The Efficiency of Rawa Mayo Irrigation Channels in Kurik Sub-Distrik, Merauke

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Abstract. The purpose of this research is to know the efficiency of irrigation networks and water loss Swamps the Mayo that occurred during the distribution of irrigation. Research methods used in this research is a research field that is by calculating the discharge of water channels, perkolasi, evaporation and seepage. The research results obtained average discharge early in the primary channel of 0.292 m³/s, the final discharge 0.25 m³/s, the loss of water, 0.042 m³/s and the efficiency of irrigation of 85.62%. On the secondary channel I average early discharge 0.268 m³/s discharge, 0.153 m³/s end, water loss of 0.115 m³/s and irrigation efficiency of 57.08%. On the secondary channel II early 0.22 m³/s debit, debit end 0.118 m³/s, water loss of 0.102 m³/s and irrigation efficiency of 53.63%. Irrigation efficiency at Mayo swamp irrigation is 46.39% where the value still meets the KP-01 (2013) Irrigation planning standard.

1. Introduction

Water is a basic need in life, both to meet human and agricultural needs. In all lines of human life the existence of water is always needed both directly and indirectly. However, water also has the potential to bring disaster, so people do business by making irrigation and drainage to manage water so that it can be utilized properly and maintain its existence.

Some of the problems that arise in irrigation processing generally come from climate factors and the irrigation network itself. Climate factors can be in the form of long drought which results in the availability of water deficits and high rainfall intensity during the rainy season resulting in surplus and flooding. While problems in irrigation networks can come from poor management management, damage to buildings, and sedimentation that occurs. This situation is also exacerbated by the loss of water that occurs through seepage and evaporation. [2] The network conditions in accordance with the Rapid Assessment of Public Works in 2009 are estimated to be approximately 52% damaged, so that their functions are not optimal in irrigation systems.[6] in reality in many fields (or even most) irrigation projects are operated in an inefficient manner. The inefficiency of the irrigation system is largely due to the over-wasteful use of water, the lack of proper functioning of the water flow...
regulators as designed, the too wide area of irrigation and so on. Partly because of management and social aspects of officers and farmers.

For agriculture, management requires the management of water resources. So that by using water resources management techniques, water distribution will be effective and efficient, providing irrigation buildings so that the water will still be obtained far from the source. [3] proper and efficient administration of irrigation water requires a discharge measurement building for each channel. The discharge measuring building functions to find out the water flow through the channel so that the provision of water to the plots of rice fields that become irrigated areas can be monitored, thus it is expected that the water supply is not excessive or deficient and in accordance with the plant water requirements in the rice field plots. The terminology of Irrigation Efficiency used refers to the Irrigation Planning Standard [4] where irrigation efficiency is a ratio between water used and tapped water, expressed in %. The purpose of this study was to determine the efficiency of the Rawa Mayo irrigation channel as well as water losses that occur in irrigation canals.

2. Research methodology
This research was conducted in the Rawa Mayo irrigation channel in the Kurik District of Merauke Regency (figure 1) in May to July 2015, the research location can be seen in Figure 1. The tools used are roll meter, stopwatch, stationery, calculator, life ball, rope, single ring infiltrometer, evaporation pans, buckets, rulers, hammers, shovels, cameras, sample rings. While the materials used in this study were: climate data, Mayo swamp network maps, Mayo swamp network data. The study was conducted by collecting primary and secondary data to be analyzed to obtain the efficiency of the irrigation channel.

![Figure 1. Map of the Research Area](image-url)
2.1. Research procedure

2.1.1 Water Discharge Measurement
Measurements of water discharge are carried out using a float ball washed on a 15 meter long channel. Measurements are made at the beginning and end of the channel. Data will then be calculated using the following formula:

\[ Q = V \times A \]

Where:
- \( Q \) = Water discharge (m\(^3\));
- \( V \) = velocity of water flow (m / s);
- \( A \) = cross-sectional area (m\(^2\))

2.1.2 Percolation Measurement
Percolation measurements using an infiltrometer ring with a span of 12 hours to ensure the soil is saturated with water. The percolation rate is then calculated by the formula:

\[ P = \frac{R - E}{T} \]

