

Research Article

# Water Balance Analysis Using the NRECA Method and the FJ Mock Method with the WEAP (Water Evaluation and Planning) Application in the Way Pisang Watershed

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**Abstract:** In a watershed, discharge data is essential to determine the flow rate of a river and is used to meet the daily water requirements of humans, plants, and animals. The Way Pisang watershed is a part of the Way Sekampung watershed, administratively located in the South Lampung Regency. In this study, the water demands analyzed include domestic, livestock, irrigation, and industrial needs. These water demands are compared with the water availability in the Way Pisang watershed. The analysis of water availability was conducted using the NRECA and FJ Mock methods, yielding results of 68.75 m<sup>3</sup>/s and 59.88 m<sup>3</sup>/s, respectively. Meanwhile, the water balance calculation was performed using the NRECA and FJ Mock methods through WEAP software. The results indicate that from January to November, the Way Pisang watershed experiences a surplus level of 63% (NRECA method), 57.7% (FJ Mock method), and 63.4% (WEAP method). Conversely, in December, it faces a deficit level of 0.62% (NRECA method), 1.37% (FJ Mock method), and 0.72% (WEAP software).

**Keywords:** Dependable Discharge; NRECA; Water Balance; Water Demand; Way Pisang Watershed..

## 1. Introduction

Water is a fundamental resource that determines the sustainability of human life and the quality of socio-economic development. The availability of water is closely related to public health, environmental conditions, agricultural productivity, and domestic activities. Adequate water resources support food security, sanitation, and economic growth, while water scarcity can lead to social, environmental, and economic crises [1], [2]. Therefore, water resources management must be carried out in an integrated, sustainable, and equitable manner.

In hydrological systems, water can be beneficial or become a disaster depending on its spatial and temporal distribution. Excess water in a certain period and location can cause flooding, while insufficient water availability can lead to drought. These two phenomena indicate an imbalance in the hydrological cycle and water resource utilization [3]. The concept of water balance is essential to understand the relationship between water input (inflow) and output (outflow) within a watershed over a certain period. Water input generally consists of rainfall, surface water, and groundwater contributions, while water output includes evapotranspiration, runoff, infiltration, and water use for domestic, agricultural, and industrial needs [4], [5].

Water balance analysis is widely used to determine whether a region experiences a water surplus or deficit. This analysis is an important basis for planning water allocation, irrigation scheduling, flood control, drought mitigation, and raw water supply systems [6]. In Indonesia, where rainfall variability is high and land-use change is significant, water balance studies are crucial for supporting sustainable watershed management [7].

Several hydrological models have been developed to estimate rainfall–runoff relationships and water availability. Among the methods frequently used in Indonesia are the FJ Mock method and the NRECA (National Rural Electric Cooperative Association) method. The FJ Mock method estimates river discharge based on rainfall, evapotranspiration, infiltration, and

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groundwater storage parameters, making it suitable for watersheds with limited hydrological data [8], [9]. Meanwhile, the NRECA method simulates runoff by considering soil moisture balance, groundwater flow, and evapotranspiration processes, and is widely applied in water resource planning studies [10].

In addition to empirical hydrological methods, integrated modeling tools are needed to simulate water allocation under various scenarios. One of the widely used tools is WEAP (Water Evaluation and Planning), developed by the Stockholm Environment Institute. WEAP is based on the principle of water balance and allows simulation of water supply, demand, allocation priorities, and future scenarios such as population growth, land-use change, and climate variability [11], [12]. WEAP has been applied in various regions to support decision-making in water resources management, especially in areas experiencing water stress or conflicting water demands [13].

The study area in this research is the Way Pisang Watershed, which is part of the Way Sekampung River Basin located in South Lampung Regency. This watershed covers an area of approximately 155.33 km<sup>2</sup> and administratively includes Palas, Penengahan, and Sragi districts. The Way Pisang River frequently experiences flooding during the rainy season, indicating high surface runoff and limited water storage capacity [14]. On the other hand, during the dry season, some parts of the watershed experience reduced water availability, which affects irrigation and domestic water supply [15]. These conditions indicate the need for a comprehensive water balance analysis to support effective water resource management.

