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Performance Evaluation of Secondary Irrigation Channels in Leuwi Urug Irrigation Area, Purwakarta Regency

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ABSTRACT

This study analyzes the performance of the secondary irrigation channels in the Leuwi Urug Irrigation Area, Purwakarta Regency, West Java. The region plays a significant role in rice production and relies heavily on efficient irrigation. However, observed issues include poor infrastructure, water loss due to leakage, and uneven distribution. The research focuses on determining the reliable water discharge and evaluating the efficiency of secondary channels. Data collection involved a field survey, hydrology and climatology data analysis, and flow measurement using the current meter method. The results show that the reliable discharge (Q_{80}) of Ciherang River is 1.35 m^3/s, which is sufficient to meet the irrigation demand of 0.033 $m^3/s/ha$. However, the average efficiency of the secondary irrigation channels is only 46%, significantly below the standard efficiency of 90%, due to unlined soil channels. Improvements in infrastructure and water distribution systems are recommended to enhance irrigation performance and agricultural productivity.

1. Introduction

Indonesia's agricultural sector plays a vital role in national food security and rural development, particularly in regions like West Java, where rice farming is a dominant activity [1]. Among the regencies contributing significantly to this sector is Purwakarta, which boasts 97,172 hectares of land, approximately 15.98% of which is dedicated to rice fields (Fig. 1). These irrigated areas are central to the region's food production systems, and their performance is closely linked to the effectiveness of irrigation infrastructure [2]. A robust irrigation system ensures not only an adequate water supply but also sustains crop productivity, particularly during dry seasons or periods of fluctuating rainfall.

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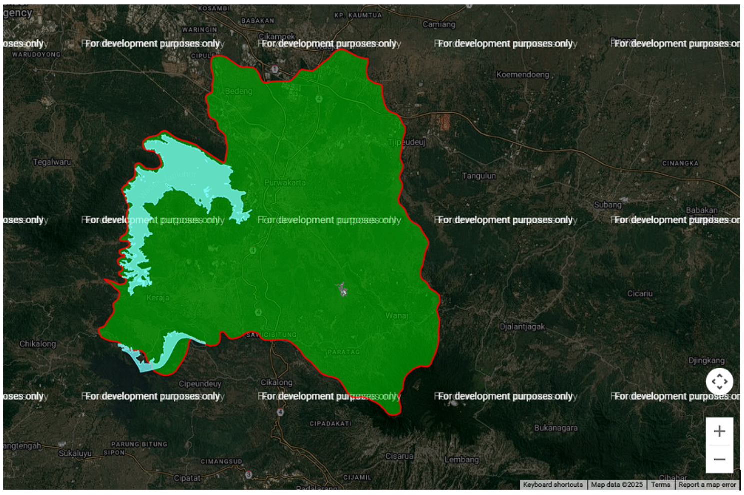

Fig. 1. Map of irrigation area in Purwakarta Regency (Source: https://bappelitbangda.purwakartakab.go.id/peta)

The Leuwi Urug irrigation area, situated in Pondok Bungur Village, Pondok Salam District, represents one of the 64 designated irrigation areas in Purwakarta (Fig. 2). Covering an area of 76.2 hectares with a functional irrigated area of 49.9 hectares, this region depends on the Ciherang River as its primary water source. The water intake system operates freely, directing natural river flow into secondary and tertiary irrigation channels without a weir-based control system. Despite efforts to improve the infrastructure, the system still exhibits signs of inefficiency, evidenced by frequent leaks, poor water distribution, and substandard channel conditions.

Fig. 2. Map of Leuwi Urug irrigation area (Source: Google Earth)

Field observations have revealed that the semi-technical irrigation system employed in Leuwi Urug, though more advanced than simple irrigation, lacks critical elements such as comprehensive flow measurement devices and sufficient water control structures. This has resulted in reduced water conveyance efficiency, particularly in secondary channels composed of unlined soil, which are prone to seepage and evaporation losses. As a consequence, water delivery to downstream plots becomes unreliable, jeopardising consistent irrigation coverage and crop yields.

