Journal of
Advanced Civil and Environmental Engineering
Vol.9, No.1, 2026, pp 1-15
ISSN: 2599-3356
DOI: http://dx.doi.org/10.30659/jacee.9.1.1-15

Analysis of Irrigation Network Operation and Maintenance Performance Improvement in Solok Regency

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(**Received:** 5th Ferbuary 2026 ; **Revised:** 12th May 2026 ; **Accepted:** 18th May 2026)

Abstract: Agricultural development is one of the main priorities in supporting sustainable food security, which requires integrated resource management and adequate infrastructure support. Solok Regency is one of the regions that plays a strategic role in supporting national food security; therefore, the performance of irrigation network operation and maintenance is a crucial factor in ensuring the sustainability of agricultural production. However, the implementation of irrigation network operation and maintenance in this region still faces various challenges that potentially reduce the reliability of irrigation services. This study aims to identify problems related to irrigation network operation and maintenance, evaluate their performance, and formulate strategies to improve irrigation network performance in Solok Regency. The urgency of this study is based on the importance of improving irrigation performance as a key support for agricultural productivity and regional food security. This study employs a descriptive qualitative approach, with data collected through field observations, interviews, and document analysis in several irrigation areas. Irrigation system performance was evaluated using the ePAKSI application to obtain the Irrigation System Performance Index (IKSI), while strategy formulation was conducted using SWOT analysis supported by IFAS and EFAS analyses. The results indicate that the operation and maintenance performance of irrigation networks in Solok Regency remains in the poor category, influenced by limited budgets, physical deterioration of irrigation infrastructure, insufficient human resources, suboptimal routine maintenance, and low participation of Water User Associations (P3A). The recommended strategy for performance improvement is the Weaknesses–Opportunities (W–O) strategy, which emphasizes leveraging external opportunities to address internal weaknesses in order to achieve sustainable improvements in irrigation performance.

Keywords: Irrigation network; Operation and maintenance performance; IKSI; e-PAKSI; SWOT

1. Introduction

Agricultural sector development remains a top priority in efforts to achieve sustainable food security in Indonesia. As an agrarian country, the success of food production largely depends on the optimization of natural resources, the quality of human resources, and adequate agricultural infrastructure support [1]. In this context, the role of local governments becomes crucial in effectively managing regional potential, particularly in areas with comparative advantages in food crop agriculture [2].

Solok Regency is one of the regions that plays an important role in supporting national food security, particularly through rice as its leading commodity [3]. Solok rice is well known for its high quality and has obtained Geographical Indication (GI) certification. A Geographical Indication is a sign that identifies the origin of a product whose quality, reputation, and characteristics are essentially attributable to geographical factors, including natural factors, human factors, or a combination of both.

Based on data from the Central Statistics Agency [4], rice production in Solok Regency reached 182,203 tons in 2023. This achievement indicates that the agricultural sector, particularly rice cultivation, remains the backbone of the regional economy. The relatively large area of agricultural land requires a reliable irrigation system to ensure that water distribution reaches all paddy fields, including those located in downstream areas of the irrigation network.

Table 1. Agricultural Production in Solok Regency

Crop Types	2022			2023		
	Planted Area	Harvested Area	Production	Planted Area	Harvested Area	Production
Padi Sawah	-	32,902.0	179,316.0	-	34,691.0	182,203.0
Padi Ladang	-	-	-	-	-	-
Jagung	415.7	260.9	2,062.4	517.3	322.8	2,529.9
Ubi Kayu	229.9	229.4	8,958.6	241.4	226.7	8,862.3
Ubi Jalar	1,335.0	1,178.8	54,524.2	1,173.2	1,293.0	59,932.8
Kacang Tanah	119.4	110.0	229.5	120.6	121.5	251.3
Kacang Kedelai	-	-	-	-	-	-
Kacang Hijau	-	-	-	-	-	-

Source : Statistics Indonesia (BPS), Horticultural Agricultural Statistics

Based on the table above, it can be seen that agricultural activities in Solok Regency cover a relatively extensive area. Therefore, to support food security, particularly in the rice cultivation sector, a well-functioning irrigation system is required to ensure adequate water distribution reaches paddy fields located in the farthest downstream areas of the irrigation network.

