https://doi.org/10.35877/jetech3699

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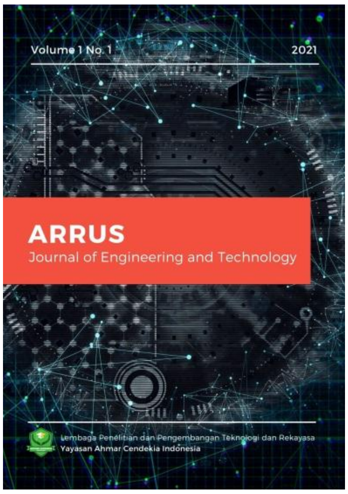
ISSN : 2776-7914 (Print) / 2807-3045 (Online)



RESEARCH ARTICLE

Performance Analysis and Actual Needs Figures for Operation and Maintenance at D.I.R. Sebakung

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Abstract: East Kalimantan has great potential as a food production center in Indonesia, supported by the Sebakung Swamp Irrigation Area (DIR) which covers an area of 13,500 hectares with a functional area of 10,290 hectares. However, inefficient irrigation management and inadequate infrastructure maintenance have resulted in suboptimal land use and decreased agricultural productivity. This study aims to analyze the performance of the existing irrigation network and determine the budget required for its operation and maintenance. The study was conducted using field observations and regulatory guidelines, including Ministerial Regulation No. 12/PRT/M/2015 and No. 23/PRT/M/2017. The results of the study indicate that most irrigation channels are below Index 3, indicating significant sedimentation and vegetation growth that inhibits water flow. The overall channel condition index is 2.10 with a network functional level of 72.50%, while several water gates in certain villages are severely damaged with an Index classification of 4. The total operational cost of managing the irrigation network is IDR 292,300,000.00 which includes personnel incentives, monitoring, office operations, and equipment maintenance. Routine and periodic maintenance costs vary, with the highest budget allocated to Sri Raharja and Babulu Laut, totaling more than IDR 187,200,000.00. To improve irrigation performance, systematic management strategies such as routine dredging, vegetation control, and rehabilitation of priority infrastructure must be implemented. These efforts will improve irrigation efficiency, ensure optimal water distribution, and support agricultural productivity in East Kalimantan.

Keywords: Swamp Irrigation, Infrastructure Performance, Maintenance Cost, Water Management

1. Introduction

East Kalimantan has great potential as one of the main food production centers in Indonesia, especially with the Sebakung Swamp Irrigation Area (DIR), which has a potential area of 13,500 hectares and a functional area of about 10,290 hectares (Ministry of Agriculture, 2020). This area, located in Babulu District, North Penajam Paser Regency, plays an important role in maintaining food security, especially in the cultivation of rice and secondary crops. However, the sustainability of this irrigation network faces various challenges, especially in the management and maintenance of water infrastructure which is still not optimal (Ministry of Public Works and Public Housing, 2019). Inefficiencies in irrigation operations have led to decreased land productivity and less than optimal agricultural yields (Firmansyah, 2022). In addition, the conversion of agricultural land into oil palm plantations and coal mining is

ISSN : 2776-7914 (Print) / 2807-3045 (Online)

increasingly threatening the availability of productive land (Satriyo, Mulyadi, & Wulandari, 2024).

The operation and maintenance (O&M) of irrigation networks is a key factor in ensuring their sustainability. Based on the Regulation of the Minister of Public Works and Public Housing (PUPR) No. 12 of 2015, proper exploitation and maintenance of irrigation networks is essential to support effective water distribution (Regulation of the Minister of Public Works and Public Housing, 2015). In addition, the PUPR Minister Regulation No. 23 of 2017 emphasizes the importance of the Operation and Maintenance Value Needs Figure (AKNOP) as a key metric in determining the budget and activities required for swamp irrigation maintenance (Central Statistics Agency, 2021). Previous studies have examined various aspects of irrigation management and risk mitigation. Armandoko (2023) identified the risks faced by contractors in irrigation projects and the mitigation strategies that can be applied. Meanwhile, Purbawijaya (2016) analyzed the risks in the rehabilitation of irrigation networks, highlighting the need for strategic planning. Kurniawan, Prayogo, and Wahyuni (2021) examined irrigation asset management strategies to improve irrigation system performance. Rohman (2018) developed an irrigation maintenance priority method, which can be applied to the Sebakung region. These studies provide a strong foundation for analyzing the performance of existing irrigation networks and determining the necessary budget for O&M activities in the Sebakung DIR. With a data-based approach that follows standard planning guidelines, this research aims to make a real contribution to more effective swamp irrigation management to support food security and increase agricultural productivity in East Kalimantan (Ministry of Public Works and Public Housing, 2021).