Given the importance of irrigation efficiency to agricultural sustainability, this study aims to assess the performance of the secondary irrigation system in Leuwi Urug. The specific objectives are to determine the reliable discharge capacity of the secondary channels and to evaluate the level of efficiency in water conveyance. The identified research gap is the lack of recent quantitative studies specifically measuring the performance of secondary canals in small- and medium-scale irrigation systems like Leuwi Urug, considering reliable discharge parameters and distribution efficiency based on actual field data [3]. Most previous studies in Indonesia have focused on macro-scale irrigation network planning or efficiency at the fully technical level [4,5], while semi-technical systems with local characteristics and infrastructure limitations have not been analyzed in detail [6]. Yet, such systems comprise a significant portion of the national irrigation network and directly impact the productivity of small-scale farmers.

The significance of this research lies not only in its contribution to providing a quantitative overview of the reliable discharge capacity and efficiency levels of secondary canals in the Leuwi Urug irrigation system, but also in its relevance to efforts to realize a sustainable irrigation system in Indonesia. The principles of sustainability in irrigation demand efficient water use, adequate infrastructure maintenance, and data-driven management to reduce water loss and ensure equitable distribution [7,8]. By identifying points of inefficiency and providing appropriate technical recommendations, this research can serve as a reference for local governments, irrigation network managers, and farmer groups in designing strategies to improve system performance that support agricultural sustainability. The results of this research are expected to strengthen local food security, optimize the use of water resources, and extend the service life of irrigation infrastructure in the region.

2. Literature Review

Irrigation plays a crucial role in agricultural productivity, particularly in areas where rainfall is insufficient or unevenly distributed [9]. It refers to the artificial application and regulation of water to support crop growth, usually sourced from rivers, reservoirs, or groundwater [10]. According to [11], irrigation infrastructure and practices are essential to ensure water availability during dry periods, maintain soil moisture, and enhance plant development. In Indonesia, irrigation systems are vital for sustaining rice cultivation, especially in highly productive agricultural regions such as West Java [12].

The main functions of irrigation include supplying water according to crop needs, improving soil conditions, and managing temperature within the root zone. Moreover, it ensures water availability during critical growth stages, helping farmers achieve consistent yields. Beyond its agronomic benefits, irrigation also supports socio-economic goals, such as food security and rural livelihood enhancement, through improved agricultural efficiency and output [13].

Irrigation systems in Indonesia are typically classified into three categories based on the level of infrastructure development: simple, semi-technical, and technical systems [14]. Simple irrigation systems involve traditional, non-permanent channels, usually made of earth, which lack precise water control mechanisms and exhibit low efficiency. Semi-technical irrigation systems, such as that in Leuwi Urug, include improved infrastructure with intake gates but often lack downstream measurement and regulation devices. These systems are typically managed by local government bodies in cooperation with farmer groups. Technical irrigation systems, by contrast, are fully developed with permanent structures, separate drainage systems, and automated controls that allow precise discharge measurements and higher efficiency rates. The classification is further guided by key parameters such as infrastructure permanence, water regulation capacity, and channel separation. For example, technical systems often achieve over 60% efficiency, while semi-technical systems achieve 40–50%, and simple systems may fall below 40%.

An irrigation system comprises several interconnected components: intake structures, main and secondary distribution channels, tertiary plots, and drainage systems [15]. The primary channel transports water from the source to main junctions, the secondary channel distributes water to tertiary plots, and the tertiary channel delivers water directly to farm-level fields. Efficiency losses typically occur in the secondary and tertiary channels, especially when unlined or poorly maintained [16]. Soil seepage, lack of control gates, and overgrowth are common causes of inefficiency in these sections.

