DEVOTION
Journal of Research and Community Service
Volume 6, Number 8, August 2025
e-ISSN: 2797-6068 and p-ISSN: 2777-0915

Analysis of Irrigation Network and Operational Real Needs (AKNOP) at Cirongkob Dam

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KEYWORDS
AKNOP, Cirongkob Weir, Irrigation, network maintenance, water distribution efficiency.

ABSTRACT
Irrigation network maintenance plays a strategic role in ensuring efficient and sustainable water distribution to support agricultural productivity. This research aims to analyze the condition of the irrigation network and calculate the Actual Operation and Maintenance Needs (AKNOP) at the Cirongkob Weir in Kuningan Regency, West Java. The research method uses a quantitative and qualitative approach through field observations, water discharge measurements, evaluation of irrigation channels and structures, and calculation of maintenance costs based on the technical guidelines of the Ministry of Public Works and Housing (PUPR). The analysis results show that the irrigation channels are generally functional, although light to moderate damage was found that affects water distribution efficiency. AKNOP calculations indicate that most of the budget is allocated to rehabilitation and contractual maintenance activities. Efforts to improve irrigation efficiency should focus on optimizing routine maintenance, strengthening farmers' institutions (P3A), and implementing water discharge monitoring. Through these strategies, the sustainability of the irrigation system and food security in the Cirongkob area can be maintained. The implications of this research provide empirical foundations for evidence-based irrigation management policies, contribute to the development of standardized AKNOP calculation methodologies for similar irrigation systems across Indonesia, and offer practical guidelines for optimizing budget allocation in irrigation infrastructure maintenance.

INTRODUCTION

Irrigation networks have an important role in supporting agricultural productivity by ensuring optimal water distribution to agricultural land, where efficiency and reliability of irrigation infrastructure are directly linked to crop yields (Junaidi et al., 2019). One of the main elements in this system is the weirs, which serve to regulate the flow of water and channel it to irrigation canals, playing a strategic role in sustainable water management (Kumar et al., 2020). However, common problems often arise, including infrastructure damage due to sedimentation, which reduces channel capacity and affects water delivery performance (Shrestha et al., 2018). The growth of wild plants in irrigation channels further exacerbates the problem by obstructing water flow and increasing maintenance burdens (Rashid et al., 2021). In addition, the lack of regular maintenance and monitoring weakens the functionality of irrigation networks, leading to inefficient water distribution and lower agricultural productivity (Fitriani & Wulandari, 2022).

Maintenance of irrigation networks is essential in the management of water resources for agriculture, as poor maintenance can lead to water losses and reduced system efficiency (Mdemu et al., 2017). A well-maintained irrigation network ensures smooth water distribution to farmland, increases crop productivity, and maintains the sustainability of the irrigation system (Rahman et al., 2020). One of the main elements in this system is the weirs, which serve to regulate the flow of water and channel it to irrigation canals, thereby optimizing water allocation and preventing conflicts among users (Pandey et al., 2021). Studies show that regular maintenance of weirs and canals significantly reduces sedimentation and enhances water delivery performance (Bossa et al., 2019). Furthermore, integrating community participation into irrigation maintenance activities has been proven effective in ensuring long-term sustainability (Wijayanti et al., 2021). Recent innovations, such as the use of GIS and remote sensing, also provide valuable tools to monitor irrigation networks and identify maintenance needs more accurately (Hasan et al., 2022). Therefore, the maintenance of weirs and irrigation networks greatly affects the overall performance of the irrigation system, ensuring both efficiency and resilience against environmental challenges (Mohan et al., 2020).

Maintenance activities include clearing channels from sedimentation and wild vegetation, repairing the physical structure of channels and dams, and repairing sluices and other supporting buildings (Tadda et al., 2020). If not done regularly and effectively, the irrigation network can be damaged, causing disruption of water distribution and reduced agricultural yields. For example, research conducted by Nanda et al. (2024) on the Pacal Irrigation Network identified that 18.11% of minor damage occurred along channels and buildings. This finding emphasizes the importance of periodic maintenance to ensure the efficiency and sustainability of the irrigation system.

