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The Evaluation of Water Loss in The Western North Tarum Irrigation Channel

Evaluasi Kehilangan Air pada Saluran Irigasi Tarum Utara Barat

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ABSTRACT

The Western North Tarum Irrigation channel plays a crucial role in supplying water to irrigated agricultural areas. However, it encounters challenges in ensuring adequate water delivery to all channel segments. This research assesses water loss during the distribution process in the Western North Tarum Irrigation channel, focusing on the evaluation of channel capacity and the impact of suboptimal water management on water loss. The study employs the HEC-RAS model, a hydraulic system analysis tool, to evaluate the channel's capacity and simulates its behavior under various discharge conditions. The evaluation reveals that two channel segments, B.TUB 13 and B.TUB 25, have exceeded their capacity limits, resulting in overflow. Sedimentation downstream, particularly in these segments, exacerbates the issue by altering the channel slope and impeding water flow. This research identifies poor water distribution management as a significant factor contributing to water loss in the irrigation channel. Inadequate scheduling and the absence of proper water measurement tools result in instances of overwatering or underwatering in some areas. The lack of monitoring and control in the irrigation system hampers the detection of uncontrolled flow in the channels, leading to substantial water loss. This research emphasizes the importance of evaluating the capacity of irrigation channels to prevent overflow and water loss, as well as water management for efficient distribution and irrigation, to ensure the sustainability of agriculture in the Western North Tarum Irrigation area.

Keywords: *HEC-RAS, irrigation channel, water distribution, water loss, Western North Tarum*

ABSTRAK

Saluran Irigasi Tarum Utara Barat memainkan peran penting dalam penyediaan air untuk daerah pertanian. Namun, saluran ini menghadapi tantangan dalam penyediaan air agar dapat memenuhi kebutuhan air irigasi pada semua segmen saluran. Penelitian ini mengevaluasi kehilangan air pada saat distribusi di saluran Irigasi Tarum Utara Barat, dengan fokus pada evaluasi kapasitas saluran dan evaluasi kehilangan air akibat manajemen air yang tidak optimal. Studi ini menggunakan model HEC-RAS dalam mengevaluasi kapasitas saluran dan menyimulasikan model saluran tersebut pada kondisi debit yang bervariasi. Evaluasi menunjukkan bahwa dua segmen saluran, B.TUB 13 dan B.TUB 25, telah melebihi batas kapasitasnya, mengakibatkan luapan air. Penelitian ini juga mengidentifikasi manajemen distribusi air yang buruk sebagai faktor signifikan yang menyumbang pada kehilangan air dalam saluran irigasi tersebut. Penjadwalan yang tidak memadai dan ketiadaan pengukuran dapat menyebabkan kelebihan dan kekurangan pemberian air di beberapa daerah. Kurangnya pemantauan dan kontrol dalam sistem irigasi menghambat deteksi aliran tidak terkendali di saluran, mengakibatkan kehilangan air yang cukup besar. Selain itu, pemeliharaan yang tidak memadai dari saluran irigasi dan pintu air memperburuk ketidakefisienan distribusi air, menyebabkan kerugian tambahan. Studi ini menekankan pentingnya evaluasi kapasitas saluran irigasi untuk mencegah kelebihan dan kehilangan air, serta manajemen air untuk distribusi air dan irigasi yang efisien dalam rangka menjamin keberlanjutan pertanian di area Irigasi Tarum Utara Barat.

Kata Kunci*: HEC-RAS, saluran irigasi, distribusi air, kehilangan air, Tarum Utara Barat*

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INTRODUCTION

The Western North Tarum Irrigation channel is the irrigation network for the North Tarum Irrigation area, with total area exceeding 45,000 ha. Located in Kanandede Village, Rongkong District, Karawang Regency, West Java Province, the Western North Tarum Irrigation channel starts at Leuweung Seureuh Weir B.TUB (Bangunan Tarum Utara Barat/Western North Tarum waterwalk) 00 and ends at B.TUB 26, as illustrated in Figure 1. The length of this channel is approximately 50 km. The Western North Tarum Irrigation area has a total target area of 457 km^2 which is divided into 4 segments including Karawang (B.TUB 1-10), Pedes (B.TUB 11-13), Rengasdengklok (B.TUB 14-17), and Batujaya (B.TUB 18-26). The irrigation scheme of the Western North Tarum is shown in Figure 2. Each B.TUB is equipped with dividing structures to distribute water from the main channel to the secondary channels. These dividing structures depicted in Figure 3 feature sluice gates, used to regulate discharge from upstream parts to each Irrigation area (Akhavan et al., 2023).

Irrigation systems comprise many integrated components (Agide. et al., 2016). These include irrigation schemes, on-farm management, and organizational structures (Lempériere et al., 2014). Irrigation schemes include the physical infrastructure for water intake, control, and distribution to irrigated areas. Given the importance of meeting irrigation demands, the irrigation scheme is indeed one of the most vital and challenging components of such systems. Efficient operation of irrigation schemes is critical to the long-term sustainability of irrigated agriculture (Mishra et al., 2001). On the other hand, poor management of water distribution systems is a major factor contributing to low efficiency (Yercan et al., 2009). The primary cause of this inefficiency in irrigation systems is inaccurate water distribution, often caused by a lack of water delivery monitoring system (Mateos, 2008). In addition, the capacity of the irrigation channel to distribute water has been degraded, leading to large water loss during distribution to irrigated areas.

Prior research indicates that water loss during operation stems from both structural issues and ineffective irrigation channel management (Mohammadi et al., 2019). The previous study explained that many irrigation structures are under improper operation, leading to unfair delivery and significant water during distribution. Another research showed that insufficient information regarding the water requirements of different areas, coupled with deficiencies in creating irrigation schedules, contributes to water losses during distribution (Hong et al., 2014). Based on both findings, it can be assumed that the lack of proper measurement and maintenance of irrigation structures contributes to water loss during distribution.

A similar problem arose in the Western North Tarum Irrigation Channel, where water from the Leuweung Seureuh weir was insufficient to meet the water demands especially in B.TUB 13. This is also shown through complaints from local residents who do not get enough water for their irrigation needs. Moreover, the lack of maintenance allowed sedimentation to accumulate in each segment of the channel. Field observations revealed B.TUB 13 and B.TUB 25 experiencing overflow, indicating uneven water distribution in the Western North Tarum Irrigation channel. This unbalance is likely due to sluice gates opening inconsistently with the demands of each irrigation area. Therefore, this study aimed to assess the capacity of the Western North Tarum Irrigation channel and quantify water loss during distribution