Channel efficiency is commonly assessed by comparing the water volume entering and exiting the system. According to the KP-01 Irrigation Planning Standard, secondary channel efficiency should ideally exceed 90% in technical systems. However, semi-technical channels often suffer from high percolation and evaporation losses, leading to much lower real-world efficiency values.

Hydrology underpins the design and operation of irrigation systems. Key hydrological components include the rainfall cycle, river discharge rates, and evapotranspiration. The hydrological cycle involves water movement through evaporation, condensation, precipitation, infiltration, and surface runoff. Understanding rainfall patterns and calculating effective rainfall is vital for irrigation planning. Effective rainfall refers to the portion of total rainfall that is available for crop use after accounting for losses [17].

Discharge from rivers, which is the main source of irrigation water, is influenced by seasonal variability. Measuring this discharge accurately is essential for predicting water availability [18]. Tools such as the current meter allow for direct field measurement of flow velocities, which are then used to calculate discharge using continuity equations.

Crop water demand is influenced by plant type, growth stage, climatic conditions, and soil characteristics. For paddy fields, water is required not only for evapotranspiration but also for land preparation and saturation [19]. The Penman-Monteith method is widely used to calculate reference evapotranspiration (ET_o), which is then adjusted using crop coefficients (K_c) to estimate actual crop water use. Other important parameters include percolation rates, water layer replacement, and effective rainfall.

Balancing water demand with available supply from the source is a primary goal of irrigation system management [20]. Inefficiencies in water delivery, often due to inadequate infrastructure or management practices, can lead to crop stress or water wastage, ultimately affecting agricultural productivity [21].

3. Method

This research employed a quantitative descriptive approach, combining field measurements with secondary data analysis to evaluate the performance of secondary irrigation channels in the Leuwi Urug irrigation area. The focus was on determining the reliable water discharge and assessing the efficiency of irrigation distribution in the secondary channel system. The study followed a sequential procedure involving literature review, field data collection, hydrological analysis, and efficiency evaluation.

3.1 Literature Review and Secondary Data

A comprehensive literature review was conducted to understand the theoretical basis of irrigation systems, hydrology, and water efficiency standards. Key references included national irrigation planning guidelines (KP-01), hydrological engineering manuals, and relevant journal publications. Secondary data were collected from various official sources, including:

- Rainfall data (2014–2023) from the Perum Jasa Tirta II Purwakarta Sector
- Topography map of Leuwi Urug Irrigation Area from the Public Works and Spatial Planning Department Purwakarta Regency
- Irrigation network schematic in Leuwi Urug Irrigation Area from the Public Work and Spatial Planning Department Purwakarta Regency
- Discharge data of the Ciherang River measured at Pondok Salam Weir from the Perum Jasa Tirta II Purwakarta Sector
- Climate data (temperature, humidity, sunshine duration) from Bandung Geophysical Station

These data sets supported the estimation of effective rainfall, evapotranspiration, and river discharge reliability.

3.2 Field Survey and Primary Data Collection

A field survey was carried out in the Leuwi Urug Irrigation Area, specifically focusing on the secondary irrigation channels. Measurements were taken on October 5, 2024, using a current meter to obtain the actual discharge and assess flow conditions in the channels. Channel cross-section dimensions and surface conditions were also recorded to evaluate water loss due to seepage and infiltration.

The discharge measurement followed standard procedures using velocity-area methods. Flow velocity was obtained by the two-point method (at 0.2d and 0.8d depths) or one-point method (at 0.6d), depending on channel depth. These velocities were then multiplied by the measured cross-sectional area to compute the flow rate.