Maintenance of irrigation networks includes a variety of activities, such as clearing channels of silt deposits and wild vegetation, repairing the structure of channels and weirs, and dealing with damage to sluices and other supporting buildings. If not done regularly and effectively, irrigation networks can be damaged, which can disrupt water distribution and reduce agricultural yields. Research conducted by Rahmadani et al. (2024) identified that damage to irrigation networks can hinder efficient water distribution, emphasizing the importance of periodic maintenance to ensure the efficiency and sustainability of irrigation systems.

In addition to physical maintenance, the evaluation of the Operation and Maintenance Real Needs Score (AKNOP) is a crucial aspect in irrigation management. AKNOP is used to identify real needs in the operation and maintenance of irrigation networks based on the actual condition of the infrastructure. Accurate calculation of AKNOP is essential in budget planning and resource allocation so that maintenance can be carried out effectively.

This research aims to investigate the existing physical conditions of the Cirongkop Dam irrigation network across its primary, secondary, and tertiary channels; identify the primary issues affecting the effectiveness of its operation and maintenance (O&P); determine the Operation and Maintenance Actual Requirement (AKNOP) needed to sustain the network's functionality; and provide recommendations for O&P planning based on AKNOP calculations to enhance the efficiency and sustainability of the irrigation system.

METHOD

This study employed a qualitative method with descriptive-inductive characteristics, aiming to provide a detailed explanation of the collected data through an inductive approach based on field observations and empirical findings.

The analysis methods used included potential discharge analysis, which estimated available water discharge based on watershed area and rainfall data over a specified period. Annual rainfall data from stations within the watershed were utilized; for example, 20 years of semi-monthly rainfall data (1999–2018) were applied for the Mejagong Dam Irrigation Area. The flagship discharge, representing the minimum reliable discharge, was determined by sorting this data and applying an 80% reliability formula. Physical condition analysis assessed the structural integrity of irrigation infrastructure, including primary structures, subdivisions, canals, drainage, and wastewater systems, to evaluate overall system performance.

Additionally, irrigation water demand was analyzed, taking into account evapotranspiration, percolation losses, crop-specific needs, and natural water contributions from rainfall and groundwater. Institutional and human resource analyses examined management capabilities, while AKNOP analysis (Operation and Maintenance Real Needs Figures) evaluated the operational and maintenance requirements of the irrigation system. These combined methods provided a comprehensive understanding of the irrigation network's performance, supporting effective water management and infrastructure sustainability.

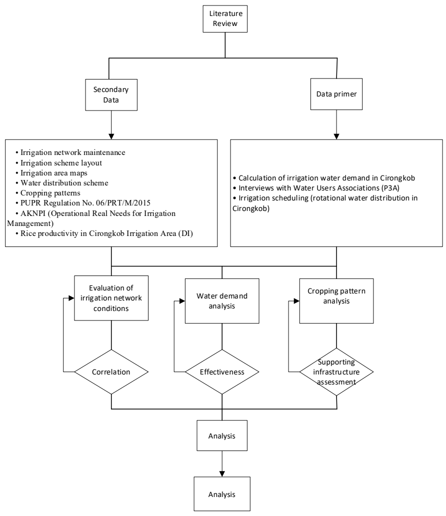

Figure 1. Research Flowchart Thinking Framewor

RESULT AND DISCUSSION

Irrigation Network Conditions

The condition of the Cirongkob Dam irrigation network based on the results of field surveys shows that most of the infrastructure is still functioning well but requires periodic maintenance. The damage found was classified into three levels, namely mild, moderate, and no damage. In general, minor damage predominates, such as cracks in rock pairs and leaks in the left and right main canals. In the main building of the Cirongkob Dam, a minor leak was found at the drain/drain gate that needed to be repaired immediately so as not to interfere with the water distribution. The left channel suffered minor to moderate damage, especially in sections 3–4 which lost the regulating door leaf. Meanwhile, the right channel showed similar damage, with some segments experiencing cracks and leaks and loss of regulating components. Assessment of channel profiles, channel efficiency, and sediment and erosion provides a comprehensive picture of the condition of the irrigation network. The efficiency value of the channel is in the category of moderate damage, caused by illegal tapping and leakage. However, in terms of sediment and erosion, conditions are still very good.