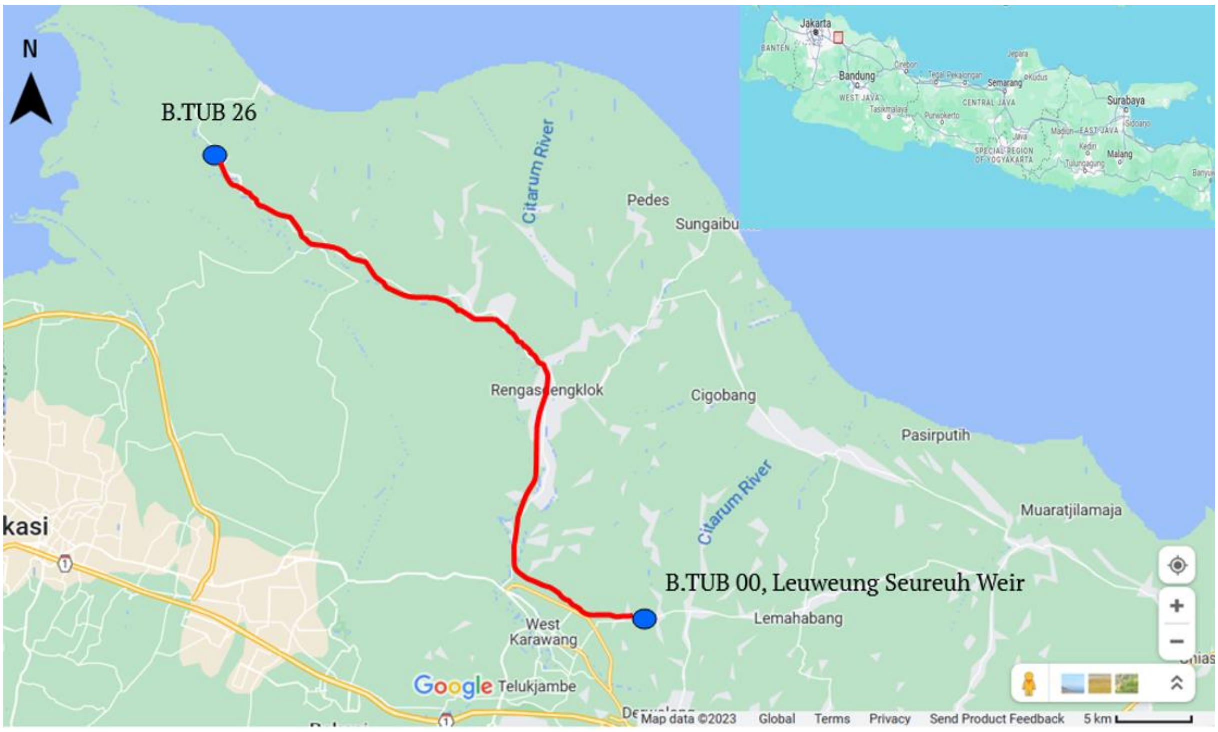


Figure 1 Study Location

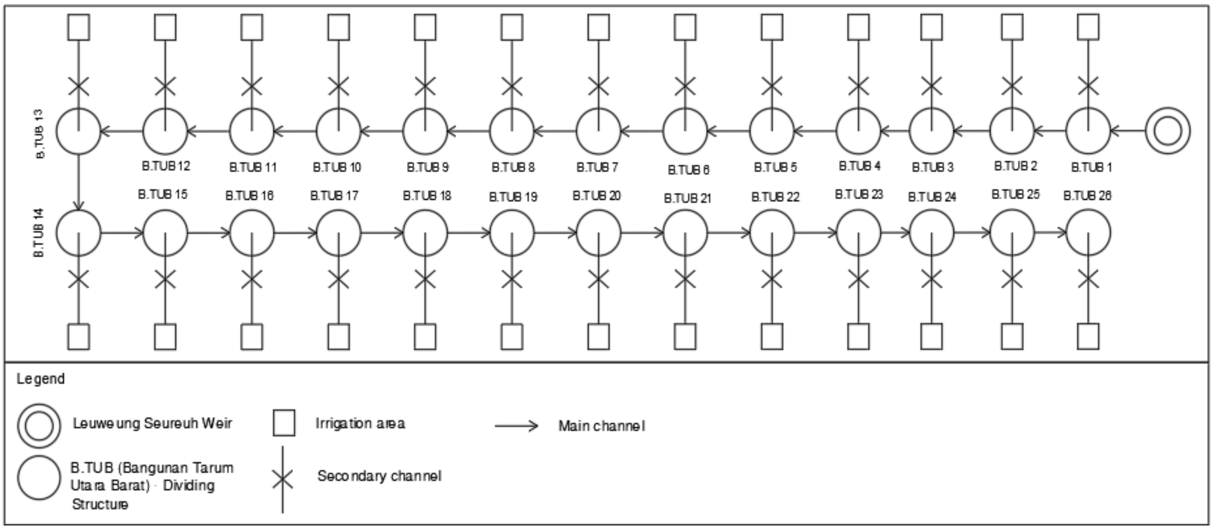


Figure 2 Schematization of Western North Tarum Irrigation

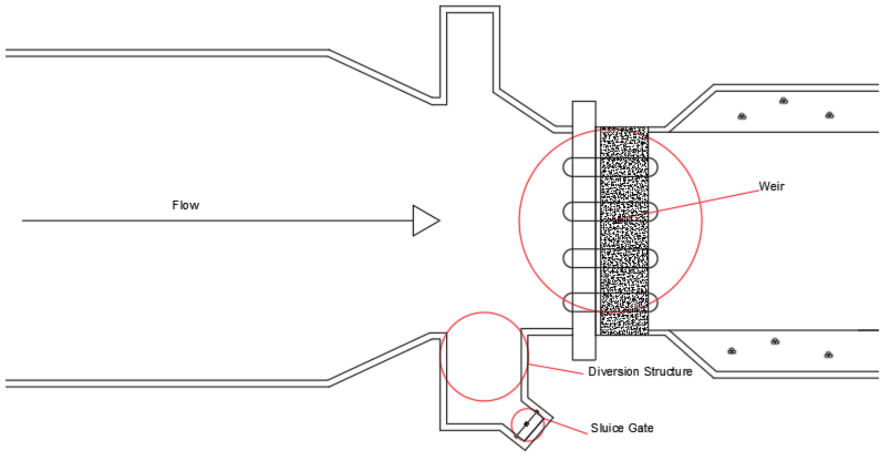


Figure 3 Details of each B.TUB

METHODOLOGY

HEC-RAS Model

One of the methods to investigate Western North Tarum irrigation problems is HEC-RAS to conduct a hydraulic analysis (Barkhordari & Hashemy Shahdany, 2022; Wanyama & Bwambale, 2023). HEC-RAS is a computer program designed to model the hydraulics of water flow through natural rivers and other channels (Traore et al., 2015). Developed by the US Department of Defense, Army Corps of Engineers, the model aimed to simulate discharge and water level in the river (Robert et al., 2012). HEC-RAS is capable of simulating steady and unsteady one-dimensional (1D) and two-dimensional (2D) flow. In one-dimensional flow modeling, several components are involved, including the steady flow model used to determine water level profiles, simulation of unsteady flow, calculations of sediment transport, and analysis of water quality. These components require various data inputs, namely geometry data from the river cross section, discharge data as boundary conditions, and other supporting data.