Where:
- \( P \) = Percolation Rate (m\(^3\) / s);
- \( R \) = decrease in water level in the infiltrometer ring (mm / s);
- \( E \) = decrease in water level in the evaporation pan (mm / s);
- \( T \) = time (s)

2.1.3 Permeability Measurement
Seepage measurement is done by testing the seepage coefficient in the soil laboratory, then it will be calculated using the formula [5] as follows:

\[ Q = k (B - 2d) \]

Where:
- \( Q \) = permeation per unit length (L\(^3\)/T/L);
- \( k \) = coefficient of permeability (L/T);
- \( B \) = width of the water surface in the channel (L);
- \( d \) = maximum depth of water in the channel (L)

2.1.4 Calculation of Irrigation Efficiency
Water Distribution Efficiency

\[ \text{Ef} = \frac{\text{Debit at the end}}{\text{Debit at the base}} \times 100\% \]

Losses are calculated based on the measurement results of discharge, loss through evaporation, percolation and seepage. The next data will be compared with the Irrigation Planning Standard [4] in Table 1.

| Table 1. Classification of Irrigation Networks |
Irrigation Network Classification of Irrigation Networks

| Overall Efficiency | High 50% - 60% | Medium 40% - 50% | Less <40% |
|--------------------|----------------|-----------------|----------|

3. Result and Discussion
3.1. Irrigation Efficiency on Primary Channels
3.1.1. Debit Measurement
In the primary channel the measurement of the cross-sectional area of the channel uses the trapezoidal formula. Measurements were made starting from the base of the saluraan (after the Mayo pump) to the door of the secondary channel and only carried out on the channel that is still used to irrigate the land. Where water flowed to the primary canal only reaches the secondary channel II. The measured channel length is 1,935 m from the total actual length of 4,028 m. the channel has a base width of 2 meters and a width of 4 meters. The results of measuring water discharge are presented in Table 2 and table 3.

Table 2. Measurement of discharge on the Primary channel

| Measurement  | Measuring point | Water level (m) | Water surface width (m) | Travel time is 15 meters (s) | Flow speed (m / s) | Area of cross section of channel (m²) | Water discharge (m³ / s) |
|--------------|----------------|----------------|-------------------------|-----------------------------|-------------------|---------------------------------------|--------------------------|
| First        | Early          | 0.40           | 2.72                    | 00:50                       | 0.30               | 0.95                                  | 0.28                     |
|              | End            | 0.51           | 2.94                    | 01:15                       | 0.20               | 1.27                                  | 0.25                     |
| Second       | Early          | 0.40           | 2.70                    | 00:46                       | 0.32               | 0.94                                  | 0.30                     |
|              | End            | 0.53           | 2.95                    | 01:17                       | 0.19               | 1.31                                  | 0.24                     |
| Third        | Early          | 0.41           | 2.73                    | 00:50                       | 0.30               | 0.97                                  | 0.29                     |
|              | End            | 0.54           | 2.97                    | 01:16                       | 0.19               | 1.34                                  | 0.26                     |

Description: Base width of channel 2 m

Table 3. Primary channel water loss

| No    | Measurement                | Debit (m³/s) |
|-------|----------------------------|--------------|
| 1.    | Average initial discharge  | 0.29         |
| 2.    | Average final discharge    | 0.25         |

Based on the debit measurement data above, the primary channel efficiency is obtained

\[
E_{f_{primer}} = \frac{\text{debit at the end}}{\text{debit at the base}} \times 100% \\
= \frac{0.25}{0.292} \times 100% \\
= 85.62 \% 
\]
Primary channel efficiency is 85.62%. The main cause of the loss of a large enough water discharge comes from a channel leak where the bulkhead used to close the channel door only uses a pile of sand sacks as seen Figure 2.

![Figure 2. Closure of the primary channel door using sand sacks](image)

The primary channel used is connected with 2 channel doors which are only insulated by sand sacks, making them vulnerable to channel leakage. Water will pass through the cracks of the sacks and can even pass through the height of the sack and cause water to flow into the duct which should be closed. The primary channel is made of stone pairs so that the factor that influences the loss of irrigation water is evaporation.