Previous studies have shown that water balance modeling can be used to evaluate water availability, identify surplus and deficit periods, and optimize water allocation for various sectors [16], [17]. However, studies that integrate hydrological simulation methods such as FJ Mock and NRECA with system-based modeling using WEAP in the Way Pisang Watershed are still limited. Therefore, this study aims to analyze the water balance between water availability and water demand using the FJ Mock method, the NRECA method, and WEAP modeling. The results are expected to provide recommendations for sustainable water resource management, flood mitigation, and drought anticipation in the Way Pisang Watershed [18].

## 2. Preliminaries or Related Work or Literature Review

### Water Needs

#### *Calculation of water requirements*

According to the Directorate General of Human Settlements (2000), there are two types of requirements for water requirements, namely: domestic and non-domestic water requirements. Domestic water requirements refer to the water used in private residences to meet daily needs such as drinking, cooking, washing, and other household needs. The units used are liters/person/day.

**Table 1.** Determination of Raw Water Service Level.

Number (of Souls)	(Lt/Capita/Day)		
	Domestic	Non-Domestic	Water Loss
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: Directorate General of Human Settlements (2000)

#### *Water Requirements for Irrigation*

Water needs for irrigation is the amount of water needed to cover the needs for water loss, evaporation and water needs for crops by looking at the amount of water obtained from rain as well as the contribution of groundwater.

#### *Water Requirements for Industry*

The clean water requirement for industry is calculated by considering the population, the average service level, and the needs of each worker. In calculating industrial water requirements, the estimated value is 10% of the population's water needs.

### **Water Requirements for Livestock**

The average water requirement for livestock is derived from FIDP research, which is included in the 1992 National Water Resources Policy Technical Report. Generally, the amount of water required by livestock is calculated by multiplying the water requirement level by the total number of livestock.

### **Water Availability**

#### **Mock FJ Method**

The FJ. Mock method has two conditions for calculating surface flow in rivers, namely the water balance below ground level and above ground level, both of which are based on rainfall, soil conditions, and climate. The basis for calculations and assumptions used in this analysis are as follows:

#### a. Rain

The value of Monthly Rainfall (P) is obtained from recording Monthly Rainfall data (mm) and the total number of rainy days that occurred in the month in question (h).

#### b. Limited Evapotranspiration (Et)/ Actual Evapotranspiration (Ea)

Limited evapotranspiration is the actual evapotranspiration with the land surface and vegetation situation taken into consideration so the equation is as follows:

$$E = ET_0 - E_a \quad (2.17)$$

$$E_a = ET_0 \times (d/30) \times m \quad (2.18)$$

With:

E = Difference between limited evapotranspiration and potential evapotranspiration (mm)

ET<sub>0</sub> = Potential Evapotranspiration

M = Percentage of land not covered by vegetation, seen from the land use map

m = 0% its use for dense forest land

m = 0% of its use for land with secondary forest at the end of the rainy season and will increase by 10% for each subsequent dry month

m = 10-40% for isolated land

m = 20-50% for cultivated agricultural land (such as= rice fields, fields, plantation)

#### c. Water Balance on the Land Surface

1) Rainwater that reaches the ground surface can be formulated as follows=

$$\Delta s = P - Et \quad (2.19)$$

If the value  $\Delta s$  is positive ( $P > Et$ ), water will then enter the soil if the soil moisture capacity is not yet met, and conversely, it will overflow if the soil is saturated. If the value  $\Delta s$  is negative ( $P < Et$ ), some groundwater will escape, resulting in a deficit. P = Rainfall

2) *Soil storage* is the change in the volume of water to moisten the soil, the amount of which depends  $\Delta s$  on soil storage and soil moisture in the previous month.

3) *Soil moisture* is the value of the volume of water to moisten the soil, the amount of which depends  $\Delta s$  on the soil moisture and soil storage of the previous month.

4) Soil moisture capacity is the volume required to achieve soil moisture capacity.

5) *Water surplus* is the value of the volume of water that will flow to the soil surface, namely  $WS = \Delta s - \text{soil storage}$ , and 0 if  $\Delta s < \text{soil storage}$ .

6) Initial storage is defined as the volume at the start of the calculation. It is considered appropriate for seasonal conditions; in the rainy season, the value can be equal to soil moisture capacity, but in the dry season, soil water content data is generally used.

