The Effect of Land Use Changes on Availability of Water Resources in The Rupit Watershed

Nurhikmawaty¹, Dinar Dwi Anugerah Putranto² and Febrian Hadinata³

Abstract

Water balance of a river watershed is significantly essential for estimating water availability to meet domestic and economic demands. In this context, several parameters such as rainfall, temperature, evapotranspiration, deficit, and surplus soil water content play a crucial role in determining water availability of a river watershed based on land use, soil type, seasonal variations, and other environmental factors. Therefore, this research aimed to estimate water balance of the Rupit watershed using the Mock method. The results showed that monthly soil water content (deficit or surplus) was significantly influenced by changes in rainfall, temperature, and land use patterns. The period from November to April experiences water surplus, while May to October is characterized by deficit. Specifically, a different response to land use was observed, where the maximum annual water content was not surplus. The total runoff for the Rupit watershed calculated from the Mock method runoff simulation was 134.42 mm/year.

Keywords: Water Balance, Water Surplus, Deficit, Runoff

INTRODUCTION

Several factors are responsible for exerting pressure on land use changes, including economic growth, urbanization, climate change, and population increase, leading to reduced water availability in river watershed. However, a decline in the economic quality of a rural area or small town can cause a reduction in the quality of land use and water availability. This phenomenon occurs due to forest encroachment to improve the economy population, through illegal mining. Changes in water storage of watershed are significantly determined by hydrological components such as rainfall, evapotranspiration, surface runoff, base flow, and groundwater infiltration (Rápalo et al., 2021), which vary with different land use.

LITERATURE REVIEW

Previous research reported that higher changes in land use of 22.2% in the impervious hilly areas of the Rawas Watershed, North Musi Rawas Regency, South Sumatra Province between 2010-2020, increased average annual runoff by 70% (Muchtar et al., 2022). The increase in surface runoff occurred due to illegal mining in the upstream area and the expansion of permits to open oil palm plantations. Meanwhile, there is an increase in flooding and evapotranspiration on agricultural land experiencing rapid land conversion. In North Musi Rawas Regency, where the primary sources of water for household and agriculture purposes are prevalent, a deficit water availability is outpacing aquifer replenishment in the Rawas watershed (Zainuddin et al., 2023). Research on land use changes using Landsat imagery (2005 and 2019) and SPOT Satellites taken in 2017, with the Mock method (1978) hydrological model in the Lematang river basin, also show an increase in maximum runoff (87.5 mm/month) and maximum surface flow (122.4 m3/sec) due to dominant forest encroachment (Yuono et al., 2020). Consequently, understanding water balance becomes crucial considering domestic and economic needs as well as availability of water in river watershed.

Water balance is a design activity that accesses the proportion of rainfall occurring in a river watershed, evapotranspiration, drainage, and groundwater recharge (Noerhayati, 2020). Estimating water availability is

¹ Post Graduate Program of Civil Engineering, Faculty of Engineering, Sriwijaya University, Jl. R. Soeprapto, Bukit Besar, Palembang, South Sumatera, Indonesia. E-mail: nurhikmawaty23@email.com, ORCID: https://orcid.org/0000-0004-5999-9979

² Department of Civil Engineering and Planning, Faculty of Engineering, Sriwijaya University, Jl. Raya Palembang-Prabumulih Km. 32, Inderalaya, South Sumatera, Indonesia. E-mail: dinardputranto@gmail.com, ORCID: https://orcid.org/0000-0001-7061-708X

³ Department of Civil Engineering and Planning, Faculty of Engineering, Sriwijaya University, Jl. Raya Palembang-Prabumulih Km. 32, Inderalaya, South Sumatera, Indonesia. E-mail: febrian.hadinata@yahoo.co.id, ORCID: https://orcid.org/0000-0002-9637-006X
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essential to meet demand and supply for irrigation, domestic use, and other activities (Ghandhari & Moghaddam, 2011).