2. Research Method and Materials [11pt, Garamond, Bold, Justified]

2.1. Study Location

This research location is in the Sebakung Swamp Irrigation Area (DIR), which includes several villages in Babulu District, North Penajam Paser Regency, and Paser Regency, East Kalimantan Province. Gunung Makmur Village (coordinates -1.5675°, 116.3808°) has a 2600-meter long primary canal with a base width of 17 meters, a height of 10 meters, and a base slope of 0.0001 meters. Gunung Mulia Village (coordinates -1.544167°, 116.420000°) has a 1000-meter long canal, with a base width of 9 meters and a height of 5 meters. Rawa Mulia Village (coordinates -1.5680°, 116.4620°) has a 6000-meter long primary canal with a base width of 9 meters and a height of 5 meters. Sri Raharja Village consists of two locations, with the first primary canal being 5000 meters long (coordinates -1.5692°, 116.4403°) and the second being 5400 meters long (coordinates -1.5674°, 116.4551°). Sumber Sari Village has two locations, the first at coordinates -1.5696°, 116.4482° with a primary canal length of 5400 meters and the second at coordinates -1.5690°, 116.4338° with a canal length of 5000 meters. Sebakung Makmur Village (coordinates -1.5688°, 116.4196°) has a 2900-meter long primary canal, while Babulu Laut Village has two locations with primary canal lengths of 2800 meters each at coordinates -1.3054°, 116.2956° (first location) and -1.3040°, 116.2953° (second location). All canals in these locations show moderate sedimentation problems and aquatic plants that interfere with their function.

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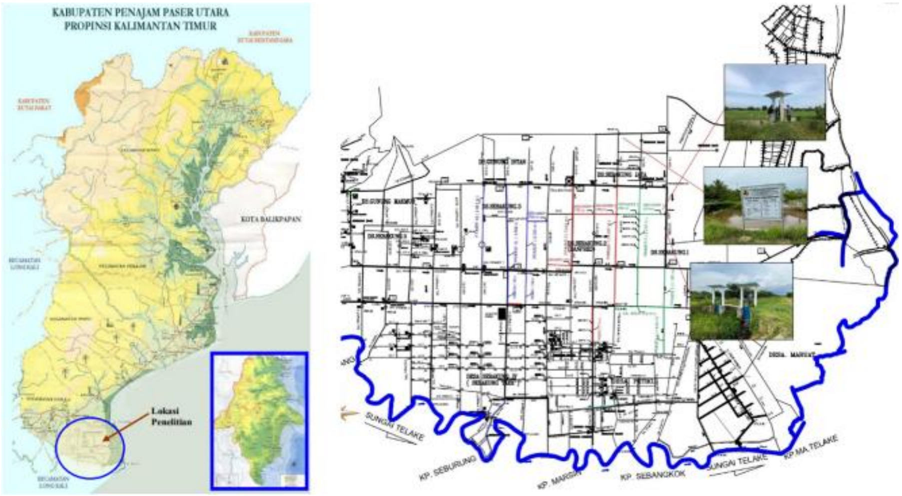

Figure 1: Research Location.

2.2. Irrigation Network Infrastructure Function Assessment Criteria

The assessment of the functional condition of irrigation network infrastructure can be done in the following way:

Irrigation channel indicator I_s is the length of the channel that functions well S_f / total channel length S_t then multiplied by its weight.