#### d. Runoff and Groundwater Storage

##### 1) Infiltration Coefficient (i)

The infiltration coefficient is calculated based on the soil porosity and slope of the drainage area. Porous soils have a higher infiltration rate than heavy, flat soils. Thermal soils, when water has not yet infiltrated into the soil, will have a low infiltration coefficient. The infiltration coefficient (I) ranges from 0.2 to 0.5. The groundwater flow recession factor (k) ranges from 0.4 to 0.7.

## 2) Groundwater Storage (Groundwater Storage)

On the surface of the simulation, initial storage must be determined, determined by local time and geological conditions, with the geological situation of the lower layer impermeable to water and no water in the river during the dry season, so that groundwater storage is zero. The formulas used are as follows =

$$V_n = k \cdot V_{n-1} + \frac{1}{2} (1+k) I_n \quad (2.20)$$

$$dV_n = V_n - V_{n-1} \quad (2.21)$$

$$I_n = i \cdot WS \quad (2.22)$$

With =

$V_n$  = Volume of water in the nth month

$V_{n-1}$  = Groundwater volume in the (n-1st) month

$K$  = Groundwater flow recession factor (catchment area recession factor) =  $q_t/q_0$

$q_0$  = Groundwater flow at the beginning (month 0)

$q_t$  = Groundwater flow at time t (month t)

$dV_{n-1}$  = Change in groundwater flow volume

$I_n$  = Infiltration of the nth month

## 3) Runoff

a) Direct runoff =  $WS - I_n$  (mm)

b) Interflow = Infiltration – groundwater volume (mm)

c) Runoff = Interflow + Direct runoff + based flow (m<sup>3</sup>/sec)

d) Base flow = River flow that is always present throughout the year (m<sup>3</sup>/second)

**NRECA Method**

Change of reservoir used as a comparison of the difference between initial and final storage. Moisture storage is determined by excess moisture, evapotranspiration, rainfall that becomes direct runoff and additional groundwater. The remainder of rainfall that flows over the surface together with base flow flows into the river flow and is called total flow, then multiplied by the watershed area. The result of this multiplication calculation is the output or result of the NRECA method in the form of river flow discharge that is in accordance with the planning period. Stages of calculating discharge using the NRECA method

a.  $Q = DF + GWF$  (2.23)

b.  $DF = EM - GWS$  (2.24)

c.  $GWF = P_2 \cdot GWS$  (2.25)

d.  $GWS = P_1 \cdot EM$  (2.26)

e.  $S = WB - EM$  (2.27)

f.  $EM = EMR \cdot WB$  (2.28)

g.  $WB = R_b - AET$  (2.29)

h.  $AET = \frac{AET}{PET} \cdot PET$  (2.30)

i.  $W_i = \frac{PET}{W_o}$  (2.31)

j.  $N = 100 + 0.20 Ra$  (2.32)

With,

$Q$  = Average flow rate ( $m^3 / dt$ )

$GWF$  = Ground water flow (mm)

$GWS$  = Groundwater reservoir / *groundwater storage* (mm)

$DF$  = Direct flow / *direct flow* (mm)

$EM$  = Excess humidity / *excess moisture* (mm)

$P_1$  = Parameters that describe the characteristics of the surface soil

$P_2$  = Parameters that describe the characteristics of the soil in

$WB$  = Water balance (mm)

$EMR$  = Excess moist ratio (mm)

$PET$  = Potential evapotranspiration /  $ET_o$  (mm)

$R_b$  = Monthly rainfall (mm)

$W_o$  = Initial moisture content (mm)

$AET$  = Actual evapotranspiration (mm)

$W_i$  = Soil moisture capacity (mm)

$Ra$  = Annual rainfall (mm)

$N$  = Nominal

### 3. Proposed Method

#### Research Location

The research location is located on the Way Pisang River, which is part of the Way Sekampung watershed in the administrative area of South Lampung Regency.

- a. To the north by the Way Sekampung Hilir River.
- b. To the west by the Way Ketibung River
- c. To the east by Ketapang District.
- d. South by Mount Rajabasa

#### Data collection

The data used in this study is secondary data from various sources. The secondary data required includes:

- a. Way Pisang Watershed
- b. Population data
- c. Livestock data
- d. Industry data
- e. Data on the use of irrigation land around the Way Pisang Watershed
- f. Rainfall and climatology data
- g. Topographic map and land use map of the Way Pisang watershed. The method used in this study is a survey method with stages of preparation, data collection, and data analysis.