Furthermore, water balance, which calculates availability and demand for water in a catchment area, is a strategy for understanding the hydrological conditions and function of water availability in watershed (Kampf et al., 2020). The Mock method is the most commonly used model to understand and analyze water balance of watershed. This model is widely used due to the simplicity of the formula, and availability of temperature, and rainfall data over a long period at several stations. The Mock method is the most widely used empirical formula in places where there are limited data and other meteorological factors (Tayebzadeh Moghadam et al., 2021).

Potential evapotranspiration (PET), along with rainfall is also the main driver of the hydrological cycle of a river watershed. Evapotranspiration is evaporation from the surface of short green plants that are elongated, actively growing, completely shaded in the soil, possess a uniform height, and are not water-deficient. The impact of PET on the annual water balance is significant due to its contribution to rainfall which determines the amount of discharge and infiltration (Xiang et al., 2020). Furthermore, PET from vegetation in hydrology is used with other hydrological data to determine water balance and soil water content to calculate actual evaporation and runoff (Milly & Dunne, 2016).

Several areas of the Rupit watershed experience water scarcity, which may be abundant in other regions. The Rupit River, which crosses Muararupit City, flows into the Rawas River, serving as the main channel for rainwater in the agricultural sector. The drying up of drinking water sources, predominantly river flows, is caused by changes in land use and climate variability (Eva et al., 2020). Therefore, effective river basin management is essential for the conservation of water resources and proper use through information systems. Based on the background, this research aimed to determine water balance in the Rupit watershed using the Mock method using remote sensing and GIS data. Additionally, the amount of watershed surface runoff was calculated using the simulated values obtained from the Mock method. The paper is organized as follows: the next section contains a comprehensive review of literature on social media and consumer decision making as well as customer engagement. Then, the hypothesis is developed based on the literature, and the following section discusses the methodology used. It is followed by the sections presenting the data analysis, findings, and conclusions of the study.

METHODOLOGY

Data Source

Spatial and non-spatial data were obtained from related institutions. While land use maps were taken using Satellite Imagery. Rainfall data was obtained from BMKG (Meteorology, Climatology and Geophysics Agency) Palembang City, for the last 10 years (2013-2022). Soil data, along with its parameters, were obtained from L-REP (Land Resource Evaluation and Planning Project, 2000).

Table 1: Spatial and non-spatial data

<table>
<thead>
<tr>
<th>Spatial and Non-Spatial Data</th>
<th>Source</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use Map</td>
<td>SPOT Image from BBWS South Sumatera VIII, Years 2017, Sentinel Image 2020 and 2023</td>
<td>Scale 1 : 10,000, 10 m</td>
</tr>
<tr>
<td>DEM</td>
<td>DEM Nas (National) (<a href="https://tanahair.indonesia.go.id/demnas/#/">https://tanahair.indonesia.go.id/demnas/#/</a>)</td>
<td>15 m</td>
</tr>
<tr>
<td>Soil Map</td>
<td>L-REP (Land Resource Evaluation and Planning Project, 2000) BAPPEDA, South Sumatera</td>
<td>Scale 1 : 50,000</td>
</tr>
<tr>
<td>Precipitation (2013-2022)</td>
<td>BBWS regions VIII South Sumatera</td>
<td>Day’s Data</td>
</tr>
<tr>
<td>Temperature</td>
<td>BBWS regions VIII South Sumatera</td>
<td>Day’s Data</td>
</tr>
</tbody>
</table>

Watershed boundaries and drainage networks in the research area were analyzed using 15 m resolution Digital Elevation Model (DEM) data obtained from DEMNAS (National Digital Elevation Model).
Rainfall and Temperature

The Rupit watershed is influenced by the subtropical climate zone. The average annual rainfall is 1,124.44 mm (2013 - 2022) as in Figure 1, with average monthly rainfall reaching 112.44 mm. In the last two decades, the highest daily rainfall recorded was 240.5 mm per day, with September to April receiving the highest. Average monthly temperature varied between 21°C to 30°C, where June, July, and August are the hottest months of the year, and January being the coldest, as shown in Figure 2.