The Cirongkob Kiri Main Channel also showed positive evaluation results, with a high final performance value. No severe damage was found, and most of the channel segments are still in the good category. The efficiency of the water flow exceeded the ideal standard, which was above 90%, and there were no significant deposits that interfered with the capacity of the channel. Overall, the condition of the Cirongkob Dam irrigation network still supports the sustainability of water distribution to agricultural land. However, regular light to moderate maintenance and rehabilitation measures are required, especially on regulating components such as sluice gates and stone pairs, to keep the system functioning optimally throughout the growing season.

Table 1. The Cirongkob Kiri Main Channel

Structure Name	Segment	Type of Damage	Damage Level
Cirongkob Weir	-	Leakage at drain gate	Minor
Left Canal	1 – 2	Cracked stone lining and leakage	Minor
Left Canal	2 – 3	Cracks and leakage	Minor
Left Canal	3 – 4	Leakage, cracked stone lining, and missing sluice leaf	Moderate
Left Canal	4 – 5	Good condition	-
Left Canal	5 – 6	Control gate not functioning properly	Minor
Right Main Canal	1a – 1b	Cracked stone lining	Minor
Right Main Canal	1b – 1	Leakage	Minor
Right Main Canal	1 – 2	Missing control gate leaf	Moderate
Right Main Canal	2 – 3	Leakage	Minor
Right Main Canal	3 – 4	Damaged stone lining and leakage	Moderate
Right Main Canal	4 – 5	Good condition	-

Source: Field Documentation Physical Condition Analysis Table of Cirongkob Dam Building

The survey results showed that most of the damage was minor and only a few points suffered moderate damage, especially on the regulating elements such as doors and stone pairs. This damage has the potential to degrade the function of the irrigation system so that it requires gradual maintenance. Channel Condition Indicator Recapitulation Channel Profile: Value 70.61 (slightly damaged) – some geometry changes reduce capacity.

Channel Efficiency: Value 60.64 (moderately damaged) – leakage and illegal tapping lowers efficiency to 60–70%.

Sediment & Erosion: Value 86.37 (good) – sediment <10 % capacity.

A total score of 126.67 puts the general condition of the channel in the range quite well, but requires maintenance to address leaks and illegal tapping.

Irrigation Water Conditions

Water analysis is carried out based on data on planting area, water needs, mainstay discharge (Q80%), and irrigation network efficiency.

1. Water Demand in Rice Fields (L/sec): The highest demand occurred in MT I (Jan- Mar), which was up to 168.81 L/sec. In MT II and MT III, demand decreased to only 14.25 L/s in December. This value is the result of calculating water needs based on the planting area and the unit of water needs of each type of plant.
2. Water Requirements at Tertiary Gates: Taking into account tertiary efficiency, water requirements increase to between 73.50 – 202.58 L/sec, depending on the growing season. There is no allocation of water for other activities outside of rice field irrigation.
3. Water Loss in the Main Network: It is assumed that water loss is between 9.19 – 25.32 L/s in months with high demand, and decreases to 2.14 L/s in dry months. This loss is due to leaks and illegal tapping.
4. Total Water Demand in Bendung: Is the sum of tertiary gate needs and network loss. Its value ranges from 82.69 – 227.90 L/sec, with its peak in February.
5. Mainstay Discharge (Q80%): A Q80% discharge indicates water availability that varies from 0.31 m^3/s to 987.40 m^3/sec. The highest discharge occurred in May, while the lowest was in October- November.
6. Water Balance (Surplus/Deficit): The highest surplus occurred in May (+794.59 L/sec), while the worst deficit was in October (−44.23 L/sec). This balance is calculated from the difference between the mainstay discharge and the total water requirement.
7. Reliability (%): The ratio between mainstay discharge and water demand showed the highest reliability in May (512.10%) and the lowest in November (63.78%). A value of <100% indicates a water deficit.