#### Preparation Stage

The preparation stage is a stage used to facilitate the progress of research, such as literature studies aimed at obtaining direction and insight to facilitate analysis, data collection and also the preparation of research results.

#### Data collection

Secondary data used in this study were obtained directly from existing records and obtained from relevant agencies:

- a. Hydrological Data  
This data includes rainfall data in areas that influence planning. To determine rainfall data, rainfall observations at observation stations are taken. Hydrological data is then used to calculate the magnitude of the mainstay discharge.
- b. Climatological Data  
Climatological data is needed to provide information about the climate of an area so that the amount of water required can be determined. Climatological data consists of:
  - 1) Average monthly temperature ( $^{\circ}\text{C}$ )
  - 2) Average relative humidity (%)
  - 3) Average duration of sunshine (%)
  - 4) Average wind speed (m/s)
- c. BPS (Directorate General of Human Settlements) data  
Used to calculate the water needs of the population.
- d. Data on planting plans and realization (FAO)  
Used to analyze water requirements for irrigation.
- e. Industrial KP/PT Data (Ministry of Public Works)  
Used to analyze water requirements for industry.
- f. Livestock Data (Directorate General of Human Settlements)  
Used to analyze the amount of water needed for livestock.

#### Data analysis

- a. Total water requirement analysis  
From the household water needs, irrigation water needs, industrial water needs, and water needs for livestock (domestic and non-domestic) that have been obtained, they will then be analyzed to calculate the raw water requirements needed.
- b. Analysis of Reliable Discharge (Water Availability)  
The hydrological and topographic data obtained are then analyzed to calculate the reliable discharge (available water availability). Reliable discharge is the river flow discharge that can be relied upon to meet the water needs in its service area. The method used in calculating water availability is the NRECA method. This method activates the monthly water balance in a catchment area which is used to calculate the total runoff value from the evaporation value, monthly rainfall, soil moisture, and groundwater availability. The steps in the reliable discharge analysis required for this

NRECA model are monthly rainfall, evapotranspiration, monthly average temperature, sunlight, relative humidity, wind speed, initial groundwater storage, initial soil moisture content, soil moisture storage capacity index in the catchment area, the percentage of water entering as groundwater flow, and the percentage of runoff flowing on the surf surface.

c. Water Balance Analysis

Analyze the water balance in each area served based on the availability and water requirements calculated in the previous step.

d. Analysis of Way Pisang Watershed Conditions

From the previous water balance analysis, the results obtained were in the form of regional conditions in the Way Pisang Watershed which were at deficit and surplus levels for current conditions.

## 4. Results and Discussion

### Data

This study utilizes rainfall and population data for the results and discussion. The rainfall data used covers the last ten years, from 2011 to 2020. The rainfall data was obtained from the Mesuji Sekampung River Basin Center (BBWS MS). This study used rainfall data from the Palas, Klaten-Penengahan, Pasuruan-Penengahan, and Palas Jaya stations. Population data was obtained from the Central Statistics Agency (BPS). This study required data on population, livestock, irrigation, and industry in the Sragi, Palas, and Penengahan sub-districts.

Palas District has 28 villages, Penengahan 22 villages, and Sragi 10 villages. The population in 2020 is presented in the table and obtained from the Central Statistics Agency.

**Table 2.** Population in Palas, Penengahan and Sragi Districts.

No	Subdistrict	Area (km <sup>2</sup> )	Amount Population (People)
1	Palas	94,7513	57,065
2	Mediation	41,9391	37,699
3	Sragi	18,6396	33,711
Way Watershed	Pisang 155.33		128,475

Source: BPS Directorate General of Human Settlements, 2018

### Water Needs

#### *Water Needs of the Population*

There are two types of water needs for the population: domestic and non-domestic. The Way Pisang River basin, located in South Lampung, covers three sub-districts: Palas, Penengahan, and Sragi. This river basin covers an area of 155.33 km<sup>2</sup> with a population density of around 127,753 people. Calculating domestic and non-domestic water needs, the total water requirement for the population in the Way Pisang River basin is 6.78 m<sup>3</sup>/second.