Figure 1: Average Monthly Rainfall
Source: BBWS regions VIII South Sumatera

Figure 2: Average monthly temperature, wind speed, solar radiation and air humidity (RH)
Source: BBWS regions VIII South Sumatera

RESEARCH METHODS

The simplest and most widely used water balance model is the F.J. Mock method (Adatika et al., 2020)

\[ GWS = k \cdot IGWS + 0.5(1 + k)I \]  \hspace{1cm} (1)

\[ \Delta GWS = GWS - IGWS \]  \hspace{1cm} (2)
where:

\[ GWS_n = \text{Groundwater storage in the } n\text{th period}; \]
\[ k = \text{Soil flow recession factor}; \]
\[ I = \text{Infiltration of the } n\text{th month}; \]
\[ \Delta GWS = \text{changes in groundwater storage } (\text{m}^3); \]
\[ IGWS = \text{groundwater storage for a period } (n - 1) \text{ in } \text{m}^3 \]

The method applied to obtain water balance of the Rupit watershed uses a GIS and the Mock method. Moreover, the Mock method is simply used to determine water balance from the field level to a river watershed. This model requires monthly temperature and rainfall data as input, while the output is monthly potential and actual evapotranspiration, soil moisture storage, water surplus, and run-off (Amazirh et al., 2017). The amount of water that can be evaporated in the research environment with sufficient water availability in the soil is called PET, calculated using the equation:

\[ E_t = E_{to} - E \quad (3) \]
\[ E = E_{to} \cdot (m/20) \cdot (18 - n) \quad (4) \]

Where:

\[ E_t = \text{limited evapotranspiration } (\text{mm}); E_{to} = \text{potential evapotranspiration } (\text{mm}); E = \text{difference between potential and limited evapotranspiration}; \]
\[ m = \text{land use}; n = \text{number rainy days} \]

Factors that influence soil water surplus are as follows: (a) Soil water content (soil storage/mm/month); (b) Soil moisture capacity (SMC/mm/month); (c) Rainwater (ER). To calculate the rainwater that reaches the ground surface, it can be counted using the following formula.

\[ ER = P - E_{to} \quad (5) \]

Where:

\[ ER = \text{rainwater reaching the surface}; P = \text{monthly rainfall and } E_{to} = \text{actual evapotranspiration} \]

Water Surplus is run-off surface water and infiltration. To calculate Water surplus (+) is determined using the formula below (Singh et al., 2004):

\[ WS = (P - E_{a}) + SS \quad (6) \]

Where:

\[ P = \text{monthly average rainfall}; E_{a} = \text{Actual evapotranspiration}; \]
\[ SS = \text{Soil Storage} \]

Soil moisture storage (SMS) consists of soil moisture capacity (SMC), zone of infiltration, surface runoff, and soil storage. Amount of Soil Moisture Storage (SMS) for each region depending on plant types, land cover, and soil type. In Mock, SMS is calculated as follows (Wang et al., 2021):

\[ SMS = ISMS + (P - E_{a}) \quad (7) \]

Where:

\[ ISMS = \text{Soil Moisture Storage}; P = \text{monthly average rainfall}; E_{a} = \text{Actual evapotranspiration}, \]

Available water is often expressed as the depth of the root zone, consisting of 80%, which is expressed as a volume fraction (Andayono, 2018). AWC depends on soil properties, soil area, and root zone depth. Estimated data on root zone depth and available water capacity according to existing soil formations is determined based on the literature on soil or vegetation types that are suitable for the conditions of the Rupit River Watershed. Actual storage changes (\( \Delta SM \)) for all months are calculated as follows (Senkondo et al., 2004)

\[ \Delta SM_{\text{month}} = STOR_{\text{month}} - STOR_{\text{previous month}} \quad (8) \]

Where:
ISMS = Soil Moisture Storage; $P =$ monthly average rainfall; $E_a =$ Actual evapotranspiration

Moreover, for calculating Total Run-off (TRO) is obtained using the equation (Komariah & Matsumoto, 2019):

$$TRO = BF + DRO + SRO$$  \hspace{1cm} (9)

Where:

$BF =$ Base Flow; $DRO =$ Direct Run-off; $SRO =$ Storm Run-off.