Or: $I_s = \frac{S_f}{S_t}$ x weight

Building indicator I_b is the number of buildings that function well B_f / total number of buildings B_t then multiplied by its weight.

Or: $I_b = \frac{B_f}{B_t}$ x weight

After the value of each indicator is known, the percentage of the physical condition of the infrastructure is calculated using the formula:

Functional condition of infrastructure $= \frac{B_f}{B_t}$

Table 1: Functional Condition Criteria for Irrigation Networks

No	Kondisi Fungsional Infrastruktur	Criteria
1	Functional level of the network > 80%	Good
2	Functional level of the network 40% - 80%	Fair
3	Functional level of the network 20% - 40%	Poor
4	Functional level of the network < 20%	Non-functional

Source: PU Regulation Number 13/PRT/M/2012

2.3. Operating Costs

(1). Incentives
- (a). Observer: Number of observers x 12 x Rp………/month
- (b). Technician: Number of technicians x 12 x Rp………/month
- (c). Water Resources Management Officer (PPA): Number of PPAs x 12 x Rp………/month
- (d). Observer Staff: Number of staff x 12 x Rp………/month

(2). Official Travel of Observers and Irrigation Technicians
- (a). Monitoring
  - (1). Observer: Number of observers x frequency x Rp………/day

(2). Technician: Number of technicians x frequency x Rp………/day

(b). Meetings (to regency/city/province/River Basin Agency)

(1). Observer: Number of observers x frequency x Rp………/day

(2). Technician: Number of technicians x frequency x Rp………/day

(3). Office Operations (as needed)

(c). Electricity: 12 x Rp………/month

(d). Telephone: 12 x Rp………/month

(e). Water: 12 x Rp………/month

(f). Office Supplies: 12 x Rp………/month

(g). Survey Materials: 12 x Rp………/month

(4). Equipment Operations (as needed)

(a). Motorcycle: Number of motorcycles x 12 x Rp………/month

(b). Generator Set: Number of generator sets x 12 x Rp………/month

(c). Lawn Mower: Number of lawn mowers x 12 x Rp………/month

(d). Others:............ x 12 x Rp………/month

2.4. Maintenance Fee

(1). Routine Maintenance

$$Ps = \frac{n}{k} \cdot f \cdot u$$
$$Pr = \frac{p\,x\,l}{k} \cdot f \cdot u$$
$$Psal = \frac{p\,x\,l}{k} \cdot f \cdot u$$
$$Pt = \frac{p\,x\,l}{k} \cdot f \cdot u$$
$$Pb = (Hb + u) \cdot n \cdot f$$

Description:

Ps = cleaning garbage in front of water structures; Pr = grass cutting; $Psal$ = channel cleaning; Pt = embankment maintenance; Pb = water structure maintenance; Hb = cost of materials/buildings; n = number of buildings functioning in one scheme (bh); k = capacity (bh/hr); f = frequency/yr; u = daily wages (Rp/hr); p = length (m) and l = average width (m);

(2). Routine Maintenance

$$Pl = \frac{p\,x\,l\,x\,t}{k} x\,f\,x\,u$$

Description:

Pl = Dredging (m3); p = length (m); l = average width (m); t = sediment height (m); k = capacity (m2/hr); f = frequency/yr and u = wage/day (Rp/hr)

2.5. Total Operation and Maintenance Costs

The overall O&M costs are as follows:

$$Total\ Biaya\ O\ \&\ P\ =\ O\ +\ PR\ +\ PB$$

Note:

O = operation; PR = routine maintenance and PB = periodic maintenance

This cost estimation formula follows the Regulation of the Minister of Public Works No. 13/PRT/M/2012, which provides technical guidelines for irrigation infrastructure management and financial planning. The regulation emphasizes the need for sustainable water resource management, ensuring optimal irrigation performance and structural integrity through systematic maintenance and operation.

https://doi.org/10.35877/jetech3699

ISSN : 2776-7914 (Print) / 2807-3045 (Online)

3. Results and Discussion

3.1. Channel Performance Index

The functional condition of the channel infrastructure includes the number, dimensions, types, and physical condition of the irrigation network, the evaluation is carried out referring to the Regulation of the Minister of Public Works and Public Housing Number 12/PRT/M/2015. The results of the functional condition assessment of the channel infrastructure are displayed in the form of a channel performance index, with criteria that have been adjusted based on the regulation. Details of the evaluation results can be seen in Figure 2 below.