In unsteady state HEC-RAS model, two boundary conditions, such as upstream and downstream boundary condition must be defined. In addition, initial conditions for this model can be established based on initial flow discharge data or elevation data. Under unsteady state conditions, HEC-RAS uses a mathematical equation, known as the Saint Venant equation (Brunner, 2016). This equation consists of the equation of the conservation of mass (continuity) and the momentum equation for open channel flow. The analysis involves two key equations: the continuity equation (1) and momentum equation (2), expressed as follows:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = Sf - So \quad (1)$$

$$\frac{\partial Q}{\partial t} + \frac{\partial Qv}{\partial x} + \frac{1}{2} gA \frac{\partial A}{\partial x} = gAso - \frac{fQ|Q|}{2A} \quad (2)$$

Where:

A : the cross-sectional area of flow (m^2)
Q : the discharge (m^3/s)
Sf : energy slope
So : channel slope
f : Darcy-Weisbach friction coefficient
v : velocity of fluid (m/s)
t : the time (s)
x : the distance along the channel (m)

Both equations are hyperbolic partial differential equations that describe the unsteady flow behavior in the channel. For each computational time step in the channel network, HEC-RAS uses numerical methods, such as the explicit or implicit scheme to discretize and solve these equations. The numerical solution involves applying appropriate boundary conditions and segmenting the channel into small sections, often between cross-sections. HEC-RAS employs an iterative process to update water levels, velocities, and discharges at each computational time step until convergence is achieved. By resolving the Saint-Venant equations, HEC-RAS determines spatial and temporal fluctuations in water levels, velocities, and other flow parameters, providing insights into flow behavior and flood dynamics in the system. This study will focus on unsteady HEC-RAS simulation to estimate the channel hydraulic parameter of Western North Tarum Irrigation channel. The basic data requirements for this simulation include geometric data of the Western

North Tarum Irrigation channel, reach lengths, boundary conditions, and flow regime.

Measurement of The Western North Tarum Irrigation Channel

The measurement of the Western North Tarum irrigation channel aims to obtain longitudinal cross-sections and cross-sectional data of the channel. These measurements are intended to evaluate the channel capacity and establish the cross-sectional geometry of the Western North Tarum channel in the HEC-RAS Program. In addition, water level measurements are also carried out to obtain instantaneous discharge at each location of weirs and diversion structures. Discharge measurements are carried out at upstream and downstream of the weir. Discharge measurements will be carried out using an Automatic Water Level Recorder (AWLR) at the Leuweung Seureuh weir with observation period of 15 days starting from 1 to 15 October 2022, which can be seen in Figure 4. Furthermore, water level measurements were taken at 6 B.TUB locations as representatives of 26 B.TUB along the Western North Tarum irrigation channel. Water level observations were conducted over a 3-day period at 3-hour intervals, with the results summarized in Figure 5. The discharge observations at B.TUB 00 and water level at B.TUB 4, B.TUB 9, B.TUB 13, B.TUB 18, B.TUB 22, and B.TUB 26 were conducted by Perum Jasa Tirta in 2022. The selection of B.TUB 00 and B.TUB 26 as observation points is due to the fact that both segments represent the upstream and downstream of the Western North Tarum irrigation channel, where both upstream and downstream are essential in HECRAS model. While, the selection of middle B.TUB, such as B.TUB 4, 9, 13, 18, 22, is based on their representation of the overall conditions of the Western North Tarum irrigation channel. These specific segments serve as indicators of the transition from upstream to downstream conditions, offering valuable insights into the behavior and flow of water across different parts of the channel. The middle segments are particularly significant as they are likely to exhibit substantial variations in channel conditions between the upstream and downstream ends.

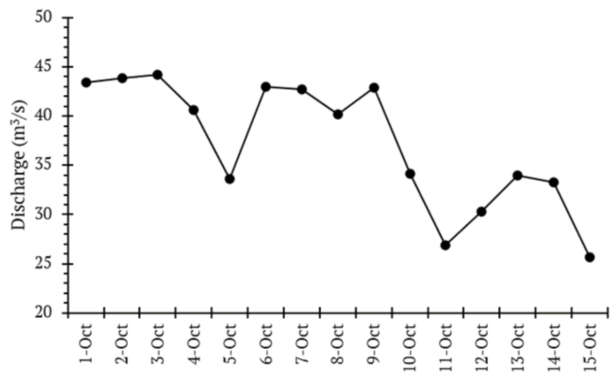
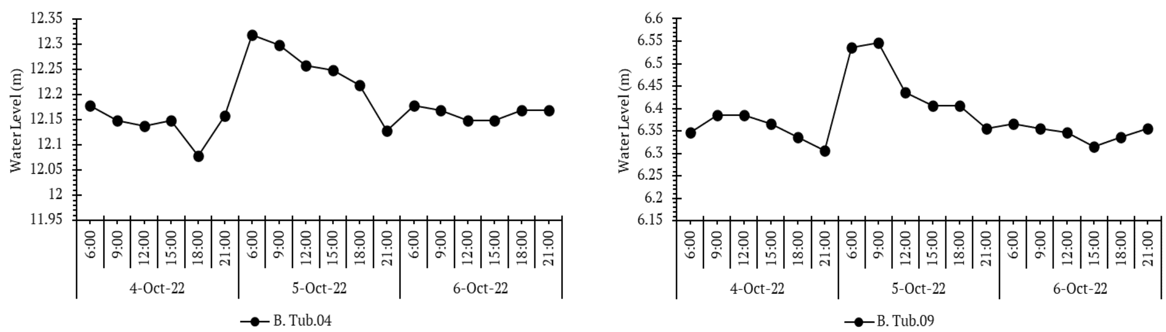


Figure 4 The Discharge Observation Results at B.TUB 00 (Leuweung Seureuh Weir)



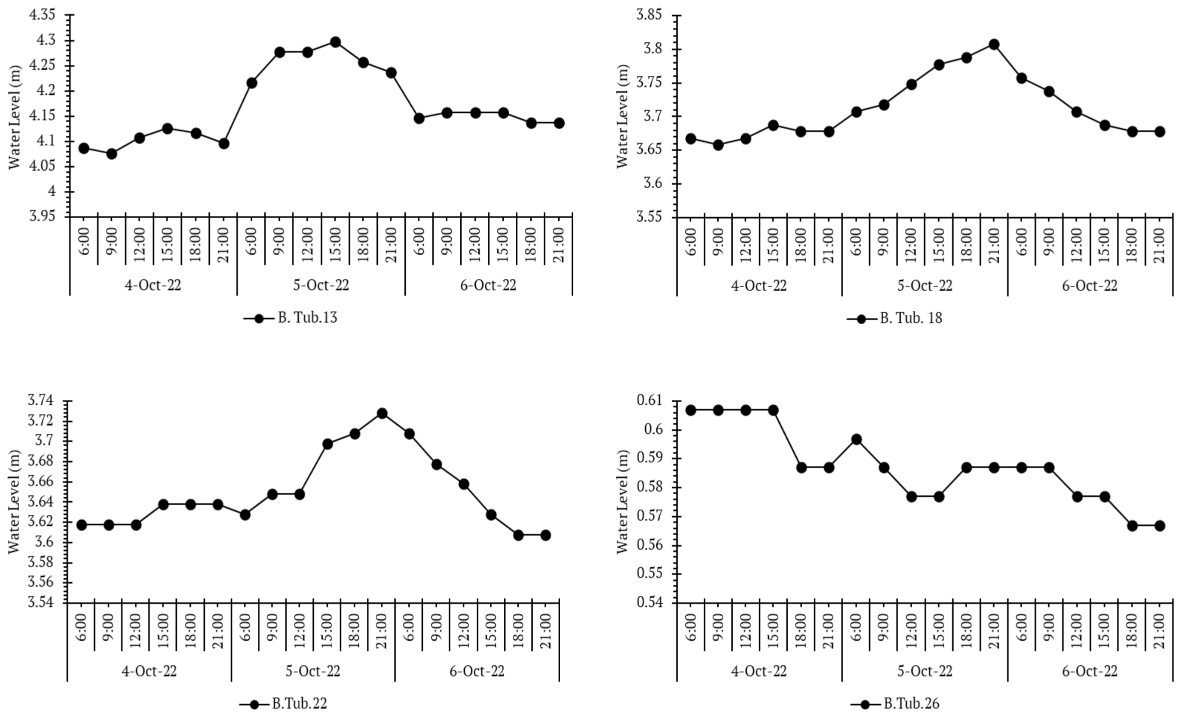


Figure 5. The Water Level Observation Results at B.TUB 4, B.TUB 9, B.TUB 13, B.TUB 18, B.TUB 22, B.TUB 26