The equation for calculating Debit is obtained using the equation:

$$Q = A \times TRO$$  \hspace{1cm} (10)

Where:

$Q =$ Debit; $A =$ Watershed area; $TRO =$ Total Run-off.

RESULTS AND DISCUSSION

Watershed Morphometry

Drainage analysis in watershed system determines the effectiveness of flow patterns, identifies areas prone to water pooling, and availability of water in the research area.

Flow Length

Stream length is one of the most important hydrological characteristics in watershed areas, providing information about surface flow characteristics. Generally, the total length of the upstream and middle sections of the Rupit River is the longest, accounting for approximately 136, 417 Km, with the upstream section, consisting of 131,260 km. All drainage channels in the Rupit river sub-system in the upstream section are a branching, dendritic pattern. Therefore, it can be concluded that the Rupit watershed has a slope of > 45% upstream and <8% downstream, serving as a basin with alluvial deposits of former sediment or river overflow.
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Basin Area (A)

Watershed area is an important parameter, complementing the river drainage length. Average watershed area in the Rupit watershed upstream of the Rupit River covers 450.77 km². Meanwhile, the middle part (Rupit Midle 2 sub watershed) has an area of 334.35 km², with watershed circumference being 96.16 km. The downstream area (Rupit Downstr Stream 1 sub watershed) has an area of 337.64 Km², with a circumference of 120.14 Km.

Drainage Pattern

In watershed, drainage patterns serve as indicators of slope, lithology, and structure, which helps to identify stages in the erosion cycle when analyzed. Drainage pattern presents several watershed characteristics through patterns and textures, which can infer the geological condition of watershed, rock strike, and deposition, including the presence of faults. Furthermore, drainage texture reflects climate, rock permeability, vegetation, and relief ratio by linking patterns with geological information.

The drainage pattern of the Rupit watershed is longitudinal and dendritic, showing a sloping area upstream and wavy downstream, with a large river system, which is a floodplain basin.

Drainage Density

Drainage density is the length of flow per unit area of a basin or watershed, which is widely used for analysis as a quantitative expression for landform estimation. However, climate functions, structural lithology, and regional relief history can be used as indirect indicators to explain the variables and landform morphogenesis. Based on the results, the drainage basin density of the Rupit watershed is 0.314 Km/Km².

Geomorphology

The Rupit watershed has unconsolidated sediments from clay to sand of different grades. Geologically, the Rupit watershed is a highland and the downstream part is a lowland with a height of 43 m above sea level. The soil material is Quaternary alluvial deposits from the Pleistocene to recent ages. Furthermore, some parts of the basin have clayey sand formations due to mud deposits which are interspersed with sand. Shallow aquifers also occur mainly in river deposits and are meandering.

Geology

Geologically, the Rupit watershed is located along the foothills of the Barisan hills, including lowlands which are Quaternary alluvial deposits from the Pleistocene to recent ages. According to previous research, flash floods at the mouth of the Rupit River have occurred repeatedly, posing a serious threat to residents and urban areas.

Geohydrology

Availability of groundwater in the alluvial zone is controlled by the thickness of the sand and clay zones. Furthermore, groundwater near the surface occurs under unconfined aquifer conditions, while deeper aquifers are observed under confined-to-confined aquifer conditions. In the Rupit watershed, aquifer levels occur in semi-limited and limited conditions. Groundwater in basins is primarily recharged by Rainfall, with some areas experiencing a worsening trend. In this research, average hydraulic gradient is 0.35 m/km, showing the porous nature of the near-surface formations of the area.

