoir, the highest reliable discharge occurs in December with a value of 0.2028 m³/second, and the lowest occurs in January with a value of 0.0377 m³/second.

5. CONCLUSION

Based on the results of the discharge simulation using the F. J. Mock method, the 90% reliable discharge value shows that the highest reliable discharge occurs in December, with a discharge value of 0.1557 m³/second for the Kampung Banjar Reservoir and 0.2028 m³/second for the Kebun Raya Reservoir.

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