Water Irrigation Demand of Western North Tarum Irrigation channel

The data on irrigation water demand for Western North Tarum irrigation channel is used to evaluate water loss during water distribution. The water loss in this study will be evaluated by comparing the simulation results of HEC-RAS with the irrigation water demand for each half-month in 2022. As the HEC-RAS does not account for water losses in the channel, the evaluation will solely compare the distributed water discharge obtained from HEC-RAS simulation with the irrigation water demand for each half-month in 2022. The irrigation water demand data is obtained from Perum Jasa Tirta II and consists of semi-monthly water irrigation demands from January to December 2022, as shown in Table 1.

Table 1 Water Irrigation Demands of Western North Tarum Irrigation Channel

B.TUB	Jan1	Jan2	Feb1	Feb2	Mar1	Mar2	Apr1	Apr2	May1	May2	Jun1	Jun2
2	0.148	0.133	0.110	0.094	0.228	0.231	0.186	0.178	0.204	0.246	0.252	0.243
4	0.663	0.598	0.491	0.424	1.021	1.036	0.835	0.796	0.915	1.101	1.128	1.089
6	0.252	0.227	0.187	0.161	0.388	0.393	0.317	0.302	0.347	0.418	0.428	0.414
8	0.383	0.345	0.284	0.245	0.590	0.598	0.482	0.460	0.528	0.636	0.651	0.628
9	0.423	0.381	0.314	0.270	0.652	0.661	0.533	0.508	0.584	0.703	0.720	0.695
10	1.069	0.963	0.792	0.683	1.646	1.669	1.346	1.283	1.475	1.775	1.818	1.755
12	0.484	0.498	0.453	0.368	0.522	0.817	0.781	0.680	0.708	0.820	0.909	0.930
13	4.207	3.799	3.960	3.798	3.772	4.469	5.540	5.905	6.347	6.800	7.201	7.694
15	6.977	6.520	6.211	5.991	6.114	6.999	7.982	9.148	9.977	10.276	11.486	12.224
16	0.348	0.386	0.369	0.291	0.274	0.615	0.639	0.534	0.527	0.597	0.692	0.730
17	0.441	0.490	0.468	0.370	0.347	0.779	0.811	0.677	0.668	0.757	0.877	0.926
18	0.503	0.559	0.534	0.422	0.396	0.889	0.925	0.773	0.762	0.864	1.001	1.057
20	1.071	1.057	1.073	1.009	1.031	1.401	1.473	1.574	1.845	1.846	1.955	2.084
22	0.344	0.344	0.399	0.369	0.314	0.314	0.633	0.663	0.579	0.571	0.633	0.751
23	0.993	0.993	1.051	1.127	1.069	1.002	1.214	1.915	1.934	1.776	1.776	2.050
24	0.784	0.784	0.853	0.876	0.807	0.769	1.101	1.513	1.467	1.373	1.415	1.646
26	1.361	1.251	1.100	1.080	1.159	1.214	1.254	1.538	1.778	1.802	2.103	2.191

B.TUB	Jul1	Jul2	Aug1	Aug2	Sep1	Sep2	Oct1	Oct2	Nov1	Nov2	Dec1	Dec2
2	0.234	0.000	0.000	0.000	0.000	0.000	0.296	0.275	0.201	0.163	0.142	0.136
4	1.048	0.000	0.000	0.000	0.000	0.000	1.326	1.234	0.903	0.731	0.636	0.610
6	0.398	0.000	0.000	0.000	0.000	0.000	0.504	0.469	0.343	0.277	0.242	0.232
8	0.605	0.000	0.000	0.000	0.000	0.000	0.766	0.712	0.521	0.422	0.367	0.352
9	0.669	0.000	0.000	0.000	0.000	0.000	0.846	0.788	0.576	0.466	0.406	0.389
10	1.689	0.000	0.000	0.000	0.000	0.000	2.138	1.989	1.455	1.178	1.026	0.983
12	0.874	0.563	0.000	0.000	0.000	0.000	0.375	0.972	0.839	0.629	0.503	0.481
13	7.821	7.939	6.671	3.935	2.573	0.987	0.000	1.170	3.565	4.198	4.429	4.782
15	12.350	12.559	10.932	8.644	5.430	2.742	0.000	1.468	3.281	5.535	6.397	6.308
16	0.678	0.660	0.000	0.000	0.000	0.000	0.000	0.730	0.685	0.495	0.379	0.362
17	0.860	0.837	0.000	0.000	0.000	0.000	0.000	0.926	0.868	0.628	0.481	0.459
18	0.981	0.956	0.000	0.000	0.000	0.000	0.000	1.057	0.991	0.717	0.549	0.524
20	2.126	2.184	1.374	1.055	0.566	0.000	0.000	0.809	0.965	1.182	1.480	1.301
22	0.759	0.704	0.658	0.000	0.000	0.000	0.000	0.000	0.680	0.663	0.431	0.352
23	2.219	2.209	2.010	1.391	0.000	0.000	0.000	0.000	0.521	1.915	1.606	1.147
24	1.746	1.704	1.562	0.777	0.000	0.000	0.000	0.000	0.744	1.513	1.185	0.876
26	2.210	2.287	2.259	2.178	1.480	0.800	0.000	0.000	0.000	0.569	0.991	0.997