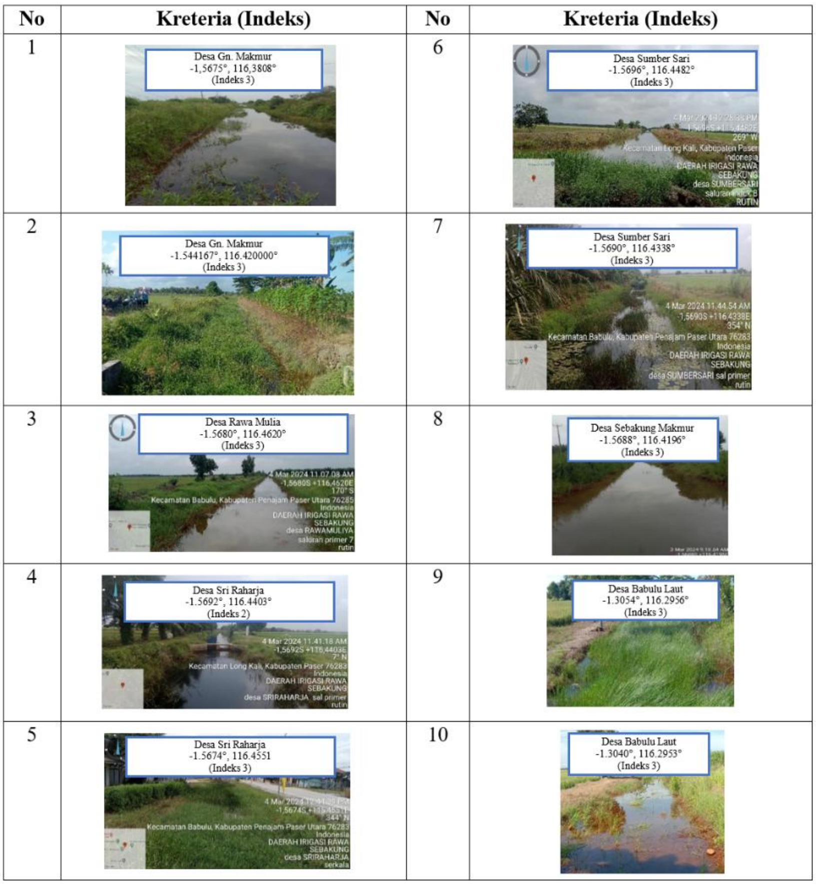

Figure 2. Channel Performance Index Based on Functional Conditions

Based on Figure 2, the assessment of the channel performance index was carried out to assess the functional condition of the irrigation network infrastructure in a number of villages. The results of the analysis show that the majority of locations have a performance index in the Index 3 category, which reflects significant disruption to the function of the channel. This disruption is caused by moderate sedimentation and the growth of aquatic plants that affect the wet cross-section, so that the function of the channel is not optimal. Sri Raharja Village (the first location) is the only location that has an Index 2, indicating relatively mild disruption compared to other locations. Meanwhile, villages such as Gunung Makmur, Gunung Mulia, Rawa Mulia, Sumber Sari, Sebakung Makmur, and Babulu Laut show a similar pattern of problems, namely the incompatibility of the channel conditions with the original design, which causes a decrease in operational effectiveness.

3.2. Building Performance Index

https://doi.org/10.35877/jetech3699

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The condition of water structures in swamp irrigation networks is one of the important components that affect the effectiveness and sustainability of the irrigation system. Assessment of the functional condition of water structures is carried out to understand the performance level of important elements such as floors/foundations, walls, wings, and water gates in swamp irrigation networks. This analysis aims to determine the performance index category of each structure based on the level of damage and functionality. The assessment results are presented in Figure 3. as follows.