### 3.1.2. Evaporation

One of the factors that causes water loss in the Rawa Mayo Irrigation network is evaporation. The measurement data for evaporation by the Mopah Merauke Meteorological Station from June to September 2015 can be seen in table 4:

| No | Month   | Evaporation | Average evaporation per day in 1 month |
|----|---------|-------------|---------------------------------------|
| 1  | June    | 108,6 mm    | 3,62 mm                               |
| 2  | July    | 113,0 mm    | 3,64 mm                               |
| 3  | August  | 101,4 mm    | 3,27 mm                               |
| 4  | September | 199,0 mm  | 6,63 mm                               |
|    | Average per day |        | 4,29 mm                               |

Based on the daily average evaporation obtained from BMKG, data on water loss due to evaporation were obtained at 0,00054 m$^3$/s on the primary channel surface. The loss due to evaporation of 0,00054 m$^3$/s has very little effect on the total water loss in the primary channel. The total loss in the primary channel was 0.042 m$^3$/s so that the effect of evaporation was only 1.28%.

### 3.2. Irrigation Efficiency on Secondary Channels 1

The secondary channel I is a channel that channels water from the primary canal to the BBI rice field. The channel is still a temporary building (not permanent). The total length of this secondary channel is 1,876 m. Secondary channel I is connected with 10 tertiary channels on the right and left side.
However, the discharge measurements carried out only take a sample of 500 m. This is because the community has started to take water using the pump once the water enters the first paddy field. So to find out the water that is completely gone is only used a measurement of 500 meters. The results of direct discharge measurements will be compared with the results of percolation, evaporation and seepage measurements. The measurement of debit data carried out in the field can be seen in tables 5 and 6.

3.2.1. Water discharge

Data from the measurement of discharge in the field can be seen in Table 5 and Table 6.

**Table 5. Measurement of discharge in the secondary channel I**

| Measurement | Measuring point | Water level (m) | Water surface width (m) | Travel time is 15 meters (s) | Flow speed (m/s) | Area of cross section of channel (m²) | Water discharge (m³/s) |
|-------------|-----------------|-----------------|-------------------------|-----------------------------|-----------------|---------------------------------------|------------------------|
| First       | Early           | 0.47            | 3.10                    | 01:10                       | 0.21            | 1.3                                   | 0.27                   |
|             | End             | 0.35            | 2.83                    | 00:58                       | 0.26            | 0.93                                  | 0.24                   |
| Second      | Early           | 0.46            | 3.12                    | 01:12                       | 0.20            | 1.29                                  | 0.26                   |
|             | End             | 0.34            | 2.82                    | 00:53                       | 0.28            | 0.90                                  | 0.25                   |
| Third       | Early           | 0.46            | 3.11                    | 01:11                       | 0.21            | 1.29                                  | 0.27                   |
|             | End             | 0.35            | 2.84                    | 00:57                       | 0.26            | 0.93                                  | 0.24                   |

Description: Base width of channel 2 m

**Table 6. Secondary channel water loss I**

| No | Measurement               | Debit (m³/s) |
|----|----------------------------|--------------|
| 1  | Average initial discharge | 0.268        |
| 2  | Average final discharge   | 0.243        |

The results of measurements of water level on secondary channels are higher than primary channels, this is because the base of the secondary channel is lower than the primary channel.

3.2.2. Percolate

The results of percolation measurements on the Secondary channel I Mayo Swamp Irrigation Network can be seen in Table 7:

**Table 7. Percolation of secondary channels I**

| No | Channel | Decrease in the Infiltrometer Ring | Decrease in Evaporation Pot | Decrease in Percolation |
|----|---------|-----------------------------------|----------------------------|------------------------|
| 1  | S1P1    | 97 mm                             | 3 mm                       | 94 mm                  |
| 2  | S1P2    | 87 mm                             | 3 mm                       | 84 mm                  |
|    | Average decrease in infiltrometer ring |                          |                            | 89 mm                  |
Percolation measurements on sample channels with a length of 500 m are 0.002575 m$^3$/s. Thus, to determine the decrease in percolation in all secondary channels, the area of the base of the channel is multiplied by the number of decreases. It is known that the channel length is 1.876 m and the channel width is 2.5m. So that the loss is 0.0096 m$^3$/s.