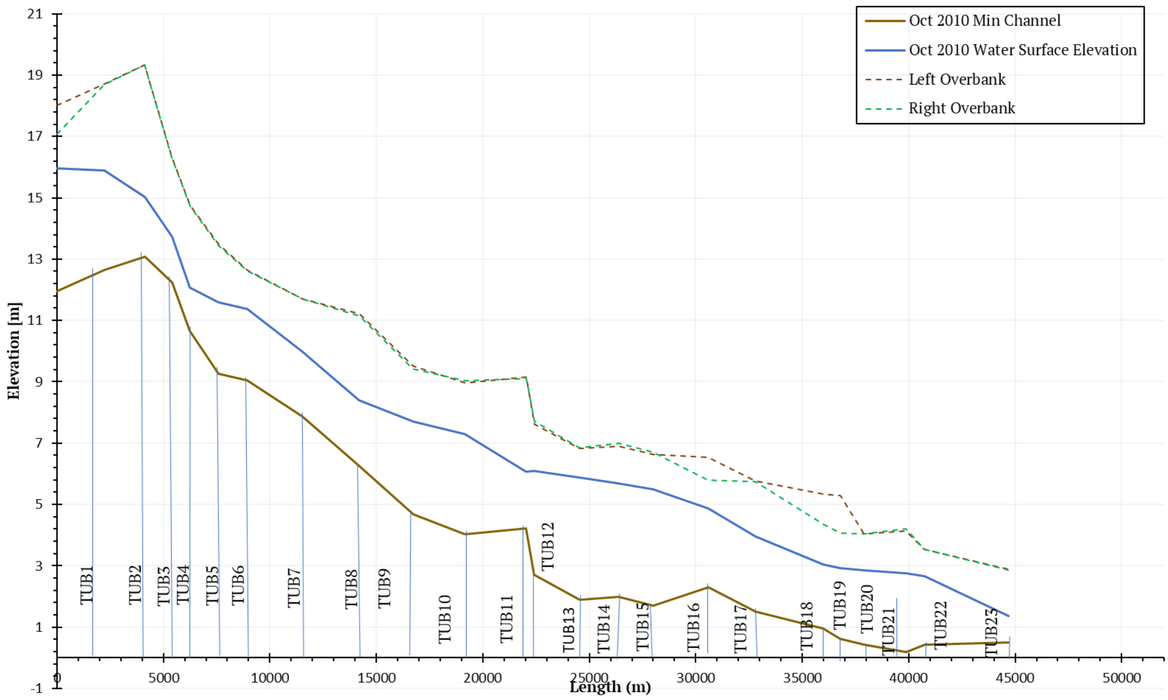
Model of The Western North Tarum Irrigation Channel

The Western North Tarum Irrigation main channel will be divided into 78 cross sections flowing from the Leuweung Seureuh Weir to the downstream, namely the B.TUB 26. These cross sections are numbered from 1 corresponding to the B.TUB 1 to number 78 corresponding to the B.TUB 26. By entering the channel station and elevation points from left to right bank in sequence along the channel, cross section coordinates were defined (Abbas et al., 2020). Each section is represented by the coordinates (X, Y), where X (the station value) is the abscissa measured from a point selected on one of the banks, and Y (the elevation value) is the ordinate measured from a horizontal plane of reference (Traore et al., 2015).

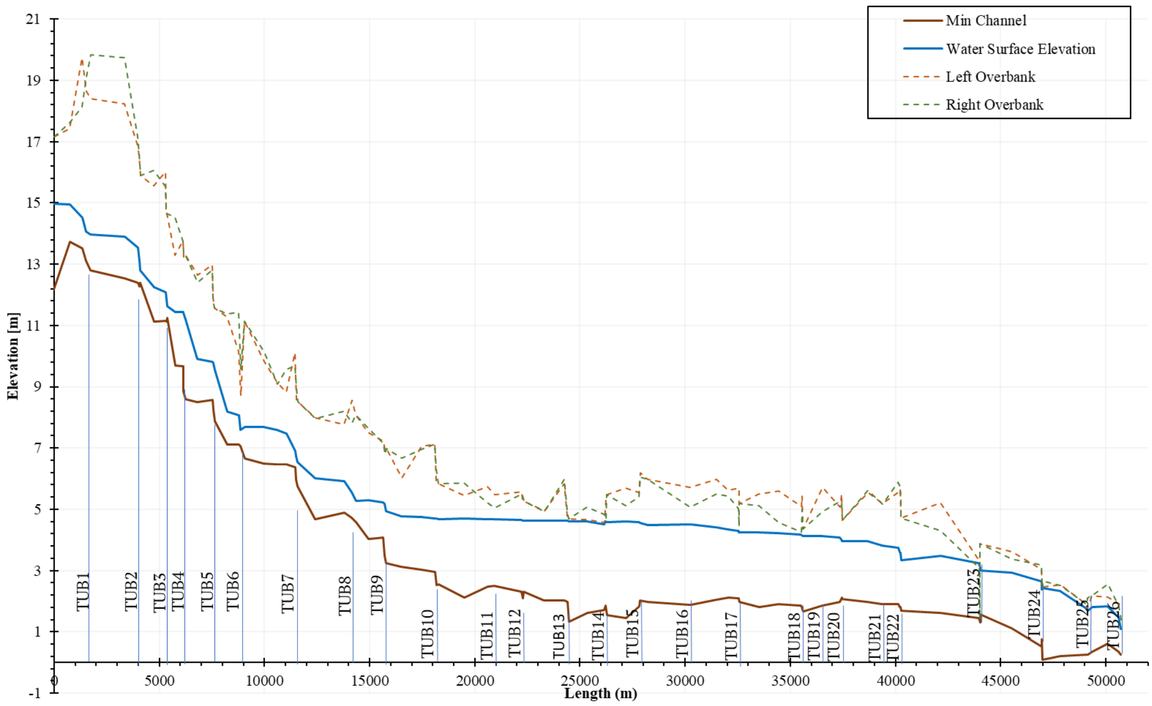
Each B.TUB will be equipped with a dividing structure modeled as an inline structure in HEC-RAS. These dividing structures will be connected to each secondary channel that functions in distributing water from main channel to each irrigation area. In HEC-RAS, the secondary channel can be represented as a lateral structure, where the channel is simulated as a side spillway on the side of the channel cross section. This spillway facilitates the distribution of water to the irrigation area. Discharge data for this channel are defined for the calculation process and to conclude the model creation after entering geometric data into the HEC-RAS software (Abbas et al., 2020).

Evaluation of Channel Capacity

Because of the decline in the capacity of the carrier channel to distribute water from the Leuweung Seureuh Weir, it is necessary to evaluate the capacity of the main channel. To evaluate the capacity of the Western North irrigation channel, supporting data such as cross-sections of the Western North Tarum irrigation channel are essential. HEC-RAS in this case is used to compute the channel capacity based on Manning equation. Two sets of irrigation channel measurements are available, conducted in October 2010 and October 2022, both performed by Perum Jasa Tirta II. These measurements can be used as a basis for comparison in evaluating the channel capacity of the Western North Tarum irrigation channel. The comparison of the two measurements can be seen in Figure 6.



(a)



(b)

Figure 6. Comparison of Channel Capacity between (a) October 2010 and (b) October 2022

According to Figure 6, there exists a difference in the channel's base elevation between the October 2010 and October 2022 measurements. Each measurement employs different benchmark measurements, which renders them incomparable based on the channel baseline. Therefore, simulations are required using the specific channel baseline for each measurement to accurately assess capacity. The simulation is conducted using HEC-RAS model. Based on Figure 6, the channel capacity in the October 2010 measurement is greater, accommodating the design water supply discharge of 40 m^3/s, while the October 2022 measurement indicates the channel capacity has been reduced to 36 m^3/s. For both simulations, the sluice gates were closed enabling water to flow solely through the main channel. On the other hand, the channel's base, as measured in October 2022, appears to have a flatter profile in the downstream compared to the upstream. As indicated in the above Figure 6, the phenomenon may be attributed to a higher rate of sediment deposition downstream, potentially impacting the channel's capacity to carry discharge (Fatxulloyev et al., 2020).