#### *Livestock Water Requirements*

Livestock water requirements are the amount of water required for livestock. Livestock are divided into four types, namely: Large livestock (cows, pigs, buffalo, horses, etc.), medium-sized livestock (goats, sheep, etc.), and small livestock (chickens, ducks, etc.). In the Way Pisang watershed, there are large and medium-sized livestock, totaling around 39,714 head. The calculation of livestock water requirements according to FIDP standards

**Table 3.** Water Requirements for Livestock (FIDP Standard).

Types of Livestock	Water Requirements (lt/head/day)
Cow / buffalo / horse	40
Goat / sheep	5
Pig	6
Poultry	0.6

Source: FIDP

From the results of the calculation of livestock water requirements above, the total livestock water requirements in the Way Pisang river basin are 0.129 m<sup>3</sup>/second.

### **Industrial Water Needs**

Industrial water requirements are the amount of water needed to meet the needs of an industry. The water needs for industry are very complex and usually correspond to the classification of the size and type of industry. In this calculation, industrial water needs are 10% of the water needs of the population of the Way Pisang river basin. From the results of the industrial water requirement calculations above, the total industrial water requirement in the Way Pisang river basin is 0.678 m<sup>3</sup>/second.

### **Irrigation Water Needs**

Irrigation water demand is the volume of water required to meet water losses, crop water needs, and evaporation, taking into account the amount of water produced naturally through rainfall and groundwater contributions. Irrigation water demand figures for the Way Pisang Watershed are obtained from the River Basin Water Resources Management Pattern Document.

From the results of the irrigation water requirement calculations above, the total irrigation water requirement in the Way Pisang river basin is 17.70 m<sup>3</sup>/sec.

### **Water Requirements of the Way Pisang River Basin**

The Way Pisang watershed's water requirement is the total water requirement. Calculating the water requirement for the Way Pisang watershed is done by adding up all the water requirements. The total water requirement for the Way Pisang watershed is obtained by adding the water requirements for the population, livestock, industry, and irrigation.

With the formula:

Water Needs of the Way Pisang Watershed

$$= \sum \text{Population Demand} + \sum \text{Livestock Demand} + \sum \text{Industrial Demand} + \sum \text{Irrigation Demand}$$

Water requirement of Way Pisang watershed = 6.74 m<sup>3</sup>/second + 0.13 m<sup>3</sup>/second + 0.674 m<sup>3</sup>/second + 17.70 m<sup>3</sup>/second = 25.25 m<sup>3</sup>/second

From the results of the water requirement calculations above, the total water requirement in the Way Pisang river basin is 25.25 m<sup>3</sup>/second, with the percentage of each requirement being:

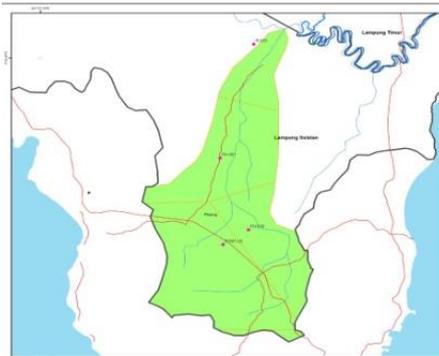
$$\text{Percentage of Needs} = \frac{\text{Kebutuhan air}}{\text{Total Kebutuhan air}} \times 100\%$$

- Population water needs =  $x 100 = 26.7\% \frac{6,74}{25,25}$
- Irrigation water requirement =  $x 100\% = 70.1\% \frac{17,70}{25,25}$
- Industrial water requirements =  $x 100\% = 2.7\% \frac{0,674}{25,25}$
- Livestock water requirements =  $x 100\% = 0.5\% \frac{0,13}{25,25}$

### **Regional Rainfall Calculation (Monthly)**

Rainfall is the height of rainwater collected in a flat, non-evaporating, non-absorbing, and non-flowing area. Rainfall is measured in millimeters or inches, but in Indonesia, the unit used is millimeters (mm). Rainfall of 1 (one) millimeter means that in an area of one square meter in a flat place, one millimeter of water is collected or one liter of water is collected.

From the annual maximum daily rainfall data, the regional rainfall in the Way Pisang Watershed will be calculated using the Thiessen Polygon method. Thiessen Polygon of the Way Pisang Watershed with four stations.