3.2.3. Evaporation
For evaporation, field measurements show that the average daily evaporation is 9.9 x 10$^{-8}$ m / s. on the sample channel, the evaporation that occurs is equal to 0.000147 m$^3$/s. With a total channel length of 1,876 m and a width over a channel of 2.97 m, the result of water loss due to evaporation is 0.00055 m$^3$/s. Water loss due to evaporation has very little effect on total water losses reaching 0.025 m$^3$/s.

3.2.4. Permeability
The results of testing in the laboratory, obtained the seepage coefficient of 0.000026 m / s, so that the water loss that occurred in the sample channel was 0.028 m$^3$/s. In all secondary channels with a length of 1,876 m, the seepage results are 0.105 m$^3$/s.

The total number of losses in the sample channel through percolation, evaporation and seepage is 0.0307 m$^3$/s. this value is greater than the measurement through direct discharge which is 0.025.

3.2.5. Total Water Loss
The loss that occurs in the secondary channel whose length is 1,876 m is 0.115 m$^3$/s. This result is the total loss from percolation, evaporation and seepage. thus the final discharge reaching the end of the channel is 0.268 m$^3$/s (initial discharge) - 0.115 (water loss) = 0.153 m$^3$/s. So that efficiency in secondary channel I is:

\[
\text{Effekunder I} = \frac{\text{debit at the end}}{\text{debit at the base}} \times 100\% = 0,153/0,268 \times 100\% = 57,08\%
\]

The efficiency of 57.08% is the efficiency of the secondary channel I. To find out the average efficiency of the secondary channel of the Rawa Mayo irrigation, other secondary channel efficiency data are needed. The results of all secondary channel efficiency are taken as the average value produced and compared to the KP-01 Planning Standard.

3.3. Irrigation Efficiency on Secondary Channels II
3.3.1. Water discharge
Results Measurement of water discharge in secondary channels II can be seen in Table 8 and Table 9.

| Measurement | Measuring point | Water level (m) | Water surface width (m) | Travel time is 15 meters (s) | Flow speed (m / s) | Area of cross section of channel (m2) | Water discharge (m$^3$/s) |
|-------------|----------------|----------------|------------------------|-----------------------------|-------------------|----------------------------------------|--------------------------|
| First       | Early          | 0,28           | 2,43                   | 00:41                       | 0,36              | 0,62                                   | 0,22                     |
|             | End            | 0,20           | 2,23                   | 00:33                       | 0,45              | 0,44                                   | 0,20                     |
| Second      | Early          | 0,26           | 2,41                   | 00:42                       | 0,36              | 0,57                                   | 0,20                     |
|             | End            | 0,19           | 2,23                   | 00:30                       | 0,50              | 0,41                                   | 0,20                     |
3.3.2. Percolate

The results of percolation measurements on the Secondary channel I Mayo Swamp Irrigation Network can be seen in Table 7:

Table 9. Secondary channel water loss I

| No. | Measurement                      | Debit (m³/s) |
|-----|----------------------------------|--------------|
| 1.  | Average initial discharge        | 0.22         |
| 2.  | Average final discharge          | 0.20         |

Table 10. Percolation of secondary channels II

| No. | Channel | Decrease in the Infiltrometer Ring | Decrease in Evaporation Pot | Decrease in Percolation |
|-----|---------|-----------------------------------|----------------------------|-------------------------|
| 1   | S2P1    | 53 mm                             | 3 mm                       | 50 mm                   |
| 2   | S2P2    | 62 mm                             | 3 mm                       | 59 mm                   |
|     | Average decrease in infiltrometer ring |                       |                           | 54.5 mm                 |

Measurements on the sample channel obtained percolation of 0.00126 m³/s. The overall length of the secondary channel II is 2.269 m so that the percolation value is obtained at 0.0057 m³/s.

3.3.3. Evaporation

For evaporation, with a water surface width of 2.328 m and a sample channel length of 500 m, an evaporation value of 0.000115 m³/s is obtained. For evaporation in all secondary channels II, which reaches 2,269 m, the results are 0.00052 m³/s.