No	Dokumentasi	Kreteria (Indeks)	No	Dokumentasi	Kreteria (Indeks)
1.		• Pondasi (1) • Dinding (1) • Sayap (1) • Pintu Air (2)	8.		• Pondasi (1) • Dinding (1) • Sayap (1) Pintu Air (2)
2.		• Pondasi (1) • Dinding (1) • Sayap (1) • Pintu Air (4)	9.		• Pondasi (1) • Dinding (1) • Sayap (1) Pintu Air (4)
3.		• Pondasi (1) • Dinding (1) • Sayap (1) • Pintu Air (4)	10.		• Pondasi (1) • Dinding (1) • Sayap (1) Pintu Air (4)
4.		• Pondasi (1) • Dinding (1) • Sayap (1) • Pintu Air (3)	11.		• Pondasi (1) • Dinding (1) • Sayap (1) • Pintu Air (4)
5.		• Pondasi (3) • Dinding (1) • Sayap (1) • Pintu Air (1)	12.		• Pondasi (3) • Dinding (1) • Sayap (1) • Pintu Air (3)
6.		• Pondasi (1) • Dinding (Indeks 1) • Sayap (1) • Pintu Air (2)	13.		• Pondasi (1) • Dinding (1) • Sayap (1) • Pintu Air (2)
7.		• Pondasi (1) • Dinding (1) • Sayap (1) • Pintu Air (2)			

Table 3 : Building Performance Index Based on Functional Conditions

Figure 3 shows that most of the concrete floors/foundations, walls, and wings are in good condition without significant damage, with the majority having an Index of 1, reflecting optimal performance. However, the condition of the floodgates varies. Several locations, such as Gunung Mulia Village and Sumber Sari Village, recorded an Index of 4 for the floodgates, indicating severe damage that cannot be repaired. On the other hand, several floodgates in other locations, such as Gunung Makmur Village and Sebakung Makmur Village, had an Index of 2, indicating moderate damage that can still be used with repair. In addition, the floors/foundations in Rawa Mulia Village and Sumber Sari Village showed an Index of 3, indicating minor damage.

3.3. Assessment Of Irrigation Network Conditions

The assessment of the condition of the irrigation network in the Swamp Irrigation Area (DIR) was carried out using two main parameters, namely the Condition and Function Index, which were applied to the channels and water structures. The results of combining these two parameters provide a comprehensive picture of the overall performance of the irrigation network. A summary of the assessment results is presented in Table 2, which not only shows

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the condition and function of the network, but also recommends repair and maintenance actions based on the results of the index analysis.

Table 2. Calculation of Irrigation Network Index in Sebakung Swamp Irrigation Area (DIR)

No.	Village	Channel	Index	Weight	Total Index	Channel Function
1.	Gunung Makmur	Primary Channel 1	1.33	3.00	4.00	72.50%
2.	Gunung Mulia	Primary Channel SK10-SP1	3.00	3.00	9.00	
3.	Rawa Mulia	Main Channel	1.33	3.00	4.00	
4.	Sri Raharja	Primary Channel 1A	1.67	3.00	5.00	
5.	Sri Raharja	Primary Channel 1B	2.67	3.00	8.00	
6.	Sumber Sari	Primary Channel 2	2.00	3.00	6.00	
7.	Sumber Sari	Primary Channel 1	2.33	3.00	7.00	
8.	Sebakung Makmur	Primary Channel SK4-SP2	1.33	3.00	4.00	
9.	Babulu Laut	Primary Channel 3 Ki BB	3.00	3.00	9.00	
10.	Babulu Laut	Primary Channel 2 Ki BB	2.33	3.00	7.00	
TOTAL				30.00	63.00	2.10
PERIODIC MAINTENANCE						

The results of the performance assessment of the swamp irrigation network in the Sebakung Swamp Irrigation Area (DIR) show that the network in the 13,500 hectare reclamation area has a Channel Condition Index of 2.10 and a network function level of 72.50%. Based on the criteria of the PU Ministerial Regulation Number 13/PRT/M/2012, this network is included in the Less category, which indicates the network's ability to regulate water management in most of the reclamation area even though there is damage to several components. This damage, if not addressed, has the potential to reduce the overall efficiency of the network.