3.3 Data Analysis Techniques

The data analysis was divided into four main parts:

a) Hydrological Analysis: Average rainfall was calculated using the arithmetic mean method and verified using the Thiessen polygon method. Effective rainfall (Re) was estimated based on 80% probability rainfall (R_{80}), following the KP-01 standard.
b) Water Needs Analysis: Crop water requirements were estimated by calculating reference evapotranspiration (ET_o) using the Penman equation. Adjustments for crop type and growth stage were made using crop coefficient values (K_c). Additional components, such as land preparation water needs, percolation, and water layer replacement were considered.
c) Water Availability Analysis: The reliable river discharge (Q_{80}) was determined from 10 years of monthly discharge data using probability analysis. The result was compared with irrigation demand to assess sufficiency.
d) Efficiency Analysis: Efficiency of secondary irrigation channels was calculated by comparing inflow and outflow discharge using the formula Eq. (1):

$$E = \frac{Q_{outflow}}{Q_{inflow}} x\ 100\% \quad (1)$$

This analysis allowed the identification of potential water losses in the system due to seepage or operational limitations.

3.4 Study Limitations

The analysis was restricted to secondary irrigation channels and did not cover tertiary channels or full hydraulic modelling of the network. Discharge data had gaps due to incomplete monitoring records at the Pondok Salam station. Moreover, field measurements were based on a single observation date, which may not reflect seasonal variability.

4. Results and Discussion

4.1 Overview of the Research Area

The Leuwi Urug Irrigation Area is located in Pondok Bungur Village, Pondok Salam District, Purwakarta Regency. It covers a total of 76.2 hectares, with a functional irrigated area of 49.9 hectares. The irrigation system utilises a free intake method from the Ciherang River, which allows river water to flow directly into the irrigation network without a weir or mechanical control structure. This system, categorised as semi-technical, has minimal regulation features and is vulnerable to inefficiencies due to its reliance on natural topography and gravity-driven flow.

Field surveys revealed that the secondary irrigation channels are mostly earthen channels (Fig. 3), which are prone to seepage, sedimentation, and structural degradation. These factors significantly affect water delivery efficiency and contribute to uneven distribution, particularly in plots located at the far end of the network.

Fig. 3. The end of existing channel condition at STA 1 + 500 (Source: Authors’ documentation)

4.2 Hydrology Analysis

Rainfall data from 2014 to 2023 were collected from three rainfall stations: Pondok Salam, Wanayasa, and Ciracas. The average monthly rainfall was computed using both the arithmetic mean method and the Thiessen polygon method to ensure representative spatial coverage. The average annual rainfall in the area is presented in Table 1.

Table 1
Recapitulation average rainfall data

Month / Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Jan	1	245.67	59.00	345.67	86.33	190.67	141.33	216.67	214.67	172.00	107.00
	2	683.33	407.33	214.67	167.00	85.00	195.00	348.33	224.00	80.33	107.00
Feb	1	161.00	325.67	393.33	167.67	283.67	322.33	310.00	386.67	145.33	88.00
	2	228.00	167.00	304.00	354.33	340.67	330.67	418.00	310.00	110.33	295.00
Mar	1	511.00	170.33	515.33	261.33	367.67	129.00	193.33	139.33	222.33	157.67
	2	425.33	465.33	471.33	149.00	281.33	129.00	432.67	302.67	131.67	317.33
Apr	1	153.00	321.00	353.33	199.33	211.33	352.00	448.33	273.67	389.67	125.00
	2	290.67	101.67	178.67	273.33	314.33	287.33	252.00	78.67	362.33	465.33
May	1	161.00	125.00	93.33	217.67	81.00	78.67	107.33	171.33	360.33	315.00
	2	191.67	59.00	250.33	2.67	217.33	46.67	251.00	244.33	130.33	37.00
Jun	1	228.33	68.00	126.00	135.33	16.00	76.33	80.33	153.00	181.00	44.00
	2	99.67	0.00	92.00	123.00	135.00	0.00	19.00	184.67	223.67	87.33
Jul	1	54.67	16.33	41.67	79.67	7.00	0.00	41.67	29.67	68.33	83.00
	2	159.67	0.00	289.00	33.33	2.67	0.00	23.67	98.00	23.67	0.00
Aug	1	28.00	30.67	84.00	3.00	0.00	0.00	94.33	143.00	95.67	0.00
	2	14.33	12.00	175.67	78.67	1.33	0.00	30.67	27.67	76.00	10.00
Sep	1	12.67	4.33	292.67	83.67	21.67	12.67	26.67	46.00	227.33	0.00
	2	1.67	10.67	316.33	172.33	5.67	0.00	184.00	95.00	85.33	4.33
Oct	1	27.00	57.33	277.00	183.00	22.67	30.00	85.33	181.00	378.67	50.67
	2	84.33	7.67	229.33	367.67	252.00	38.00	313.00	258.67	176.67	124.67
Nov	1	189.67	354.33	272.00	313.00	224.67	326.33	170.67	500.67	212.33	215.00
	2	108.67	266.67	222.00	213.00	292.33	148.00	133.67	176.67	263.67	208.33
Dec	1	110.00	244.00	112.00	163.33	240.67	318.00	129.67	280.00	313.33	321.67
	2	487.00	233.67	5.00	164.33	108.00	424.33	121.33	263.67	198.67	225.67