3.3.4. Permeability

The results of laboratory testing, obtained the seepage coefficient of 0.000023 m/s. By referring to these results, the results of seepage calculations that occur in the sample channel are 0.021 m³/s. Seepage that occurs in all secondary channels II is 0.096 m³/s.

The amount of water loss from percolation, evaporation and seepage in the sample channel is 0.022 m³/s. the resulting value is higher than the measurement of discharge using a buoy ball as in the secondary channel I. The loss calculated from the measurement of discharge is 0.017 m³/s. so that there is a difference of 0.005 m³/s.

3.3.5. Total Water Loss Secondary Channel II
Secondary channel II through percolation, evaporation and seepage of 2,269 m the amount of water lost is 0.102 m³/s. so the amount of water discharge at the end of the channel is the initial discharge - water loss = 0.22 - 0.102 = 0.118 m³/s. thus the efficiency of the secondary channel II is:

\[
Ef_{\text{sekunder II}} = \frac{\text{debit di jang}}{\text{debit di pangka}} \times 100\% \\
= \frac{0.118}{0.22} \times 100\% \\
= 53.63\% 
\]

From the results of the calculation of secondary channel I and secondary channel II, the average efficiency of 55.35% is obtained. This efficiency is still below the standard [3] where the standard set is 90% for secondary channels. However, in the existing provisions [4] only the average / combined efficiency of the primary, secondary and tertiary channels is listed.

Low efficiency is closely related to the wall and the base of the channel made of soil / not permanent. Based on the results of soil physical analysis in the Laboratory of Chemical and Soil Fertility of Sebelas Maret University, the percentage of sand was 39.52%, Dust was 44.63% and clay was 15.84%, so the class of texture of the soil was sandy clay (Sandy Loam). The high percentage of sand and dust results in easier water escaping. The clay fraction which is actually needed as a waterproof material is actually low in number, which is 15.84%. This is the main cause of water loss.

[1] Sandy soil, namely soil with a content of 70% sand, low porosity (<40%), most large pore spaces so that aeration is good, water conductivity is fast, but the ability to store water and nutrients is low. Soil is called clay textured if the clay content is> 35%, the porosity is relatively high (60%), but most are small pores. As a result the conductivity of water is very slow and the air circulation is not smooth. The ability to store water and nutrients in tall plants.

3.4. Mayo Swamp Irrigation Network Efficiency

From the results of measurements in the field, the values for each channel are shown in table 11:

| Channel   | Debit Base | Debit Edge | Water Loss | Efficiency |
|-----------|------------|------------|------------|------------|
| Primary   | 0.292      | 0.25       | 0.042      | 85.62%     |
| Secondary | 0.244      | 0.135      | 0.109      | 55.35%     |

Irrigation efficiency is obtained by multiplying between efficiency in the primary, secondary and tertiary channels. But in this study tertiary channels cannot be measured because the channels are not used. So the efficiency results obtained are

Mayo Swamp Efficiency = primary efficiency x secondary efficiency average

Efficiency of Swamp Mayo = (85.62% x 55.35%) x 100% = 47.39%
This is in accordance with the existing guidelines [4], which states that the overall efficiency for semi-technical irrigation networks is 40% - 50%, so that the Rawa Mayo Irrigation Efficiency of 47.39% still meets these criteria.

4. Conclusions
Based on the results of research and discussion can be concluded:

- Irrigation efficiency in the primary channel is 85.62%. With an average initial discharge of 0.292 m³/s, the final discharge is 0.25 m³/s and water loss is 0.042 m³/s.

- Irrigation efficiency in the secondary channel I was 57.08%. With an average initial discharge of 0.268 m³/s, the final discharge is 0.153 m³/s, and water loss is 0.115 m³/s.

- Irrigation efficiency in secondary channel II was 53.63%. With an initial discharge of 0.22 m³/s, the final discharge is 0.118 m³/s, and water loss is 0.102 m³/s.

- Irrigation Efficiency in the Rawa Mayo Irrigation is 46.39% and still meets the KP-01 Irrigation Planning Standards (2013).

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