Land Use and Vegetation

The Rupit watershed has a land cover of more than 53.264%, predominantly consists of broadleaf forest, and 37.6% of the area is used for smallholder plantations. In the downstream of water catchment area, built-up and cultivation areas dominate approximately 2% of the Rupit urban area. The built-up area consists of rural households, which are majorly occupied by non-irrigated rice fields, rivers/lakes/situ/ponds, open land, and settlements. Different land uses are shown in Figure 4, while the coverage area and magnitude of other parameters are presented in Table 3.
Table 3 Area and type of land use distribution in the Rupit watershed

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Area_(Ha)</th>
<th>Area_Km2</th>
<th>C_Coeficient</th>
<th>RD</th>
<th>ET/ET0</th>
<th>A_%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thicket Forest</td>
<td>33,703,350</td>
<td>337,037</td>
<td>0.010</td>
<td>0.100</td>
<td>0.800</td>
<td>20,000</td>
</tr>
<tr>
<td>Dense forest</td>
<td>64,863,250</td>
<td>648,633</td>
<td>0.010</td>
<td>0.100</td>
<td>0.900</td>
<td>20,000</td>
</tr>
<tr>
<td>Land not planted</td>
<td>6,520</td>
<td>0.065</td>
<td>0.100</td>
<td>0.100</td>
<td>0.800</td>
<td>15,000</td>
</tr>
<tr>
<td>Industrial Plantation</td>
<td>13,058,940</td>
<td>130,590</td>
<td>0.040</td>
<td>0.780</td>
<td>0.850</td>
<td>20,000</td>
</tr>
<tr>
<td>People's Plantations</td>
<td>69,575,830</td>
<td>695,757</td>
<td>0.070</td>
<td>0.100</td>
<td>0.800</td>
<td>20,000</td>
</tr>
<tr>
<td>Settlement</td>
<td>225,160</td>
<td>2,250</td>
<td>0.510</td>
<td>0.050</td>
<td>0.600</td>
<td>30,000</td>
</tr>
<tr>
<td>Non-irrigated rice fields</td>
<td>995,410</td>
<td>9,954</td>
<td>0.430</td>
<td>0.100</td>
<td>0.900</td>
<td>20,000</td>
</tr>
<tr>
<td>River/Lake/Pond</td>
<td>1,264,260</td>
<td>12,642</td>
<td>1.000</td>
<td>0.000</td>
<td>0.000</td>
<td>46,000</td>
</tr>
<tr>
<td>Open Field</td>
<td>1,347,800</td>
<td>13,479</td>
<td>0.832</td>
<td>0.050</td>
<td>0.400</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Source: Sentinel Image Interpretation, 2022

Figure 4: Distribution of land use in the Rupit watershed

Source: Sentinel Image Interpretation, 2023

Hydrology

Rain Intensity

From the existing rainfall data, rain intensity for every 10-minute interval during extended periods of 2, 5, 10, 50, and 100 years is depicted in the form of an IDF (Intensity Duration Frequency) curve, graphically shown in Figure 5.

Variations in Water Availability

APWL in watershed is obtained from monthly rainfall and temperature. Based on the results, several deficits and surpluses of soil water content were observed during the dry season and rainy season.

The results showed that plants from October to April have access to soil water content. Meanwhile, in May and September, plants experienced a relative lack of water, predominantly remaining dry as shown in Table 4.
### The Effect of Land Use Changes on Availability of Water Resources in The Rupit Watershed