Table 2. Distribution of Paddy Field Areas in Solok Regency

Subdistrict	Irrigation Type					
	Technical Irrigation	Semi-Technical Irrigation	Simple Irrigation	Non-Public Works Irrigation	Rainfed	Total
Pantai Cermin	720.00	88.0	342.0	513.31	-	1,663.31
Lembah Gumanti	-	217.03	449.77	-	-	666.80
Hiliran Gumanti	-	-	473.00	793.49	59.00	1,325.49
Payung Sekaki	525.00	-	227.00	80.53	-	832.53
TIgo Lurah	-	-	665.00	442.05	10.00	1,117.05
Lembang Jaya	839.00	293.82	41.00	125.06	-	1,298.88
Danau Kembar	-	-	-	23.01	-	23.01
Gunung Talang	608.00	1,673.00	796.84	-	-	3,077.84
Bukit Sundi	1,730.00	596.00	6.00	316.13	-	2,648.13
IX Koto Sungai Lasi	128.00	75.00	470.83	-	-	671.83
Kubung	1,330.00	1,002.00	80.00	193.63	284.00	2,889.63
X Koto Diatas	-	113.00	1,014.00	220.91	91.00	1,438.91
X Koto Singkarak	650.00	392.00	784.95	410.79	122.33	2,360.07
Junjung Sirih	109.00	381.74	27.27	-	30.00	548.01
2023	**6,637.00**	**4,831.59**	**5,377.66**	**3,118.91**	**596.33**	**20,561.49**
2023	**6,637**	**4,831.59**	**5,373.99**	**3,118.91**	**600.00**	**20,561.49**

Source: Statistics Indonesia (BPS)

Administratively, Solok Regency covers an area of approximately 373,800 hectares, with irrigated paddy fields totaling 20,561.49 hectares. This area is distributed across various districts with different types of irrigation systems, ranging from technical and semi-technical irrigation to simple irrigation, non Public Works (non-PU) irrigation, and rainfed paddy fields. These conditions indicate that irrigation networks play a strategic role in supporting the sustainability of the agricultural sector in Solok Regency.

According to the Regulation of the Minister of Public Works and Housing Number 12 of 2015 [5], an irrigation area is defined as a unit of land that receives water from an irrigation network. An irrigation network is a system consisting of canals, structures, and ancillary facilities that function to supply, distribute, utilize, and dispose of irrigation water through primary, secondary, and tertiary networks [6]. Irrigation itself refers to efforts to provide and manage water to support agricultural activities through various methods, including surface irrigation, swamp irrigation, groundwater irrigation, pump irrigation, and pond irrigation [7].

To ensure that irrigation networks function optimally, continuous operation and maintenance (O&M) activities are required. Irrigation network operation includes regulating water distribution, operating control gates, preparing cropping pattern plans, allocating water, and conducting monitoring and evaluation activities. Meanwhile, irrigation network maintenance aims to maintain and ensure optimal network functionality through continuous activities such as routine maintenance, repairs, preventive measures, and system protection [5].

The performance of irrigation network operation and maintenance has a direct impact on agricultural productivity, environmental sustainability, and farmers' welfare. However, the success of irrigation O&M management is not solely determined by the availability of physical infrastructure, but also by the overall performance of the irrigation system, which encompasses physical infrastructure, crop productivity, supporting facilities, organizational and personnel capacity, documentation, and the institutional condition of Water User Associations/P3A [8]. To assess this performance objectively and measurably, the government has established the Irrigation System Performance Index (IKSI) as an official evaluation instrument in accordance with the regulations of the Ministry of Public Works and Housing [9].

Along with technological advances and irrigation modernization policies, the evaluation of irrigation network performance is currently supported by the use of the ePAKSI (electronic Irrigation Asset and Performance Assessment) application. This application enables asset inventory, physical condition assessment, and irrigation network performance evaluation to be conducted digitally, in an integrated manner, and based on systematically documented field data [10]. The use of ePAKSI is expected to improve the accuracy of IKSI assessments and serve as a basis for decision-making in irrigation network operation and maintenance planning.