Model Calibration

Several parameters such as the channel roughness coefficient (Manning's Coefficient), the weir coefficient, and the coefficient for each sluice gate on the secondary channel, require calibration. Since no previous data are available for reference during operation, these parameters must be estimated. They will be obtained by simulating the channel using the HEC-RAS program and comparing the results with observation data. The simulation was done using varying discharge from 1 October to 15 October 2022 that represents the discharge released from B.TUB 00 (Leuweung Seureuh Weir). Through this simulation, the parameters will be adjusted to achieve optimal agreement between simulated and observed data.

Based on the simulation results, the following parameter values were determined: the channel roughness value is 0.02, the weir coefficient is 1.4, and the sluice gate coefficient is 0.65 for all sluice gates except the B.TUB 2, where it is 0.6. The value of the sluice gates opening in each channel capacity was obtained through model calibration. The calibration model is intended to compare the measured water levels with the simulated water levels obtained from the model. This calibration process is conducted using flow data measured after the gate opening of Leuweung Seureuh Weir and water level data from the Automatic Water Level Recorder (AWLR) measurement along the irrigation channel. The water level measurements were carried out for 3 days from 4 to 6 October 2022 at several B.TUB, such as B.TUB 4, 9, 13, 18, 22, and 26. The result of the sluice gates opening is shown in Figure 8. The model calibration will be adjusted based on the water level measurements taken from 4 to 6 October 2022.

Based on the calibration results that have been carried out, it has been observed that B.TUB 26 has the largest difference compared to the other B.TUBs. The difference between the calibration results and the measurement results in B.TUB 26 is 50 % as shown in Figure 9. Figure 9 shows boxplots that illustrate the simulation of Western North Tarum irrigation channel using water level measurement data from 4 to 6 October 2022, at 6 a.m., 9 a.m., 12 p.m., 3 p.m., 6 p.m., and 9 p.m. As shown in the Figure 7, the significant difference in B.TUB 26 is attributed to the overflow occurred at B.TUB 25. As a result, the measured water levels during observation are lower compared to the simulation results obtained using HEC-RAS. Therefore, these conditions contribute to a significant difference between the observation results and the calibration result.