**Figure 1.** Thiessen Watershed Way Pisang Polygon.

Source: 2017 Analysis Results

Based on the Thiessen Polygons that have been created, the area of each region can be calculated using the AutoCAD program. Thiessen Table of the Way Pisang River Basin

- a. The area of the Way Pisang watershed = 155.34 km<sup>2</sup>
- b. Thiessen Polygon Area of Palas Rainfall Station = 43.07 km<sup>2</sup>
- c. Thiessen Polygon area of Klaten rain station = 31.93 km<sup>2</sup>
- d. Thiessen Polygon Area of Pasuruan Rainfall Station = 63.66 km<sup>2</sup>
- e. Thiessen Polygon Area of Palas Jaya Rainfall Station = 16.67 km<sup>2</sup>
- f. Thiessen Palas Coefficient =  $\frac{100}{155,33} \times 43,07 = 0.27$
- g. Thiessen Klaten Coefficient =  $\frac{100}{155,33} \times 31,93 = 0.20$
- h. Thiessen Pasuruan Coefficient =  $\frac{100}{155,33} \times 63,66 = 0.41$
- i. Thiessen Palas Jaya coefficient =  $\frac{100}{155,33} \times 16,67 = 0,10$

An example of calculating the maximum daily regional rainfall in 2008 is:

- a. Regional rainfall (P, region) in 2011 =  $(116 \times 0.27) + (15.5 \times 0.20) + (232 \times 0.40) + (58.1 \times 0.10) = 279.5 \text{ mm}$

After obtaining the monthly rainfall values for each two weeks from 2011 to 2020, the average rainfall value is then obtained by averaging the monthly rainfall values for each two weeks from 2011 to 2020. To calculate water availability, P80 data is required, obtained from the monthly rainfall calculations.

#### **Water Availability Analysis Using the NRECA Method**

The results of calculations using the NRECA method show highly fluctuating and varied discharge values. These calculations are based on rainfall and evapotranspiration data (Modified Penman) obtained from the hydrological characteristics of the drainage area and research conducted by Nippon Koei. The calculation criteria and simulation assumptions for this method include:

- a. Rainfall data was obtained from annual, monthly, and bi-weekly rainfall data from Klaten-Penengahan (PH-030), Palas (PH-031), Pasuruhan-Penengahan (R-021), Palas Jaya (R-233) stations.
- b. Rainy day data, data obtained from rainy day data in each rain.

#### **Rainfall-Discharge Simulation Using the NRECA Method**

Water availability calculations aim to determine the amount of water available in primary water sources to meet existing water needs. The NRECA (Non-Recorded Catchment Area) method is one method that can be used to calculate water availability.

#### **Water Availability in the Way Pisang River Basin**

The water availability of the Way Pisang watershed is the result of the calculation of the reliability of availability using the NRECA method with a probability figure of 80% as shown in table 4.28. The results of the calculation of the mainstay discharge Q80 and total water availability are shown in table 4.30.

From the results of the water availability calculations above, the total water availability in the Way Pisang watershed is 68.75 m<sup>3</sup>/second.

#### **Results of Water Balance Calculations Using the NRECA Method**

Water balance analysis is a comparative calculation between total water availability and demand in the Way Pisang River Basin. After obtaining the availability and needs of water in the Way DASBanana, it can be seen in Figure 4.2 that the water balance in the Way watershedBanana is at a surplus level. The surplus percentage can be calculated using the formula:

$$\text{Surplus Percentage} = \frac{\text{Total Available Water} - \text{Total Water Requirement}}{\text{Total Available Water}} \times 100\%$$

$$\text{Surplus Percentage} = \frac{\text{Total Available Water} - \text{Total Water Requirement}}{\text{Total Available Water}} \times 100\%$$

$$\text{Surplus Percentage} = \frac{68,75 - 25,29}{68,75} \times 100\% = 63\%$$



**Figure 2.** Water Balance Graph of Way River Basin Bananas with the NRECA Method.

Based on the analysis of water needs and water availability calculations using the NRECA method above, the water balance graph shows that water availability in the Way Pisang Watershed until January, February, March, April, May, June, July, August, September, October and November was at a surplus level of 63%, while in December it experienced a deficit of 0.62%.

