

## Analysis of Discharge and Efficiency of Irrigation of Primary Canal of Aik Bual Reservoir, Central Lombok Regency

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### ARTICLE INFO

*Keywords:* Flow Rate, Canal Efficiency, Irrigation, Manning Method, Water Loss

*Received :* 10 February

*Revised :* 15 March

*Accepted:* 30 April

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### ABSTRACT

This study aimed to evaluate the flow rate and effectiveness of the main canal in the Aik Bual Reservoir as part of the irrigation network supporting agricultural activities. The method used in this study was a quantitative approach with hydraulic analysis using the Manning equation. The data obtained included the canal cross-sectional dimensions, canal bed slope, roughness coefficient, and discharge measurements at upstream and downstream points. This data was then processed to determine the flow capacity and water distribution efficiency. The analysis results indicated that the flow rate calculated using the Manning method was 1.20 m<sup>3</sup>/s. Meanwhile, field measurements showed a decrease in discharge from upstream to downstream, with the discharge recorded at 0.96 m<sup>3</sup>/s. This represents a water loss of 0.24 m<sup>3</sup>/s during the distribution process. These results indicate a canal efficiency of 80%, which is considered good according to irrigation canal efficiency standards, which range from 70% to 90%. Estimated water loss is caused by several factors, such as leaks in the canal walls and bottom, sedimentation that reduces the cross-sectional capacity, and the growth of weeds that obstruct water flow. Furthermore, the physical condition of the canal, which is not yet fully watertight, also affects distribution efficiency

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## **INTRODUCTION**

Water availability for irrigation purposes is a crucial element in the successful operation of an irrigation area. Even if the water supply is adequate, if its distribution is not properly managed, the water will not be able to cover the entire designated area. Decreased effectiveness can occur due to poor irrigation network management, which in turn increases water loss through seepage, percolation, and inappropriate distribution arrangements. Irrigation channel performance can be evaluated based on water flow efficiency, uniformity, and adequacy of water supply. Furthermore, the condition and characteristics of the network are also important indicators in assessing irrigation channel performance. This study aims to analyze water flow and efficiency in the main canal of the Aik Bual Reservoir.

The irrigation network includes channels, structures, and additional facilities that form a system for providing, dividing, distributing, using, and managing irrigation water discharge. Operationally, this network is divided into three categories: primary, secondary, and tertiary irrigation (based on Government Regulation Number 20 of 2006).

Of these three types of networks, tertiary irrigation networks play a direct role in providing irrigation water services to rice fields. These include tertiary canals, quarter canals, and drainage canals, as well as tertiary and quarter canals, and other supporting structures (Nusa Tenggara River Basin Center, 2021).

Irrigation canals are a crucial element in water resource management, particularly in agricultural areas that rely on surface water availability. The presence of reservoirs (*embung*) as water reservoirs plays a crucial role in ensuring a continuous water supply, particularly during the dry season. The Aik Bual Reservoir is one of the water infrastructures in Lombok that plays a key role in meeting agricultural irrigation needs. However, optimal water use depends heavily on the performance of the main canal that carries water from the reservoir to the agricultural fields (Triatmodjo, 2010).

Flow rate in main canals is a crucial parameter for assessing irrigation system performance. Insufficient flow rate can result in water shortages or excesses on agricultural land and can impact crop productivity. Generally, flow rate calculations are performed using hydraulic methods such as the Manning or Chezy equations, which take into account cross-sectional conditions, channel roughness, and channel bed slope (Chow, 1959). Therefore, accurate flow rate analysis is essential to understand the channel's ability to optimally deliver water.

In addition to flow rate, channel efficiency is also an important indicator for assessing irrigation system performance. Channel efficiency reflects the ratio between the amount of water entering and the amount reaching the service point. Water loss can occur due to leaks, seepage, evaporation, or poor physical condition of the channel. According to Mays (2011), low channel efficiency indicates inefficiencies in the water distribution system that need immediate improvement to improve overall irrigation performance.

Frequent problems in main canals, including those in the Aik Bual Reservoir, include sedimentation, structural damage, and weed growth that can

obstruct water flow. This situation leads to decreased flow capacity and increased water loss along the canal. Previous research has shown that inadequate canal maintenance can result in efficiency falling below the established standard, which is around 70–80% for the main canal (Directorate General of Water Resources, 2013).

Considering these conditions, in-depth research is needed to analyze the flow rate and efficiency of the main canal in the Aik Bual Reservoir. The results of this study are expected to provide a realistic picture of the canal's performance and serve as a basis for planning rehabilitation and more efficient irrigation management. Furthermore, this research can also serve as a reference for developing irrigation systems in other areas with similar characteristics.