Example of Q80% Calculation (Interpolation): If the 14-year annual discharge sequence data:
$Q_{80}\% = n \times 0.8 = 14 \times 0.8 = 11.2 \rightarrow Q80\%$

between the 11th and 12th data. Example:

$Q11 = 0.295\ m^3/sec$

$Q12 = 0.244\ m^3/sec$

Interpolation: $Q80\% = 0.295 + (11.2-11)/(12-11) \times (0.244 - 0.295) = 0.289\ m^3/det$

These results are used as a basis in the calculation of the need and reliability of irrigation systems.

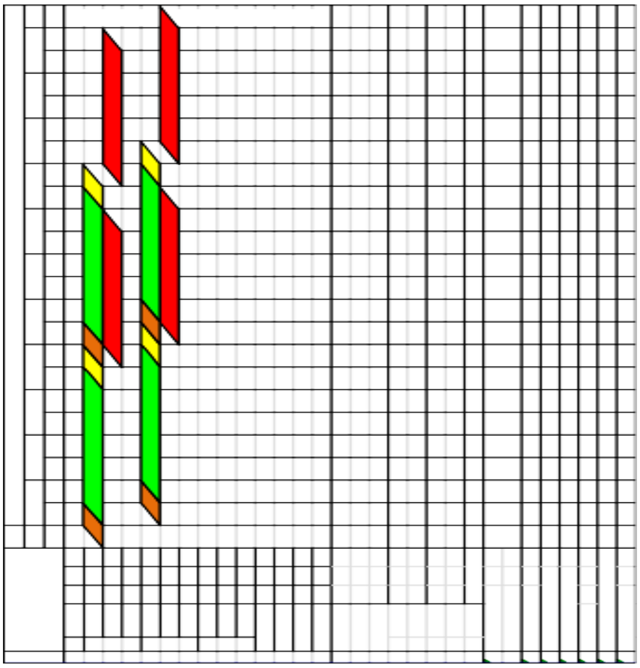

Figure 2. the calculation of the need and reliability of irrigation systems
Source : SATPEL CISUBA

This graph shows that the irrigation system is quite reliable in the rainy season (MT I) and inadequate in the dry season (MT III). Efficient water management is required, including:

a. Storing water in surplus (e.g. with reservoirs or reservoirs).
b. Set the planting schedule so that it does not accumulate during the low discharge period.
c. Reduce planting area in months with high potential water deficits (August– November).
d. Figure 3. Debit Comparison Chart