3.4. Requirements For Operational Personnel D.I.R Sebakung

In the management of swamp irrigation networks, the need for operational personnel is determined based on the criteria listed in PUPR Regulation No. 12/PRT/M/2015. This regulation is designed to ensure that the number and role of personnel are in accordance with the area managed and the complexity of the irrigation infrastructure. The results of the calculation of the need for operational personnel for the Sebakung Swamp Irrigation Area are presented in Figure 4 as follows:

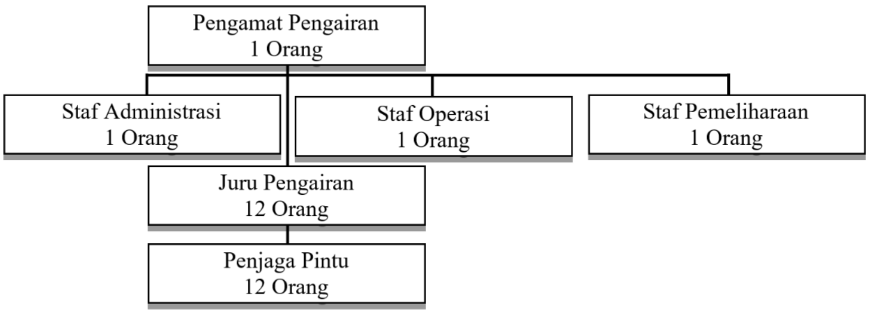

Figure 4. Organizational Structure of D.I.R Sebakung Operations Personnel Needs

3.5. Operating Costs

The operating costs in managing swamp irrigation networks consist of several main components that support operational activities and the sustainability of network functions. One important component is incentives for observers, irrigation officers, Water Gate Officers (PPA), and other supporting staff. The next component includes office operating costs, which include routine needs such as electricity, telephone, water, office stationery (ATK), survey materials, and other equipment.

Based on the calculation of the operating costs of the Rawa Sebakung Irrigation Area, with a total allocation of Rp292,300,000.00 covering four main components: incentives, official travel, office operations, and equipment operations. Incentives for observers, irrigation officers, and staff are the largest component with a budget of Rp117,600,000.00 which aims to support personnel performance in managing the irrigation network. In addition, official travel for monitoring and coordination costs Rp67,000,000.00 including travel costs to districts/cities and Jakarta for training and monitoring. Other components include office operations of Rp15,300,000, which includes needs such as stationery and telephones, and equipment operations of Rp73,200,000, including the use of generators, and network maintenance tools. Equipment operational costs are the second largest, with a focus on supporting field activities. With this structured budget distribution, the management of the swamp irrigation network can run effectively, ensuring the maintenance and function of the network in supporting optimal water governance.

3.6. Maintenance Cost Budget Plan

3.6.1. Routine Maintenance Budget Cost

The budget plan for routine maintenance is prepared based on the specific needs of each village in the Rawa Sebakung Irrigation Area as shown in Figure 5.

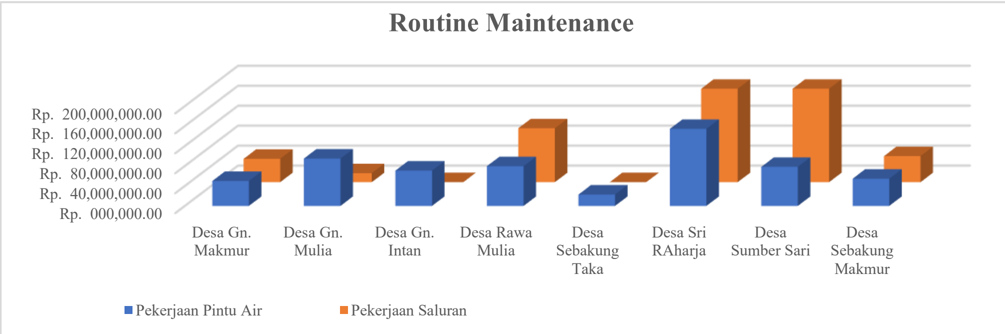

Figure 5. Routine Maintenance Cost Chart

The graph in Figure 5 shows the allocation of routine maintenance costs showing the variation in needs in each village in the Rawa Sebakung Irrigation Area. For the sluice gate work, Sri Raharja Village recorded the highest allocation of Rp154,383,924.14, followed by Gunung Mulia Village with Rp94,787,609.65 and Rawa Mulia Village with Rp79,675,066.87. In contrast, Sebakung Taka Village had the lowest allocation, which was Rp22,822,842.60, reflecting a smaller scale of sluice gate maintenance.