## LITERATURE REVIEW

### The Concept of Discharge Flow in Open Channels

Discharge flow is the amount of water flowing through a channel area over a specific period of time. In open channel hydraulic studies, discharge is the primary factor in determining the channel's capacity to meet irrigation needs. In general, discharge can be formulated as follows:

$$Q = A \times V$$

Where  $Q$  is the discharge ( $\text{m}^3/\text{second}$ ),  $A$  is the flow area ( $\text{m}^2$ ), and  $V$  is the flow velocity ( $\text{m}/\text{second}$ ). The determination of flow velocity is greatly influenced by the physical conditions of the channel, such as bed slope, surface roughness, and cross-sectional shape (Chow, 1959).

### Discharge Equation Using the Manning Method

One method widely used to calculate discharge in open channels is the Manning equation. This method is used to determine flow velocity based on channel characteristics:

$$V = \frac{1}{n} \times R^{2/3} \times I^{1/2}$$

Therefore, the discharge can be written as:

$$Q = \frac{1}{n} \times A \times R^{2/3} \times I^{1/2}$$

Where  $n$  is the roughness coefficient according to Manning,  $R$  is the hydraulic radius (m), and  $S$  is the channel bed slope. The value of  $n$  is greatly influenced by the channel material, for example, soil, block stone, or concrete (Chow, 1959; Triatmodjo, 2010).

### Water Requirements and Irrigation Planned Flow Rate

The planned flow rate for an irrigation channel is determined by the water requirements of the crops, the area irrigated, and the efficiency of the system itself. Water requirements are influenced by evaporation and transpiration, the type of crop grown, and weather conditions. When designing irrigation, the planned flow rate must be able to meet the highest demand to avoid water shortages during critical periods of crop growth (Directorate General of Water Resources, 2013).

### **Irrigation Channel Efficiency Concept**

Irrigation channel efficiency indicates the ratio between the amount of water reaching its destination and the amount of water flowing from its source. Mathematically, channel efficiency can be expressed as:

$$Efisiensi = \frac{Q_{out}}{Q_{in}} \times 100 \%$$

where  $Q_{in}$  is the incoming flow rate and  $Q_{out}$  is the flow rate arriving at the service point. This efficiency reflects the level of water loss within the channel system (Mays, 2011).

### **Water Loss in Canals**

Water loss in irrigation canals can be influenced by various factors, including:

- Seepage caused by soil conditions or canal structure
- Evaporation from the water surface
- Leaks in the canal structure
- Overgrowth of wild vegetation and sedimentation that disrupt flow

This water loss can reduce the available flow downstream and reduce the overall efficiency of the system. Generally, earthen canals have higher water losses than concrete canals (Mays, 2011; Triatmodjo, 2010).

### **Irrigation Canal Efficiency Standards**

Based on irrigation planning guidelines, primary canal efficiency typically ranges from 70% to 90%, depending on the condition of the canal's construction and maintenance. Lined canals (concrete or masonry) generally have better efficiency than earthen canals. Assessing this efficiency is crucial to determine whether the irrigation system is still functioning optimally or requires rehabilitation (Directorate General of Water Resources, 2013).

## **METHODOLOGY**

### **Research Type**

This study is a quantitative descriptive study aimed at assessing the water flow and efficiency of the main canal using field data and hydraulic calculations. The method chosen is mathematical analysis using hydraulic formulas for open channels.

### **Research Location and Duration**

This research will be conducted in the Aik Bual Main Canal, located in Central Lombok Regency.

The research duration is planned to last approximately 2 to 3 months and includes: Data collection from the field, data processing and analysis, and report preparation

### **Data Types and Sources**

#### **1. Primary Data**

Data obtained directly from field measurements:

- Channel width and depth
- Flow velocity (using a flow meter or float method)
- Channel bed slope
- Channel physical condition (material, damage, and vegetation)

## 2. Additional Data

Data obtained from relevant institutions:

- Irrigation discharge plan data
- Irrigation system maps
- Information on land area and water requirements
- References and standards for irrigation planning

## Data Collection Methods

The approaches used in this research include:

- Direct observation → measuring the size and condition of the channel
- Flow measurement → using a float or flow meter
- Documentation → photographing the channel condition
- Literature review → references on hydraulics and irrigation systems

## Data Analysis Methods

### 1. Flow Discharge Analysis

Discharge is calculated using the basic formula:

$$V = \frac{1}{n} \times R^{2/3} \times I^{1/2}$$

and/or Manning's formula:

$$Q = \frac{1}{n} \times A \times R^{2/3} \times I^{1/2}$$

Analysis Stages:

- Calculate the cross-sectional area (A)
- Determine the hydraulic radius (R)
- Determine the channel slope (S)
- Determine the roughness coefficient (n)
- Calculate the flow rate (Q)