To determine effective rainfall, the R_{80} value was calculated using probability analysis based on 10 years of historical data. For rice crops, 70% of the 80% dependable rainfall was used in calculating effective rainfall, while 50% was used for crops, in accordance with the KP-01 irrigation planning standard. Based on the analysis (Table 2), the effective rainfall (R_{80}) was determined to be sufficient to support most of the crop water requirements, especially during the rainy season. However, during the dry season, reliance on river discharge becomes crucial. Monthly variations in effective rainfall highlighted the need for regulated water storage or supplemental irrigation to balance the supply-demand mismatch during peak dry months.

Table 2
Effective rainfall data

Period		R_{80}	Effective Rainfall (Rice)		Effective Rainfall Crops)	
			(mm)	(mm/day)	(mm)	(mm/day)
Jan	1	90.93	63.65	4.24	45.46	3.03
	2	89.89	62.92	3.93	44.94	2.81
Feb	1	148.81	104.17	6.94	74.41	4.96
	2	180.56	126.39	9.72	90.28	6.94
Mar	1	143.41	100.39	6.69	71.70	4.78
	2	135.52	94.86	5.93	67.76	4.23
Apr	1	163.30	114.31	7.62	81.65	5.44
	2	118.78	83.14	5.54	59.39	3.96

Table 2 (*Continued*)

May	1	83.74	58.62	3.91	41.87	2.79
	2	39.15	27.40	1.71	19.57	1.22
Jun	1	49.33	34.53	2.30	24.67	1.64
	2	4.22	2.96	0.20	2.11	0.14
Jul	1	9.07	6.35	0.42	4.54	0.30
	2	0.00	0.00	0.00	0.00	0.00
Aug	1	0.00	0.00	0.00	0.00	0.00
	2	3.26	2.28	0.14	1.63	0.10
Sep	1	6.19	4.33	0.29	3.09	0.21
	2	2.26	1.58	0.11	1.13	0.08
Oct	1	27.67	19.37	1.29	13.83	0.92
	2	48.30	33.81	2.11	24.15	1.51
Nov	1	194.70	136.29	9.09	97.35	6.49
	2	136.85	95.80	6.39	68.43	4.56
Dec	1	115.93	81.15	5.41	57.96	3.86
	2	110.96	77.67	4.85	55.48	3.47

4.3 Water Needs Analysis
4.3.1 Evapotranspiration estimation

Evapotranspiration (ET_0) was calculated using the modified Penman method, incorporating climate data such as temperature, solar radiation, humidity, and wind speed. Monthly adjustment factors (c), and extraterrestrial radiation (Ra) were applied as per the KP-01 standard. Table 3 presents the evapotranspiration values. The ET_0 ranged from 2.08 mm/day to 3.23 mm/day, peaking during June to October.