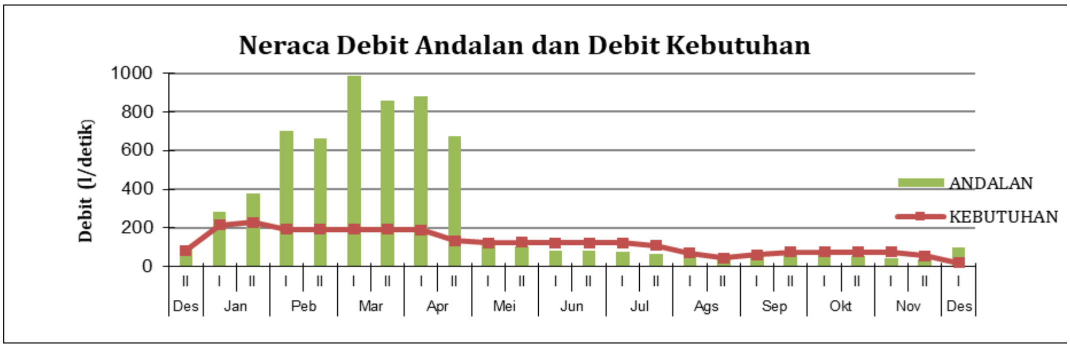

Figure 3. Graph of mainstay discharge and discharge needs
Source: SATPEL CISUBA

Analysis of Factors affecting Operation and Maintenance Effectiveness

1. Technical Factors (Design, damage, water availability)

Technical factors are one of the crucial aspects in the implementation of O&P. on the Cirongkob Dam, some of the technical problems found include:

a. Light to moderate damage to some tapping buildings and sluices.

b. Channel leakage at some point that causes water loss.
c. Sedimentation and narrowing of channels, which inhibit the optimal flow of water.
d. The design of the channel has not been adapted to the current topography and dynamic planting patterns.
e. Fluctuations in water discharge, especially in the dry season, affect the stability of water distribution.

2. Institutional Factors (OP Officers, P3A/GP3A)

   Irrigation management institutions play an important role in ensuring the smooth running of O&P. At the research site, the institutions consist of:

   a. The Regional Technical Implementation Unit (UPTD) is tasked with supervising the irrigation network.
   b. Weir Operations Officer (POB), Mantri, and Water Gate Officer (PPA) who are responsible for discharge arrangements and maintenance implementation.
   c. The Water User Farmers Association (P3A) and the P3A Association (GP3A) as the field level implementer.

3. Socio-Economic Factors (farmer participation, contribution costs)

   Community participation, especially farmers as the main users of irrigation water, is still relatively low. Problems identified include:

   a. Lack of cost and labor contribution from farmers in O&P activities.
   b. Lack of awareness of the importance of regular maintenance for irrigation sustainability.
   c. Dependence on the government in terms of financing and technical management.

AKNOP Analysis

The calculation of AKNOP refers to the AKNOP Basic Knowledge module, which divides the needs into three parts: AKNOP weirs, channels and buildings, and motion weirs. The weir knob covers sluice gate operation, cleaning, and light maintenance. The channel AKNOP is calculated based on the results of the inventory and the actual physical condition of the channel, while the motion weir AKNOP is adjusted to the special technical of this type of weigh.

Table 2. Condition of Cirongkob Dam Management Personnel

Position	Required	Civil Servant (PNS)	Non-Civil Servant	Total Available	Shortage
Observer / UPTD / Head of SUP	1	1	0	1	0
Ranting Staff / UPTD / SUP	1	0	1	1	0
Field Operator / Technician (Mantri/Juru)	1	1	0	1	0
Dam Operation Officer (POB)	1	0	1	1	0
Gatekeeper (PPA)	2	0	2	2	0

Source : SATPEL CISUBA

An analysis of organizational and personnel structure involves an assessment of the number and competence of officers involved in irrigation management, including observers, clerks, and support staff. The availability of adequate human resources is essential to guarantee smooth operation and maintenance.

Table 3. 0.1 OP's condition

Component	Actual (%)	Max (%)	Min (%)	Optimum (%)
Physical Infrastructure	23.23	45	25	35
Crop Productivity	12.01	15	10	12.5
Supporting Facilities	7.33	10	5	7.5
Organizational Personnel	10.17	15	7.5	10
Documentation	4.23	5	2.5	5
Water Users Association (P3A)	3.35	10	5	7.5
TOTAL	**60.32**	**100**	**55**	**77.5**

Source : SATPEL CISUBA office data

The index of the operating conditions and maintenance of the irrigation network showed a total score of 60.32%. This value indicates that the network condition is in the category of being quite good, although it is not optimal. Dominant components such as physical infrastructure and personnel organization are performing adequately, but improvements are still needed in the P3A role and system documentation.