Meanwhile, for the calculation of the projected water balance for the next 10 years, an analysis has been carried out for the water balance in 2030. The results obtained are that, in 2030, water availability is able to meet water needs from January to November with a surplus level of 62.15%, while in December there is a deficit of 2.19%.

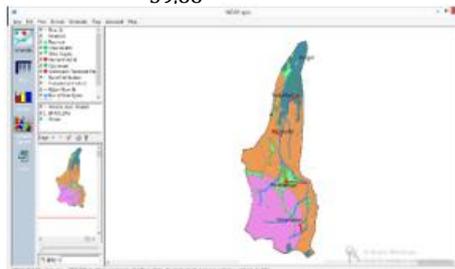
#### **Water Availability Analysis Using the Mock FJ Method**

After calculating regional rainfall, the next step is to convert rainfall into streamflow using the FJMock method. The FJMock calculation will be performed for each month of the year.

#### **Results of Water Balance Calculations Using the FJ. Mock Method**

Water balance analysis is a comparison between the availability and total water needs in the Way Pisang River Basin. After obtaining the value of water availability and needs in the Way DAS Bananas with the FJ method. Mock, it can be seen in Figure 3 that the water balance in the Way watershed Bananas is at a surplus level. The surplus percentage can be calculated using the formula:

$$\text{Surplus Percentage} = \frac{59,88 - 25,29}{59,88} \times 100\% = 57.7\%$$



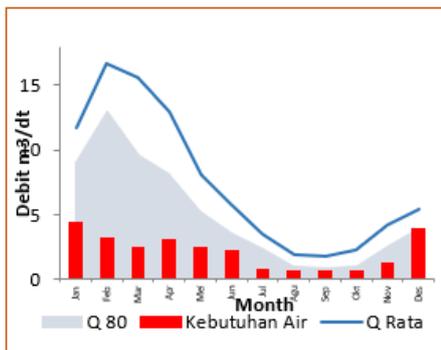
**Figure 3.** Way River Basin Water Balance Bananas with the FJ Mock Method.

Based on the analysis of water needs and water availability calculations using the FJ. Mock method above, the water balance graph shows that water availability in the Way Pisang Watershed until January, February, March, April, May, June, July, August, September, October, November was at a surplus level of 57.7%, while in December it experienced a deficit of 1.37%.

Meanwhile, for the calculation of the projected water balance for the next 10 years, an analysis has been carried out for the water balance in 2030. The results showed that, in 2030, water availability was able to meet water needs from January to November with a surplus level of 56.5%, while in December there was a deficit of 2.92%.

#### **Water Balance Analysis Using WEAP Software**

The water balance is calculated using the WEAP software, the method used is to input known and previously calculated values such as the amount of water availability and annual water needs, land area, percentage value of needs per period, and the amount of consumption each year to obtain the water balance.

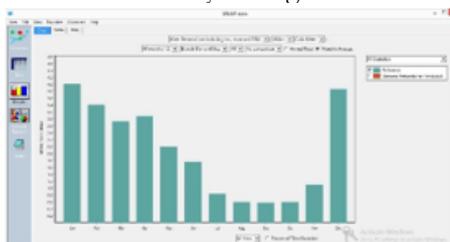


**Figure 4.** Schematic of demand and supply of water allocation in the Way Pisang watershed.

**Total Water Needs of the Way Pisang Watershed using WEAP software**

The Way Pisang watershed's water requirement is the total water requirement for the watershed. Calculating the Way Pisang watershed's water requirement can be done by adding up all available water requirements.

Based on the results of the calculation of water requirements using WEAP software, the total value of water requirements in the Way Pisang watershed is 25.11 m<sup>3</sup>/second.



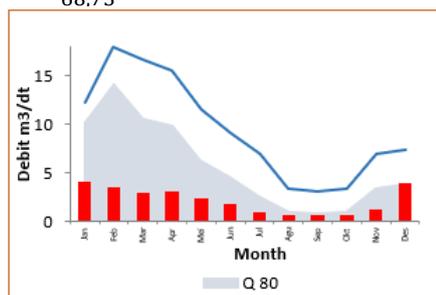
**Figure 5.** Way Pisang Watershed Water Needs using WEAP software.