<table>
<thead>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Precipitation (P, mm/month)</td>
<td>31,05</td>
<td>56,85</td>
<td>43,75</td>
<td>40,80</td>
<td>39,25</td>
<td>36,90</td>
<td>27,65</td>
<td>34,25</td>
<td>37,25</td>
<td>42,15</td>
<td>37,54</td>
<td>36,88</td>
<td>46,43, 3</td>
</tr>
<tr>
<td>2</td>
<td>Rain Days (r, days)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Days of Month (H, days)</td>
<td>31</td>
<td>28</td>
<td>30</td>
<td>31</td>
<td>30</td>
<td>31</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>Temperature (T, °C)</td>
<td>29,90</td>
<td>30,05</td>
<td>30,50</td>
<td>31,90</td>
<td>31,10</td>
<td>30,40</td>
<td>30,05</td>
<td>30,90</td>
<td>30,80</td>
<td>30,75</td>
<td>31,50</td>
<td>30,50</td>
<td>36,5, 0</td>
</tr>
<tr>
<td>5</td>
<td>Sunshine (%)</td>
<td>93</td>
<td>9,50</td>
<td>10,30</td>
<td>10,20</td>
<td>9,70</td>
<td>9,30</td>
<td>10,50</td>
<td>10,90</td>
<td>10,30</td>
<td>10,30</td>
<td>9,60</td>
<td>8,60</td>
<td>36,5</td>
</tr>
<tr>
<td>6</td>
<td>Relative Humidity (%)</td>
<td>94,50</td>
<td>93,50</td>
<td>94,50</td>
<td>93,20</td>
<td>93,80</td>
<td>91,80</td>
<td>91,10</td>
<td>91,00</td>
<td>91,10</td>
<td>91,90</td>
<td>91,80</td>
<td>93,80</td>
<td>36,5</td>
</tr>
<tr>
<td>7</td>
<td>Wind Speed (w, km/h)</td>
<td>14,0</td>
<td>14,0</td>
<td>18,0</td>
<td>8,0</td>
<td>14,0</td>
<td>8,0</td>
<td>8,0</td>
<td>10,0</td>
<td>24,0</td>
<td>12,0</td>
<td>10,0</td>
<td>99,3</td>
<td>36,5</td>
</tr>
</tbody>
</table>

#### Potential Evapotranspiration (mm/month)

| 2 | 2.2 | 2.0 | 1.8 | 1.5 | 1.6 | 1.8 | 2.0 | 2.2 | 2.1 | 2.1 | 1.8 | 1.6 | 1.9 |

#### Meteorological Data

<table>
<thead>
<tr>
<th>Year</th>
<th>Ed (mm Hg)</th>
<th>hxe (mm)</th>
<th>Ea  (mm/month)</th>
<th>Ep  (mm/month)</th>
<th>E1  (mm/month)</th>
<th>Ep  (mm/month)</th>
<th>E1  (mm/month)</th>
<th>Ep  (mm/month)</th>
<th>E1  (mm/month)</th>
<th>Ep  (mm/month)</th>
<th>E1  (mm/month)</th>
<th>Ep  (mm/month)</th>
<th>E1  (mm/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>37,54</td>
<td>37,54</td>
<td>37,54</td>
<td>37,54</td>
<td>37,54</td>
<td>37,54</td>
<td>37,54</td>
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<td>37,54</td>
<td>37,54</td>
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<td>37,54</td>
</tr>
<tr>
<td>1994</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
<td>38,23</td>
</tr>
</tbody>
</table>

#### Water Surplus (mm/month)

| 170,5 | 56,05 | 62,86 | 61,30 | 57,62 | 53,61 | 57,49 | 62,59 | 63,28 | 66,65 | 62,44 | 64,61 | 839, 0 |

#### P-Ea ; (mm/month)

| 139,4 | 1,8 |

#### SMS = ISMS + (P-Ea) ; (mm/month)

| 60,52 | 61,32 |

#### ISMC (mm/month)

| 60,52 | 200 |

#### SS (mm/month), if P-Ea > 0.5xS |

| 139,4 | 1,8 |

#### WX (mm/month); (G2) + (30) |

| 0,00 | 0,00 |

#### TOR (mm/month)

| 0,30 |

#### IC(g)

| 0,30 | 0,40 | 0,30 | 0,27 | 0,30 | 0,30 | 0,30 | 0,35 | 0,25 | 0,50 | 0,35 | 0,30 |