Table 3
Evapotranspiration Value

No	Description	Units	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CLIMATE DATA														
1	Air Temperature (T)	oC	23.77	23.64	23.85	23.95	24.08	23.54	23.14	23.46	24.15	24.16	23.78	24.10
2	Sun Radiation (S = n/N)	%	4.12	3.96	4.38	4.92	5.58	5.73	6.91	6.94	6.46	5.36	4.18	3.98
3	Air Humadity (Rh)	%	78.58	80.09	80.18	80.63	79.01	77.70	74.33	71.54	68.86	73.14	80.16	78.43
4	Wind Speed (U)	m/s	2.00	1.82	1.46	1.26	1.24	1.27	1.55	1.62	1.67	1.58	1.34	1.57
5	Number of Days (N)	day	31	28	31	30	31	30	31	31	30	31	30	31
CALCULATION														
6	Correction Factor	C	1.1	1.1	1.0	0.9	0.9	0.9	0.9	1.0	1.1	1.1	1.1	1.1
7	Saturation Vapor Pressue (ea)	mbar	29.41	29.18	29.54	29.72	29.94	29.02	28.34	28.89	30.09	30.11	29.43	29.97
8	Actual Vapor Pressure (ed)	mbar	23.11	23.37	23.69	23.96	23.66	22.55	21.06	20.67	20.72	22.02	23.59	23.51
9	(ea-ed)	mbar	6.30	5.81	5.85	5.76	6.29	6.47	7.28	8.22	9.37	8.09	5.84	6.46
10	Wind function (f(u))		0.28	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
11	W		0.74	0.74	0.74	0.74	0.74	0.73	0.73	0.73	0.74	0.74	0.74	0.74
12	Extra-Exterial Radiation (Ra)	mm/day	15.93	16.04	15.56	14.57	13.27	12.62	12.92	13.87	14.96	15.74	15.89	15.83
13	Sun Radiation (Rs)	mm/day	4.31	4.33	4.23	4.00	3.69	3.52	3.68	3.95	4.22	4.36	4.30	3.48
14	Net Short Gel Radiation (Rns)	mm/day	3.45	3.46	3.38	3.20	2.95	2.81	2.94	3.16	3.38	3.49	3.44	2.79
15	Temperature Function (f(T))		15.35	15.33	15.37	15.39	15.42	15.31	15.23	15.29	15.44	15.44	15.36	15.43
16	Real Vapor Pressure Function (f(ed))		0.13	0.13	0.13	0.12	0.13	0.13	0.14	0.14	0.14	0.13	0.13	0.13
17	Sun Radiation Function (f(n/N))		0.14	0.14	0.14	0.14	0.15	0.15	0.16	0.16	0.16	0.15	0.14	0.14
18	Net Wave Radiation (Rnl)	mm/day	0.27	0.26	0.27	0.28	0.29	0.30	0.34	0.35	0.34	0.31	0.27	0.27
19	Netto Radiation (Rn)	mm/day	3.18	3.20	3.11	2.92	2.66	2.51	2.60	2.81	3.04	3.18	3.18	2.52
20	Potential Evapotranspiration (ETo)	mm/day	3.08	3.05	2.72	2.31	2.17	2.08	2.19	2.66	3.21	3.23	3.04	2.56

4.3.2 Land preparation water demand

The land preparation phase, particularly for rice fields, requires significant water input. The Van de Goor and Zijlstra method was applied to calculate the water demand during this stage, considering factors such as open water evaporation and percolation rates. Using a saturation depth of 300 mm and a land preparation period of 30 days, the maximum irrigation requirement during this phase was approximately 9.82 mm/day (Table 4).