Table 4. Irrigation Management Real Needs Figures (AKNPI)

NO	Irrigation Area/Office Object	OPERATION	MAINTENANCE	REHABILITATION	SUPPORTING MNT of IRRI.	SUPPORTING ORGANIZATION	WATER USE IMPROVE (P3A)	TOTAL
			SELF-MAINTAINED	CONTRACTUAL				
			Routine	Periodic				
1	D.I. Ciromper	439,537,965	548,266,005	328,496,878	1,379,611,965	1,230,626,160	35,500,000	35,510,000

Source : SATPEL CISUBA office data

The total budget of AKNOP for the Cirongkob Dam reached IDR 3,644,409,115, with the largest allocation for contractual maintenance (IDR 1.28 billion) and rehabilitation (IDR 1.23 billion). Direct operational costs reach IDR 429 million, while routine and periodic self-management maintenance is around IDR 337 million. Funds for farmer empowerment, coaching, and disaster reserves are also allocated to support institutional strengthening and preparedness.

Realization of Planting Time

Table 5. Planting realization table

Month	**Rice (ha)**		**Secondary Crops (ha)**			**Sugarcane (ha)**	**Others**	**Total Planted Area (ha)**	**Fallow**
	Rainy Season	Dry Season (Licensed)	Dry Season (Unlicensed)	MT.1	MT.2	MT.3			
1	0	0	167				157		30
2	30							30	157
3	68							68	129

4	82							82	115
5	197							197	
6	197							197	
7	197							197	
8	197							197	
9	187	10						197	
10		53	95		49			197	
11		53	95		49			197	
12		53	95		49			197	
13		53	95		49			197	
14		53	95		49			197	
15		51	95	2	49			197	
16				3		194			197
17				3		194			197
18				3		194			197
19				3		194			197
20				3		194			197
21				3		194			197
22				3		194			197
Peak Planting Area (ha)	197	53	95	167	0	49	194	0	0
Planting Intensity Season 2 MT (**)	100%	27%	48%	85%	0%	25%	98%	0%	0%

Source : SATPEL CISUBA office data

The Cirongkob Dam has an intensive agricultural system with a three-season planting pattern (MT.1, MT.2, MT.3), dominated by rice, palawija, and sugarcane. The planting intensity reached 250%, indicating optimal land utilization. Rice dominates the rainy season, while palawija and sugarcane are planted in the following season. Bero fields appear in a few months as part of crop rotation. This system requires good irrigation to maintain productivity.

Strategic Recommendations for Planning and Management of Irrigation Network O&P

1. Technical Strategy Focus on identifying and handling structural damage to pipelines, maintenance of sluices, and installation of discharge measuring devices at strategic points to support technical decision-making.
2. Institutional Strategy Strengthening the role of P3A and UPTD through training, improving planting schedule coordination, and involvement of farmers in O&P performance evaluation.
3. Funding Strategy Optimization of O&P funds at priority scale, cost- sharing models between the government and farmers, and labor- intensive irrigation programs to support local workforces.
4. Sustainable Management Model An integrated regional model that involves all stakeholders, equipped with a periodic evaluation system and digitization of irrigation information for efficiency and accuracy of long- term management.

CONCLUSION

This research analyzed the condition of the irrigation network and calculated the Operation and Maintenance Real Needs (AKNOP) at the Cirongkob Dam in Kuningan Regency. The findings revealed that the irrigation infrastructure was generally in good condition, with mostly light to moderate damage that did not significantly disrupt water distribution. Water demand based on annual planting patterns was generally met during the rainy season, but deficits occurred in dry months such as October and November. The total AKNOP requirement was estimated at IDR 3.64 billion, primarily allocated for contractual maintenance and channel rehabilitation. Although operation and maintenance management were effective to some extent, improvements were needed, particularly in institutional capacity and participatory funding strategies. Future research could focus on developing integrated water management approaches that address seasonal water deficits and enhance stakeholder participation in maintenance funding to improve system sustainability.

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