In channel work, Sri Raharja Village and Sumber Sari Village have the highest cost allocation of Rp187,200,000.00 each, indicating intensive needs for handling sedimentation and aquatic plants. Rawa Mulia Village and Sebakung Makmur Village allocated Rp108,000,000.00 and Rp52,200,000.00 respectively, while Gunung Intan Village and Sebakung Taka Village did not have an allocation for channel work, indicating no need or priority for maintenance in this aspect.

3.6.2. Periodic Maintenance Budget Cost

Periodic maintenance is an essential element in ensuring the sustainability of the function of the swamp irrigation network in the Rawa Sebakung Irrigation Area. In the swamp irrigation network in the Rawa Sebakung Irrigation Area, not all villages have carried out periodic maintenance derived from the results of the search survey but only in 2 villages. The Periodic Maintenance Cost Plan can be seen in Figure 6 as follows:

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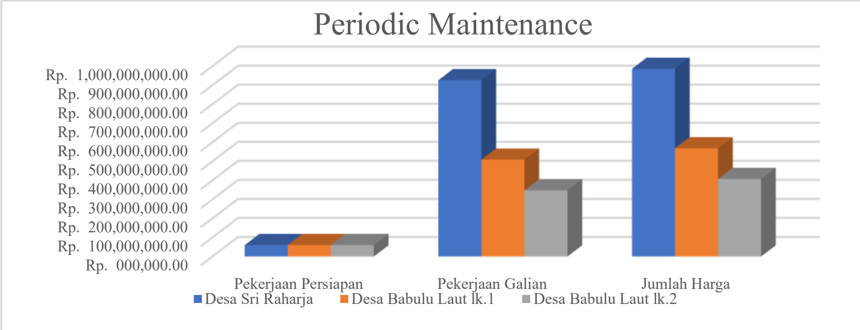

Figure 6: Periodic Maintenance Cost Chart

Figure 6 shows that the maintenance costs consist of preparation work (mobilization and demobilization) and mechanical excavation work. Sri Raharja Village has the highest cost allocation with a total of IDR 986,370,699.81, which is dominated by mechanical excavation work with a volume of 28,950 m³. Babulu Laut Village is divided into two work locations, with a total cost of IDR 568,727,832.88 for Location 1 and IDR 407,781,730.24 for Location 2. In both locations, the preparation work has the same budget, which is IDR 60,000,000.00, while the excavation work costs vary depending on the volume of work carried out. Location 1 has an excavation volume of 15,898 m³ with a total cost of Rp 508,727,832.88, while Location 2 has a smaller excavation volume, namely 10,869 m³, with a cost of Rp 347,781,730.24.

4. Conclusion

The performance of the Sebakung Swamp Irrigation Area (DIR) in East Kalimantan is categorized as "Poor" with a Condition Index of 2.10 and a function level of 72.50%, mainly due to sedimentation and wild vegetation growth that impede water flow. Although most of the irrigation structures are in good condition, severe damage to the water gates in Gunung Mulia and Sumber Sari Villages reduces the efficiency of water regulation.

The total operational cost of the irrigation network is IDR292,300,000, including labor incentives, monitoring, office operations, and equipment maintenance. Routine and periodic maintenance costs vary by village, with Sri Raharja and Babulu Laut Villages requiring the highest budget, reaching more than IDR187,200,000.00. To improve performance, routine dredging, vegetation control, and priority rehabilitation of damaged water gates are needed, while optimizing the maintenance budget for long-term sustainability.

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