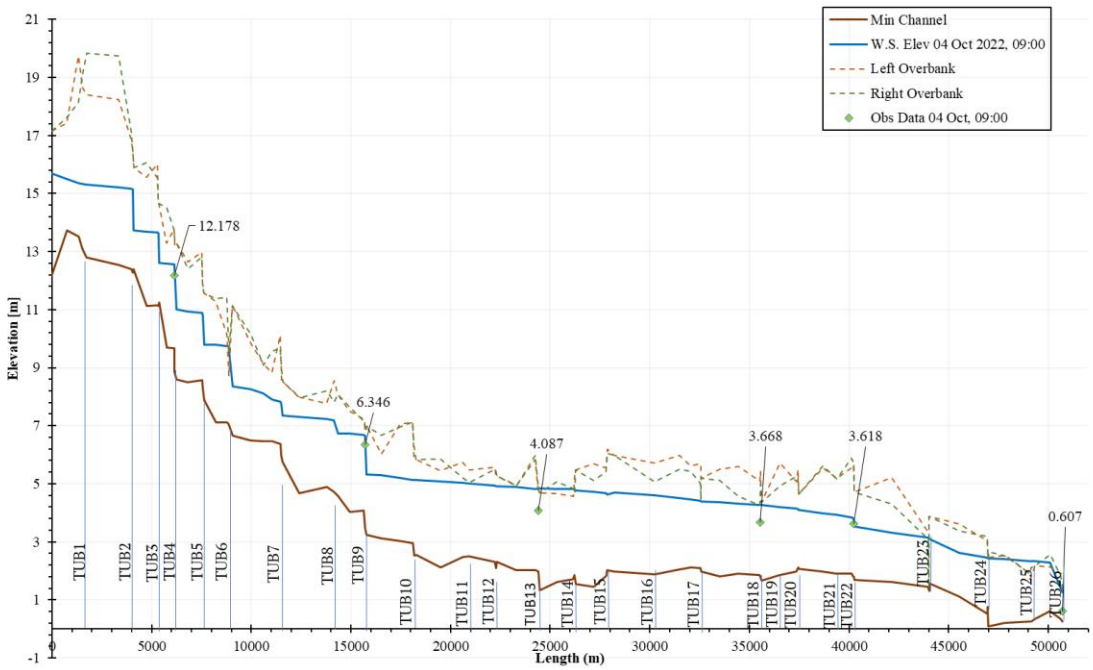


Figure 7. Model calibration based on the observation of water elevation at 9 am

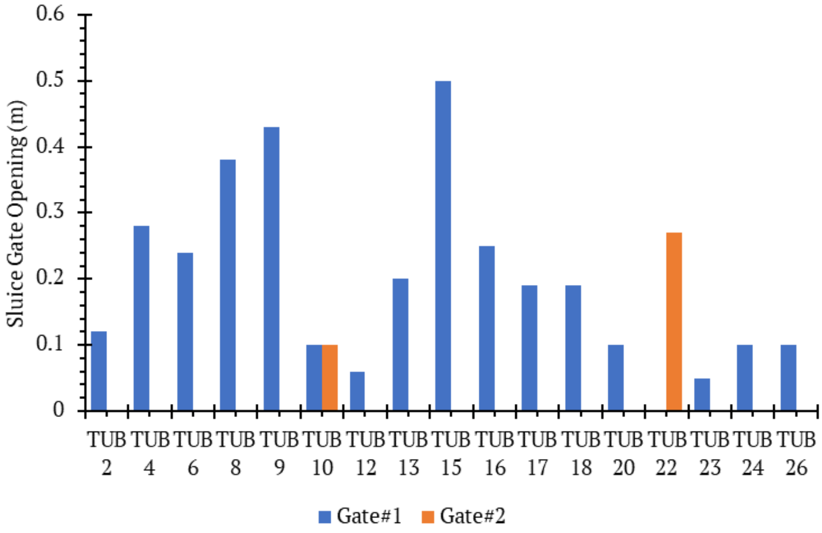


Figure 8 Sluice Gates Opening at each B.TUB

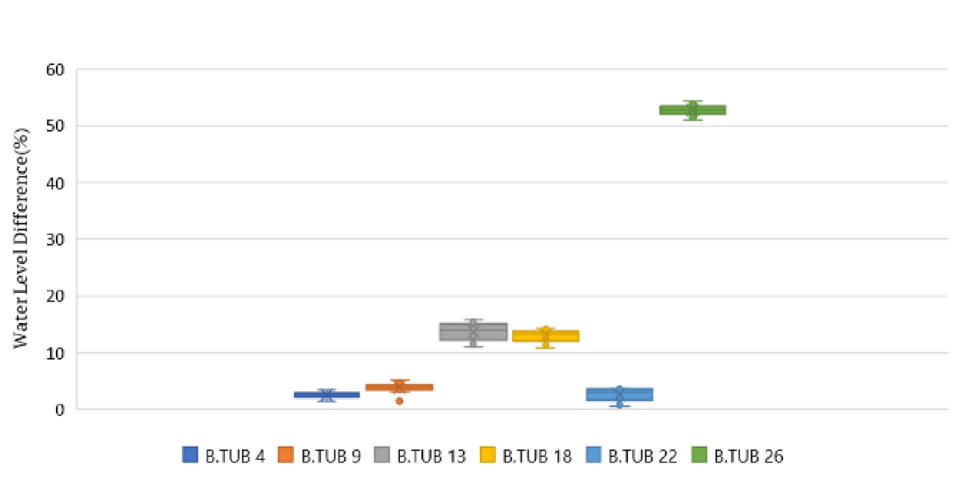


Figure 9 Water Level Difference between Simulation and Observed Results

RESULT AND DISCUSSION

Simulation of Western North Tarum Irrigation Channel

The simulation results of Western North Tarum irrigation channel can be shown in Figure 10. according to these results, only B.TUB 13 and B.TUB 25 experience overflow, while the other segments still operate within their existing capacity. The overflow in segments B.TUB 13 and B.TUB 25 is caused by the channel capacity of these segments, which cannot accommodate the flow of water intended for distribution to other segments. In addition, the presence of sedimentation downstream, especially in segments B.TUB 25, also exacerbates overflow in this segment. High levels of sedimentation downstream of the channel lead to B.TUB 25 exceeding its capacity. Moreover, sedimentation affects the slope of the channel, which changes and makes the slope inadequate in each segment. A flat or inadequate slope in the channel impedes water flow, reducing capacity and potentially causing overflow. In segment B.TUB 13, the channel slope tends to be flatter compared to other segments, with an elevation increase in the subsequent segment. Consequently, the slope of the channel becomes unsuitable for channeling water, resulting in overflow at B.TUB 13.

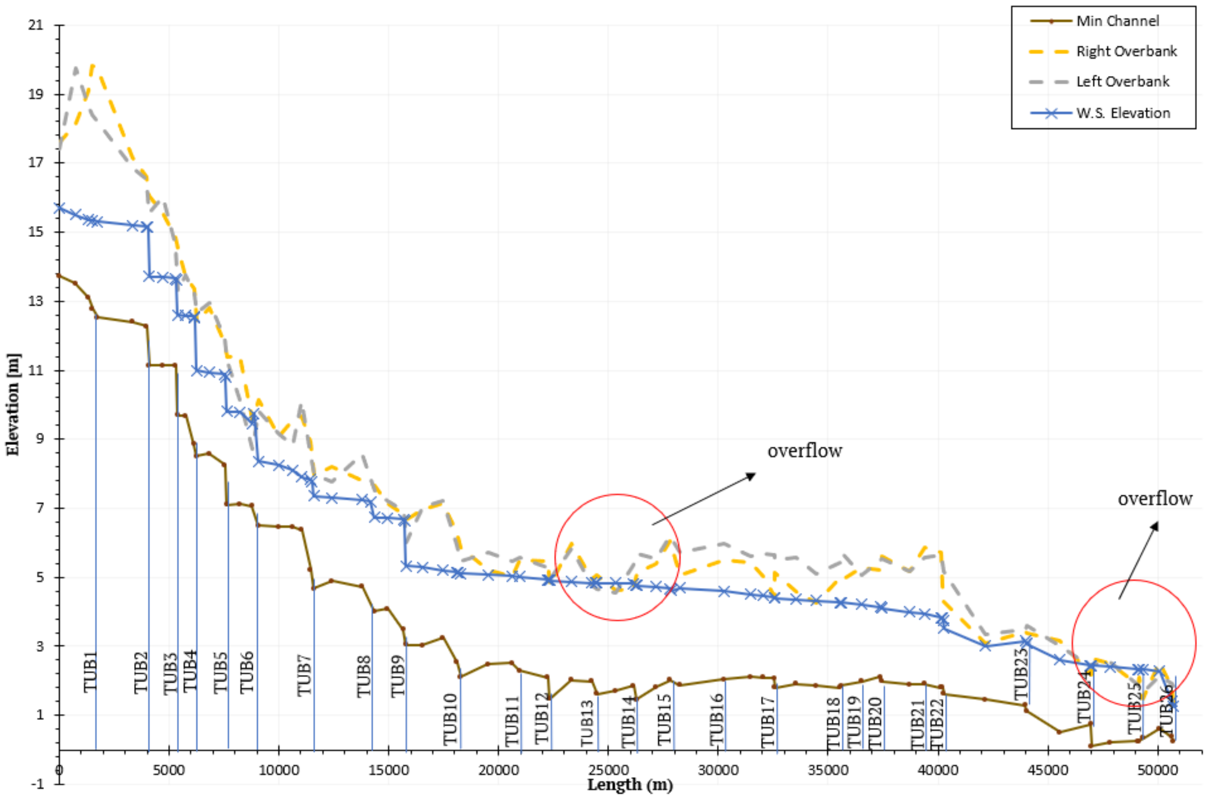


Figure 10 Simulation Results of Western North Tarum Irrigation Channel based on 2022 measurement

Evaluation of Water Loss during Water Distribution

The evaluation of water loss during water distribution in Western North Tarum Irrigation channel will be conducted by comparing the discharge simulated using HEC-RAS model with the irrigation water demands. The comparison of the simulated model and irrigation water demands will be carried out at B.TUB 2 until B.TUB 26.

Based on Table 2, it is evident that the fulfillment of water demands in Western North Tarum irrigation channel does not align the existing irrigation requirements (red color). The water distribution fails to meet the irrigation demands in most B.TUB for each half of the month. This discrepancy underscores the inefficiency of the current water distribution system and highlights the need for improvements to ensure adequate water supply for irrigation purposes.

Table 2 Water Demands Fulfillment Results

B.TUB	Month																							
	Jan1	Jan2	Feb1	Feb2	Mar1	Mar2	Apr1	Apr2	May1	May2	Jun1	Jun2	Jul1	Jul2	Aug1	Aug2	Sep1	Sep2	Oct1	Oct2	Nov1	Nov2	Dec1	Dec2
TUB 2	■	■			■	■				■	■	■	■						■					
TUB 4		■			■	■				■	■	■	■						■	■			■	
TUB 6					■	■						■	■						■	■			■	
TUB 8	■	■	■		■	■	■		■	■	■	■	■						■	■	■			■
TUB 9	■	■	■	■	■	■	■	■	■	■	■	■	■						■	■			■	
TUB 10	■	■	■	■	■	■	■	■		■	■	■	■						■	■				
TUB 12	■					■	■	■	■	■	■	■	■							■	■	■	■	
TUB 13	■									■	■	■	■	■										
TUB 15	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						■	■	■
TUB 16						■	■	■	■	■	■			■						■	■	■		
TUB 17						■	■	■	■	■	■	■	■	■						■	■	■	■	
TUB 18																								
TUB 20									■	■	■	■	■	■								■	■	■
TUB 22									■	■	■	■	■								■	■	■	
TUB 23								■	■	■	■	■	■	■	■							■	■	
TUB 24								■	■	■	■	■	■	■	■							■	■	
TUB 26	■	■	■						■	■	■	■	■	■	■	■								
Note	■	the realization of water distribution does not meet the irrigation water demand																						

