Water balance for irrigation area

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Abstract. Water balance for the irrigation area will be achieved if every time for irrigation water needs is never greater than the availability of water and in certain same conditions. Salamdarma irrigation area is located on the border area of the Indramayu and Subang regions, West Java Province which is managed by PT Jasa Tirta II Patrol Section. The purpose of this research is to control the water balance of Salamdarma irrigation area. The analysis by taking into account the needs and availability of water for irrigation. The method used is water balance from rainfall data using hydrology analysis with R80 % for potential discharge and cropping pattern analysis for water requirement. The results of the analysis show that the amount of average water requirement is 30 m3/s and the average potential discharge is 64 m3/s. This means that the needs and availability of water in Salamdarma irrigation area are still balanced.

1. Introduction
To support government programs in realizing food self-sufficiency, especially rice, sufficient water is needed for irrigation water needs. Fulfillment of these needs is carried out with the use of irrigation water so that there is a balance between needs and availability [1]. One of the greatest challenges for irrigated agriculture is the fact that many irrigation projects have a deficit of irrigation water, while simultaneously having other amounts of irrigation water going to unreasonable or non-beneficial uses [2]. Salamdarma Weir is located on the border of the Indramayu and Subang regions, located in the administrative area of Anjatan District, Indramayu, West Java, Indonesia, which is managed by PT Jasa Tirta II Patrol Division. In 2018, the Salamdarma irrigation area has a total service area of 35871 hectare, the service area includes Subang and Indramayu region. The existence of Salamdarma irrigation area has an important role for the farmers especially during dry season to support water requirement and water availability for plant. What must be studied is that there is a difference in the analysis of irrigation water requirements from the previous calculation of 28 m3/s, while the calculation was 28.7 m3/s [3]. This encourages the author to research the needs and availability of water with efficient water use.

2. Methodology
2.1. Data and object
Salamdarma weir located on the border area between Subang and Indramayu Region. Precisely located in the administrative area of Bugis Tua Village, Anjatan District, Indramayu, West Java, Indonesia. The rainfall data used from 1998 to 2017 from five rainfall station in Cipunagara watershed, that is: Cisalak, Sindanglaya, Subang, Pagaden and Pusakanegara.
2.2. Data analysis technique

The method used in the calculation of the average rainfall area of the watershed is Polygon Thiessen method. Effective rainfall is determined the amount of $R_{80}$ which is the rainfall whose magnitude can be exceeded by 80% [4]. According to Charles the dependable flow is the minimum river flow for a prescribed probability that can be used for irrigation. The probability of being fulfilled is set at 80% (the probability that the river flow is lower than the dependable flow is 20%) [5].

The water requirement coefficient on the canals is as follows: Primary water requirement coefficient is 1.25, Secondary water requirement coefficient is 1.10 and Tertiary water requirement coefficient is 1.05 [6]. In order to meet water requirement for crops, the determination of cropping patterns is a matter to consider [7].

3. Result and discussion

3.1. Analysis of potential discharge

Polygon Thiessen result in Cipunagara watershed can be seen on figure below:

![Polygon Thiessen in Cipunagara watershed](image)

**Figure 1.** Polygon Thiessen in Cipunagara watershed.

Based on the result of the Polygon Thiessen calculation, obtained the area of watershed for each area of the rainfall station. The polygon area of rainfall station can be seen on table 1 below:

| Rainfall Station | Area (km²) |
|------------------|------------|
| Cisalak          | 201.13     |
| Sindanglaya      | 462.21     |
| Subang           | 200.72     |
| Pagaden          | 275.03     |
| Pusakanegara     | 156.36     |

From the result of polygon thiessen formula, the average rainfall area of Cipunagara watershed for January I 2017 is 93 mm/15 days (example calculation). For effective rainfall with $R_{80}$ is

\[
R_{80} = \left(\frac{n}{5}\right) + 1
\]

\[
= \left(\frac{20}{5}\right) + 1
\]
From May II to October I = max rainfall x 0.2
= 234 x 0.2
= 47

Value for R80 in May II is 47. Then potential discharge Q for two weekly Cipunagara watershed is table below

| Month     | Rainfall R 80 % (m) | Volume (m$^3$) | Q (m$^3$/s) |
|-----------|---------------------|----------------|-------------|
| January I | 0.00576             | 7459200        | 86          |
| January II| 0.00909             | 11771550       | 136         |
| February I| 0.00851             | 11020450       | 128         |
| February II| 0.00526            | 6811700        | 79          |
| March I   | 0.00608             | 7873600        | 91          |
| March II  | 0.00626             | 8106700        | 94          |
| April I   | 0.00510             | 6604500        | 76          |
| April II  | 0.00347             | 4493650        | 52          |
| May I     | 0.00305             | 3949750        | 46          |
| May II    | 0.00312             | 4040400        | 47          |
| June I    | 0.00219             | 2836050        | 33          |
| June II   | 0.00241             | 3120950        | 36          |
| July I    | 0.00207             | 2680650        | 31          |
| July II   | 0.00193             | 2499350        | 29          |
| August I  | 0.00154             | 1994300        | 23          |
| August II | 0.00150             | 1942500        | 22          |
| September I| 0.00165           | 2136750        | 25          |
| September II| 0.00332         | 4299400        | 50          |
| October I | 0.00261             | 3379950        | 39          |
| October II| 0.00261             | 3379950        | 39          |
| November I| 0.00541             | 7005950        | 81          |
| November II| 0.00713           | 9233350        | 107         |
| December I| 0.00527             | 6824650        | 79          |
| December II| 0.00722           | 9349900        | 108         |