Table 4
Water needs at rice field during land preparation

Parameter	Units	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ETo	mm/day	3.078	3.052	2.718	2.314	2.173	2.082	2.194	2.663	3.209	3.226	3.037	2.559
Eo	mm/day	3.4	3.4	3.0	2.5	2.4	2.3	2.4	2.9	3.5	3.5	3.3	2.8
P	mm/day	2	2	2	2	2	2	2	2	2	2	2	2
M	mm/day	5.39	5.36	4.99	4.55	4.39	4.29	4.41	4.93	5.53	5.55	5.34	4.82
T	day	45	45	45	45	45	45	45	45	45	45	45	45
S	mm	300	300	300	300	300	300	300	300	300	300	300	300
K	-	0.808	0.804	0.748	0.682	0.659	0.644	0.662	0.739	0.829	0.832	0.801	0.722
IR	mm/day	9.72	9.70	9.47	9.20	9.10	9.04	9.12	9.43	9.81	9.82	9.69	9.36

4.4 Water Availability Analysis

The reliable discharge analysis in this study aims to determine the reliable discharge using historical discharge data of the Ciherang watershed measured at Pondok Salam weir, which represents the real condition of water availability at a certain time. In this reliable discharge analysis using the Weibull method by calculating Q_{80} or 80% probability for irrigation purposes based on historical data. The result of calculation to determine the reliable discharge is presented in Table 5.

Table 5
Reliable discharge Q_{80} data

Month	Period	
	1	2
Jan	1.90	2.17
Feb	2.35	1.67
Mar	2.18	2.34
Apr	2.41	2.32
May	2.33	2.36
Jun	1.88	1.85
Jul	1.43	0.24
Aug	1.04	0.85
Sep	0.14	0.14
Oct	0.12	0.16
Nov	0.00	0.30
Dec	0.29	1.98

The reliable discharge obtained gives an overview of the availability of water that can be relied upon for irrigation. Based on the calculation result, the reliable discharge average value of 1.35 $m3/sec$. This reliable discharge is then compared with irrigation water needs to determine the adequacy of water supply in secondary channels in meeting the irrigation needs of rice fields, especially in the plant season.

4.5 Irrigation Channel Efficiency Analysis

In this study, the efficiency of the irrigation secondary channel is calculated by calculating the actual discharge in the secondary irrigation channel using a current meter at each channel point; the channel efficiency is determined by comparing the discharge at several points of the divider building along the secondary channel.

Table 6
Efficiency of irrigation secondary channel

Secondary Channel	Upstream Discharge (m^3/sec)	Downstream Discharge (m^3/sec)	Water Loss (m^3/sec)	Channel Length (m)	Efficiency (%)
STA 0 - 0+857	0.84	0.52	0.38	857	62%
STA 0+857 - 1+262	0.52	0.26	0.51	405	49%
STA 1+262 - 1+500	0.26	0.11	0.56	238	44%
STA 1+500 - 1+868	0.11	0.03	0.70	368	30%
Average					46%

The measurement current meter method was implemented on the 05th of October 2024. This secondary channel has a square cross-section, so the calculation of its cross-section uses the formula for a square cross-section.

The results revealed that the average efficiency of the secondary irrigation channel was 46%, well below the expected standard of 90% for properly functioning systems. The low efficiency was primarily attributed to (1) seepage losses from unlined soil channels, (2) lack of flow regulation structures, such as control gates and measurement devices, and (3) poor maintenance, including sediment accumulation and overgrown vegetation.

5. Conclusions

The analysis of the secondary irrigation system in the Leuwi Urug Irrigation Area reveals that while water availability from the Ciherang River is sufficient to meet agricultural water demands (reflected by a reliable discharge of 1.35 m^3/s), the overall performance of the irrigation network remains suboptimal due to infrastructural limitations. Field measurements showed that actual discharge reaching the fields averaged only 0.54 m^3/s, and the calculated efficiency of the secondary irrigation channels was merely 46%, far below the ideal standard of 90%. This inefficiency is largely attributed to unlined earthen channels, seepage losses, and the absence of proper water control and monitoring systems. To enhance the system’s functionality, targeted improvements in channel design, maintenance practices, and water management infrastructure are essential. Such interventions will not only increase irrigation efficiency but also support sustainable agricultural productivity and food security in the region.

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