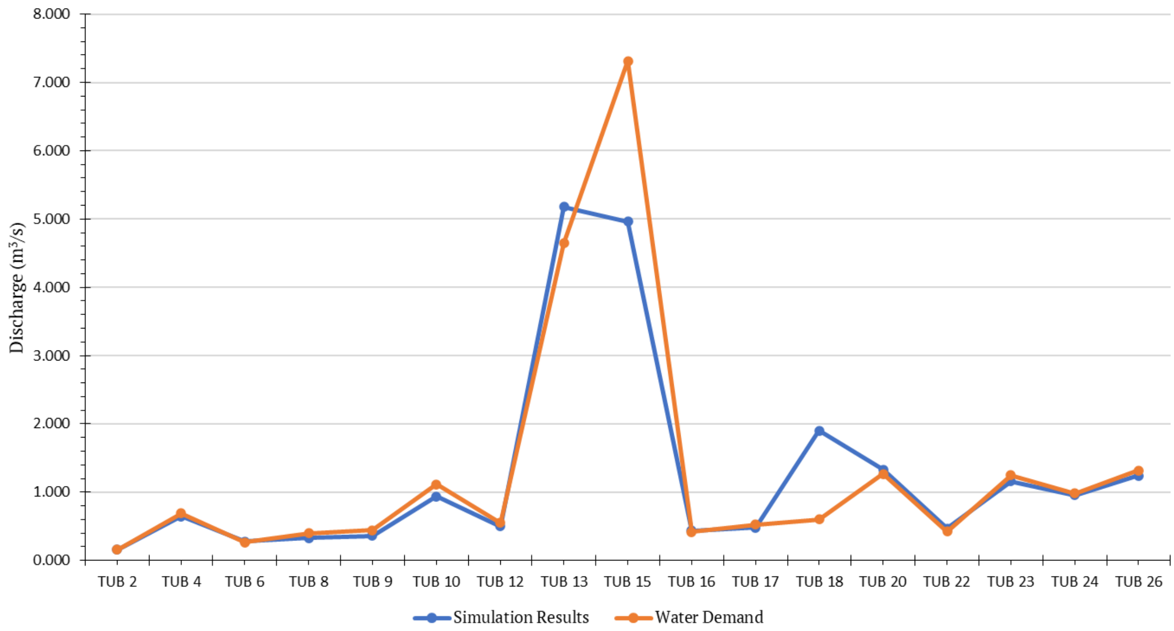


Figure 11 The Difference Between Average Simulation Results and Average Water Irrigation Demands in 2022

Figure 11 shows the comparison between average simulation results and average water irrigation demands from January to December 2022 at each B.TUB. Based on Figure 11, it can be stated that the actual water supply in some B.TUB does not align with the water irrigation demands. Since HEC-RAS used in this study does not account for water losses along the channel, the water distributed to each B.TUB should be greater than the irrigation water demand. However, it is observed that the irrigation water demands in B.TUB 13 are not fulfilled, leading to underwatering. Similar issues were observed in several B.TUB experiencing water shortages in 2022. When the water distribution falls short of the irrigation water demand, these B.TUB are prone to water losses. This discrepancy shows that the provision of water from the Leuweung Seureuh Weir is not in accordance with the water demands of each irrigation area in the Western North Tarum irrigation channel.

The difference between water supply and water irrigation demands can occur from misaligned sluice gate operations at each B.TUB, failing to meet the irrigation water demands of each area. This discrepancy contributes to water loss in the Western North Tarum irrigation channel, likely due to poor management of water distribution. Inefficient water distribution management can lead to uneven distribution through the channel, resulting in overwatering or underwatering in some areas due to improper scheduling or inadequate water measurement tools. This uneven distribution not only leads to water loss but also exacerbates issues such as waterlogging and runoff, reducing overall irrigation efficiency.

On the other side, inadequate monitoring and control further compound these challenges. Without proper monitoring and control measures in place, detecting issue like uncontrolled flow in the channels becomes challenging. Uncontrolled flow in irrigation channels can result in severe water loss and waste of valuable water resources. Additionally, inadequate irrigation channel and sluice gate maintenance can lead to inefficiencies in water distribution, adding to water losses. The absence of periodic maintenance also affects the undetected channel capacity which can lead to a decrement in overall channel capacity over time.

This study is focused on assessing the hydraulic performance of the Western North Tarum irrigation channel, with a specific emphasis on the accuracy of hydraulic simulations and their implications for water management practices. The discrepancy between the observed and simulated water surface levels in B.TUB 26 indicates that the model calibration process may not have adequately captured the complexities of real-world conditions. This difference could be attributed to various factors, including the inherent limitations of the HEC-RAS model in accurately representing water losses along the channel, such as seepage, infiltration, and evaporation, which were not considered in this particular model (Brunner, 2016; Mohammadi et al., 2019). The simulation of the Western North Tarum irrigation channel also reveals instances of overflow in B.TUB 13 and B.TUB 25, as well as the impact of sedimentation on channel capacity. These issues contribute to water loss during distribution. The assessment of water loss during distribution highlights the inefficiencies of the water distribution system, as demonstrated by the disparities between simulated discharges and water demands.

Additionally, the Western North Tarum irrigation channel experiences significant water loss due to overflowing in certain B.TUB, resulting in various impacts on agricultural productivity and environmental sustainability in the area. The overflowing leads to waterlogging in nearby fields, which adversely affects crop yields. Moreover, the overflows at B.TUB 13 and 25 cause erosion of the channel banks and surrounding areas, potentially leading to sediment deposition in the channel and downstream regions. These issues also obstruct the irrigation system, reducing the efficiency of water distribution in the Western North Tarum irrigation channel.

CONCLUSIONS

The assessment of the Western North Tarum irrigation channel's capacity and the subsequent examination reveal a complex interaction of factors that contribute to both water shortages and overflowing issues. A comparison of the channel's capacity measurements in October 2010 and October 2022, demonstrates a significant decrease in the channel's capacity over time. This decline is partially due to sediment accumulation, which levels the channel's bed, particularly in the downstream areas, thus diminishing its efficiency in water conveyance. The simulation results of Western North Tarum irrigation channel, further emphasize the issue, indicating that only specific sections (B.TUB 13 and B.TUB 25) face overflowing, while others function within their designated capacity. This overflow is exacerbated by sedimentation, which not only reduces the channel's slope but also leads to water loss.

The evaluation of water loss during water distribution further complicates the situation. The comparison of simulated discharges with irrigation water demands, reveals that the water distribution system fails to meet the irrigation demands in most B.TUB for each half of the month. This inefficiency is compounded by the model's inability to account for water losses, leading to both under-irrigation and overflow in certain segments.

In conclusion, the analysis reveals a critical mismatch between the irrigation water demands and the actual water supply, exacerbated by the inability of the HEC-RAS model to accurately account for water losses due to seepage, infiltration, and evaporation. The sedimentation and the resulting changes in the channel's slope and capacity further complicate the situation, leading to both water shortages and overflow in different segments of the irrigation channel. These findings underscore the need for a more comprehensive approach to managing water distribution in the Western North Tarum irrigation channel, including the development of more accurate models that account for water losses and the implementation of strategies to mitigate sedimentation and improve the channel's capacity and efficiency.

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