**Results of Water Balance Calculations with WEAP software**

Water balance analysis is a comparative calculation between water availability and demand. After obtaining the availability and needs of water in the Way DASBanana with WEAP software, then the water balance in the Way DAS can be seenBananaais at a surplus level. The surplus percentage can be calculated using the formula:

$$\text{Surplus Percentage} = \frac{\text{Total Available Water} - \text{Total Water Requirement}}{\text{Total Available Water}} \times 100\%$$

$$\text{Surplus Percentage} = \frac{68,75 - 25,11}{68,75} \times 100 = 63.47\%$$



**Figure 6.** Way River Basin Water Balance Pisang With WEAP Software.

Based on the analysis of water demand and water availability calculations using WEAP software, the water balance graph shows that water availability in the Way Pisang Watershed until January, February, March, April, May, June, July, August, September, October and November is at a surplus level of 63.47%, while in December it experienced a deficit of 0.77%. Meanwhile, for the calculation of the water balance projection for the next 10 years, an analysis has been carried out for the water balance in 2030 using WEAP software. The results obtained are that, in 2030 the water availability is able to meet water needs in January to November with a surplus level of 58.53%, while in December it experienced a deficit of 2.56%.

### ***Results of Water Balance Analysis with the NRECA method and the FJ Mock method Using the WEAP Application***

After conducting a water balance analysis using the NRECA method and the FJ Mock method, as well as using the WEAP (Water Evaluation and Planning) application, the following results were obtained:

**Table 3.** Results of Water Availability Calculation Using the FJ. Mock Method and the NRECA Method (m<sup>3</sup>/sec).

Month	FJ. MOCK Availability (m <sup>3</sup> /sec)	NRECA Availability (m <sup>3</sup> /sec)
1	9.02	10.15
2	12.95	14.24
3	9.57	10.66
4	8.11	9.84
5	5.19	6.29
6	3.49	4.63
7	2.26	2.64
8	1.03	1.05
9	0.82	0.84
10	0.99	1.08
11	2.59	3.44
12	3.86	3.89
<b>Amount</b>	<b>59.88</b>	<b>68.75</b>

From the table above, it can be seen that the water availability value in the Way Pisang Watershed using the FJ. Mock method is 59.88 m<sup>3</sup>/second, while the water availability value using the NRECA method is 68.75 m<sup>3</sup>/second.

**Table 4.** Water Balance Calculation Results Using the FJ. Mock Method, NRECA Method, and WEAP (Water Evaluation and Planning) Application.

Month	WATER BALANCE		WEAP APPLICATION	
	FJ METHOD (%)	MOCK METHOD (%)	WATER BALANCE NRECA METHOD (%)	WATER BALANCE (%)
1	51.86		57.19	60.57
2	75.76		77.96	76.12
3	74.53		77.12	72.60
4	61.86		68.56	68.70
5	54.12		62.13	63.09
6	38.65		53.78	62.23
7	65.63		70.62	68.59
8	38.59		39.89	42.96
9	22.91		24.69	30.92
10	36.34		41.34	44.34
11	54.79		66.04	67.78
12	-1.37		-0.62	-0.77

Meanwhile, for the calculation of water balance using the FJ. Mock method, the NRECA method and the WEAP (Water Evaluation And Planning) application, it can be seen that in months 1 (January) to 11 (November) the results obtained were that the water needs in the Way Pisang Watershed could be met 100% with a surplus percentage of the value in the table above. In December, there was a deficit or failure of water supply of 1.37% (With the FJ. Mock Method), 0.62% (With the NRECA Method), and 0.77% (Using the WEAP Application).

## 5. Conclusions

Then the following conclusions are obtained:

- a. Water requirement 25.29 m<sup>3</sup>/second.
- b. The total water requirement for the next 10 years is projected to be 26.02 m<sup>3</sup>/second.
- c. Results of the water balance analysis of the Way Pisang watershed:
  - 1) NRECA: 63%. December deficit of 0.6%.
  - 2) FJ. Mock: 57.7%. December deficit of 1.37%.
  - 3) WEAP application: water experienced a surplus of 63.4%. December experienced a deficit of 0.72%.
- d. Water balance analysis results:
  - 1) NRECA: 62.16%. December deficit was 2.19%.
  - 2) FJ. Mock: 56.5%. December deficit of 2.92%.
  - 3) WEAP application: experienced a surplus of 58.53%. December had a deficit of 2.56%.

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