#### Infiltration (i); (31)x if, (mm/month)

| 0,00 | 0,32 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |

#### R (monthly flow-recession constant)

| 0,90 | 0,85 | 0,75 | 0,88 | 0,95 | 0,90 | 0,75 | 0,80 | 0,92 | 0,70 | 0,85 |
Soil water content deficit was observed to be minimal in dense forest (129.73 mm), thicket forest (134.58 mm), land not planted (89.63 mm), and non-irrigated rice fields (94.85 mm) as well as settlement, and water bodies (0.675 mm). Similarly, annual moisture surplus in the soil was minimum in dense forest (234.68 mm), followed by thicket forest (237.61 mm), land not planted (239.415 mm), non-irrigated rice fields (239.936 mm), as well as settlement and water bodies (243.079 mm). The weighted annual watershed deficit was –400.000 l/days, while the surplus was 0.0089 mm at February – March.

Source: Results of Analysis (add year)

Soil water content deficit was observed to be minimal in dense forest (129.73 mm), thicket forest (134.58 mm), land not planted (89.63 mm), and non-irrigated rice fields (94.85 mm) as well as settlement, and water bodies (0.675 mm). Similarly, annual moisture surplus in the soil was minimum in dense forest (234.68 mm), followed by thicket forest (237.61 mm), land not planted (239.415 mm), non-irrigated rice fields (239.936 mm), as well as settlement and water bodies (243.079 mm). The weighted annual watershed deficit was –400.000 l/days, while the surplus was 0.0089 mm at February – March.

**Figure 5**: IDF curve for return period 2-100 years

Source: Precipitation Data Analysis

### The Rupit Watershed Run-off Surface

Surface runoff (Run-off) simulations from the Mock model were compared with runoff obtained from existing data in BWWS Region VIII, South Sumatra, and routine visits to the research area. The observed runoff value was 134.42 mm/year and Stream Flow was 95.23 m³/sec.
Analysis of Raw Water Needs

Raw water needs are based on the projected population of the Rupit sub-watershed for the last ten years of data starting in 2022 in 2 sub-districts that are included in the Rupit sub-watershed area, namely Rupit and Karang Jaya sub-districts. Analysis of raw water needs in this research includes domestic and non-domestic water needs. From the results of calculating clean water needs in Rupit and Karang Jaya sub-districts, the recapitulation of clean water needs is 4,790,899.1 liters/second in 2021 and in 2031 (10 year projection) the total clean water need in Rupit and Karang Jaya sub-districts is equal to 7,085,181.4 liters/second.

![Graph showing water needs and availability in Rupit sub-watershed]

**Fig 6: Availability and Needs in the Rupit sub-watershed**

Source: Results of Analysis

**CONCLUSION**

In conclusion, this research focused on estimating water balance to monitor the management of watershed such as the Rupit Watershed. The area is a new urban center designated as the capital of North Musi Rawas Regency, South Sumatra Province. Furthermore, North Musi Rawas Regency has administrative boundaries, the same as the Rawas watershed boundaries. The Rupit watershed is the downstream part, which often experiences flooding at the mouth of the Rupit river. During the analysis, water balance of the Rupit watershed was calculated using the Mock method.

The highest rainfall and evapotranspiration only occur in January, while other months recorded average of 56-66 mm/month. It was discovered that excessive water during the wet months (November-March) led to flooding, causing damage to infrastructure, such as residential buildings, roads, and bridges.

In the months of April-October, there was water shortage, with forest destruction and encroachment through illegal gold and coal mining causing a decline in the quality of surface water and protected forest environment.

The weighted annual watershed deficit obtained was 400,000 l/days, while the surplus was almost non-existent. Simulations of runoff against rainfall showed a significant and coherent catchment response to rainfall patterns.

Due to low rainfall and soil water content levels from previous months, February showed the highest discharge of 56.85 m³/second, with a runoff coefficient of 0.73.

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Conflicts Of Interest

The author and all the authors of this paper have no conflict of interest in any form regarding the data, research results and articles in the paper written and proposed for publication in the journal.

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