### 2. Channel Efficiency Evaluation

Efficiency is determined using the following formula:

$$Efisiensi = 1 + \frac{Q_{out}}{Q_{in}} \times 100 \%$$

Analysis steps:

- Measure upstream flow (Q\_in)
- Measure downstream flow (Q\_out)
- Calculate water loss
- Determine channel efficiency

### 3. Water Loss Evaluation

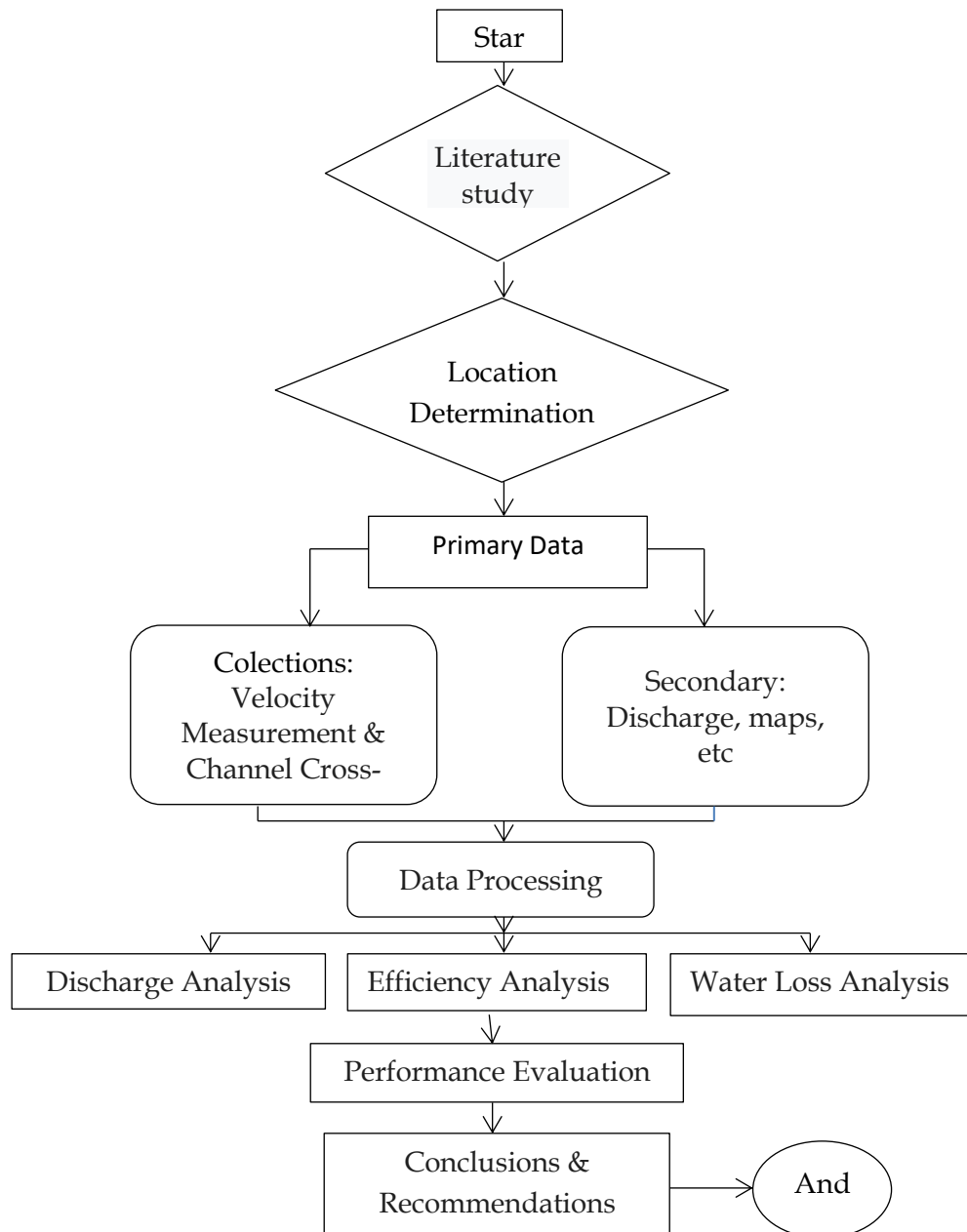
Water loss is obtained from the difference in flow:

Next, the causes are analyzed:

- Leakage
- Evaporation
- Leakage
- Sedimentation and vegetation

### Research Flowchart

Below is a research flowchart that can be applied:



### RESEARCH RESULT

#### Channel Calculation Data

Given:

Upper width  $b_1 = 3.3$  m

Lower width  $b_2 = 1.5$  m

Water depth  $h = 0.60$  m

Bed slope  $S = 0.0015$

Manning's coefficient  $n = 0.025$  (stone masonry)

Hydraulic Parameter Calculation

Cross-Cross Area (A)

$$\begin{aligned} A &= \frac{(b_1 + b_2)}{2} \times h \\ &= \frac{(3.3 + 1.5)}{2} \times 0.60 \\ &= 1.44 \text{ m}^2 \end{aligned}$$

Eave slope (m)

$$\begin{aligned} m &= \frac{b_1 + b_2}{2h} \\ &= \frac{3.3 + 1.5}{2 \times 0.60} \\ &= \frac{4.8}{1.2} = 1.5 \end{aligned}$$

Wetted perimeter (P)

$$\begin{aligned} P &= b_2 + 2h \sqrt{1 + m^2} \\ &= 1.5 + 2 \times 0.60 \sqrt{1 + 1.5^2} \\ &= 3.66 \text{ m} \end{aligned}$$

Hydraulic radius (R)

$$R = \frac{A}{P} = \frac{1.44}{3.66} = 0.393 \text{ m}$$

### **Manning's Discharge Calculation**

Manning's formula:

$$\begin{aligned} Q &= \frac{1}{n} \times A \times R^{2/3} \times I^{1/2} \\ &= \frac{1}{0.025} \times 1.44 \times (0.393)^{2/3} \times (0.0015)^{1/2} \\ &= 40 \times 1.44 \times 0.537 \times 0.0387 \\ &= 120 \text{ m}^3 / dt \end{aligned}$$

### Analysis of Aik Bual Primary Channel Efficiency

Field measurements obtained:

Upstream discharge  $Q_{in} = 1.20 \text{ m}^3/\text{sec}$

Downstream discharge  $Q_{out} = 0.96 \text{ m}^3/\text{sec}$

The efficiency is obtained as follows:

$$\begin{aligned}\text{Efficiency} &= \frac{Q_{out}}{Q_{in}} \times 100 \% \\ &= \frac{0.96}{1.20} \times 100 \% \\ &= 80 \%\end{aligned}$$

Therefore, the water loss in the primary channel is:

$$\begin{aligned}\text{Loss} &= Q_{in} - Q_{out} \\ &= 1.20 - 0.96 = 0,24 \text{ m}^3/\text{det}\end{aligned}$$

### DISCUSSION

The study results show that the flow calculated using the Manning method is higher than actual field conditions. This indicates that theoretically, the canal has a large enough capacity, but in reality, performance decreases due to physical and operational factors.

The canal efficiency of 80% indicates that the irrigation system is still functioning well, but not optimally. In a perfect irrigation system, the higher the efficiency, the less water loss will occur. A loss of  $0.24 \text{ m}^3/\text{s}$  is quite significant, especially considering the water requirements for large agricultural areas.

If this situation is allowed to persist, in the long term it can cause:

- Reduced water availability in downstream areas
- Imbalance in water distribution between agricultural areas
- Decreased agricultural yields

### CONCLUSIONS AND RECOMMENDATIONS

#### Conclusions

Based on the flow and efficiency analysis of the Aik Bual Reservoir main channel, it can be concluded that:

- The flow rate calculated using the Manning method was  $1.20 \text{ m}^3/\text{s}$ , indicating that the channel is capable of delivering water according to irrigation needs.
- The channel efficiency was recorded at 80%, which is categorized as good according to irrigation channel efficiency standards (70–90%).
- Water loss was recorded at  $0.24 \text{ m}^3/\text{s}$ , indicating that there are still inefficiencies in the water distribution system.
- The main factors causing water loss include leaks in the channel walls, sedimentation, and the growth of weeds that obstruct the flow.
- Overall, the main channel remains operable, but requires maintenance improvements to achieve higher efficiency levels.

### Recommendations

- Repairing canal linings to reduce seepage (e.g., plastering or concreting)
- Periodically cleaning sediment to maintain cross-sectional capacity
- Regularly monitoring discharge at upstream and downstream points
- Developing a water distribution schedule (rotation) for more equitable distribution
- Improving coordination between irrigation officers and farmers

### ADVANCED RESEARCH

Based on the analysis and discussions, several recommended steps are as follows:

- Conduct further research with more observation points (multi-segment).
- Use more accurate discharge measuring instruments (current meters/digital sensors).
- Develop hydraulic models (HEC-RAS or other software) for more detailed analysis.
- Examine the relationship between canal efficiency and agricultural productivity.

### ACKNOWLEDGMENT

Thank you to all parties, especially the relevant agencies and Aik Bual village government officials who have assisted in research and data collection.

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