From the table above we can calculate with formula:

$Rainfall (m) = \frac{R80\%}{1000}/15$

$Volume = Rainfall (m) \times \text{watershed Area (m}^2\text{)}$

$Q (m^3/s) = \frac{Volume (m^3)}{86400 \text{ s}}$

Rainfall Volume Discharge formula is

$(Rainfall/100) \times (\text{watershed area} \times 1000000)$

Example Calculation data on Januari I

Rainfall = \(\frac{86.366}{1000}\)/15
= 0.00576 m/day

Volume = 0.00576 m $\times$ 1295446600 m$^2$
= 7458884 m$^3$/day

$Q (m^3/s) = \frac{7458884 \text{ m}^3/\text{day}}{86400 \text{ s}}$
= 86.330 m$^3$/s
3.2. Analysis of irrigation water requirement

Example Calculation November 1

\[ KAS = SKA \times Area \]
\[ = 1.2 \text{ l/s. ha} \times 19405 \text{ hectare} \]
\[ = 32386 \text{ l/s} \]

\[ KAS \text{ tertiary} = 1.25 \times 32386 = 29107 \text{ l/s} \]

\[ KAS \text{ Secondary} = 1.10 \times 29107 = 32018 \text{ l/s} \]

\[ KAS \text{ Primary} = 1.05 \times 32018 = 33619 \text{ l/s} \]

Crop water requirement = 33619 l/s

Total amount = crop water requirement + Water Req Industry + Water Req Etc

\[ = 33619 + 100 + 50 \]
\[ = 33769 \text{ l/s} \]
\[ = 34 \text{ m}^3/\text{s} \]

| Planting Periode | Month   | Water Requirement (l/s) |
|------------------|---------|-------------------------|
| November I   | 33769   |
| November II  | 51939   |
| December I   | 41581   |
| December II  | 41581   |
| January I    | 41581   |
| January II   | 41581   |
| February I   | 26044   |
| February II  | 12602   |

**Figure 2.** Chart of potential discharge.
Table 3. Cont.

| Month   | Water Requirement (m^3/s) |
|---------|---------------------------|
| March I | 32476                     |
| March II| 49751                     |
| April I | 39940                      |
| April II| 40214                     |
| May I   | 40214                      |
| May II  | 40214                      |
| June I  | 25109                      |
| June II | 11316                      |
| July I  | 18194                      |
| July II | 28860                      |
| August I| 21799                      |
| August II| 21799                    |
| September I| 21799                  |
| September II| 21799                |
| October I| 9272                       |
| October II| 4205                      |

Figure 3. Chart of water requirement.

Figure 4. Chart of water requirement and potential discharge.
From the result of water requirement compared to potential discharge that is available in Salamdarma Irrigation area, the average of water requirement is 30 m$^3$/s and the average of potential discharge is 64 m$^3$/s, it can be concluded that the potential discharge has fulfilled the requirement water in Salamdarma irrigation area.

3.3. Analysis of cropping pattern and group system
Salamdarma irrigation has service area of 35871 hectare of field, based on KP 01 Irrigation Design Standard 2013 (Page 179), the irrigation area that has service area more than 25000 hectare needed to be divided into some groups (group system), group system has function to reduce peak-taking demand of irrigation water [8]. In Salamdarma irrigation the group system divided into 2 groups of planting period, the first group system starts at November I and the second group system start at November II. The cropping pattern is arranged based on the availability of the water in irrigation area, from the comparison between potential discharge and water requirement in Salamdarma irrigation area, the potential discharge has met the requirement water, so it can be concluded that Paddy-Paddy-Palawija (Secondary Crop) that supposed for the irrigation area that has plenty of water available is suitable to be used in Salamdarma irrigation area, because Salamdarama irrigation has plenty of water available to support the water requirement based on comparison between potential discharge and water requirement.

4. Conclusion
The average of water requirement in Salamdarma irrigation area is 30 m$^3$/s and the average of potential discharge is 64 m$^3$/s. Based on the comparison between potential discharge and water requirement, the potential discharge has fulfilled the irrigation water requirement for agricultural sector using paddy-paddy-palawija, as the cropping pattern suitable based on the available of irrigation water in Salamdarma.

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References
[1] Masood A, Mazhar E and Amit K 2014 Water Balance Modeling For Efficient Water Management in Canal Command IOSR-JMCE 11 47-53
[2] Swichtenberg and Bill 1999 Conservation Through Irrigation Water Engineering & Management 146(9) 5
[3] PJT II 2003 to 2005, 2006 Collective Data Djuanda Dam of Water Demand
[4] Ven Te Chow 1980 Open Channel Hydraulics (Mc Graw–Hill LTD)
[5] Charles M B 1999 Irrigation Water Balance Fundamentals (USCID Denver, Colo: ITRC) p 1-13
[6] The Ministry of Public Work General Directorate of Water Resources 2013 KP-01 Design Criteria of Irrigation, Indonesia
[7] Withers B and Vipond S 1974 Irrigation Design and Practice (London: B T Betsford Limeted)
[8] Setegn S G, Chowdary V M, Mal B C, Yohannes F and Kono Y 2011 Water balance study and irrigation strategies for sustainable management of a tropical Ethiopian lake: a case study of Lake Alemaya Water resources management 25(9) 2081-2107