Nevertheless, the implementation of performance evaluation based on IKSI and ePAKSI at the regional level still faces various constraints. Common challenges include limited human resources with adequate understanding of the assessment instruments, insufficient maintenance budgets, physical degradation of irrigation infrastructure, and suboptimal coordination between local governments and farmer institutions [11]. These conditions may result in evaluation outcomes not being fully utilized as a basis for formulating strategies to improve irrigation network operation and maintenance.

Previous research [12] indicates that scheduled and periodic operation and maintenance activities can reduce the level of irrigation network damage. However, the implementation of irrigation O&M in Solok Regency continues to face several challenges, including policy changes, limited budgetary support, and low community and farmer participation in irrigation network maintenance. These conditions have the potential to reduce irrigation network performance and negatively affect the effectiveness of water delivery to agricultural land. In fact, improving the performance of irrigation network operation and maintenance can provide significant benefits, such as increased water-use efficiency, reduced infrastructure damage, and overall improvements in agricultural output.

Therefore, a study is required that not only evaluates the performance of irrigation network operation and maintenance based on IKSI using the ePAKSI application, but also formulates practical and sustainable performance improvement strategies. Strategic analyses, such as SWOT analysis, are essential to identify strengths, weaknesses, opportunities, and threats in the management of irrigation network operation and maintenance in Solok Regency. Through this approach, the resulting recommendations are expected to serve as a basis for comprehensive improvements in irrigation network performance and to support sustainable regional food security.

2. Literature Review

2.1. Irrigation and Irrigation Networks

Irrigation is one of the main components of lowland agricultural systems, particularly in regions where rice is cultivated as a leading commodity. Adequate, evenly distributed, and sustainable water availability is a fundamental prerequisite for ensuring optimal crop cultivation processe [13]. Therefore, irrigation should not be understood merely as the activity of conveying water to paddy fields, but rather as a planned and integrated water management system [14].

In practice, irrigation is implemented through irrigation networks, which consist of a series of physical infrastructures such as canals, hydraulic structures, and ancillary facilities that function to convey, regulate, and dispose of irrigation water [15]. These networks begin at the headworks as the water intake structure and extend through primary, secondary, and tertiary canals that directly serve agricultural land. The level of completeness and the physical condition of irrigation networks greatly determine the quality of water delivery services received by farmers [16].

In regions with extensive paddy fields and diverse irrigation network distributions, such as Solok Regency, irrigation systems play a strategic role in sustaining agricultural production. However, their scale and structural complexity require effective operation and maintenance (O&M) management to ensure that system performance remains aligned with its design objectives.

The irrigation networks in the Bdr. Ambacang, Bdr. Imang, and Bdr. Bawah Gunung Irrigation Areas exhibit distinct structural characteristics. Bdr. Ambacang has a relatively complete and integrated network, supporting its function as a major agricultural service area. In contrast, Bdr. Imang and Bdr. Bawah Gunung show variations in canal extent, distribution, and network condition, reflecting differences in regional physical characteristics and management challenges. These structural differences have direct implications for water service delivery, operational effectiveness, and maintenance requirements. Network complexity and infrastructure condition are therefore key factors influencing irrigation system performance, as further analyzed in the performance evaluation section.

Overall, the presentation of irrigation network schematics for each irrigation area provides an overview of the variations in network structure and coverage across Solok Regency. These differences in network characteristics indicate that irrigation management cannot be implemented using a uniform approach, but instead must be adapted to the specific conditions and needs of each irrigation area to ensure effective and sustainable water service delivery [17].

2.2. Irrigation Network Operation

To ensure that irrigation networks function effectively, well-planned and continuous irrigation operation activities are required. Irrigation network operation refers to a series of water management activities aimed at regulating water allocation and delivery in accordance with crop water requirements and the availability of water resources [18]. These activities are not only technical in nature but also managerial, as they involve planning, implementation, and control of water distribution.

The scope of irrigation network operation begins with the planning stage, which includes the collection of hydrological data, planted area data, and crop water requirements [19]. These data serve as the basis for preparing water supply plans and cropping pattern plans. The next stage is the implementation of operations, which includes the operation of control gates, regulation of flow discharges, and water distribution within primary, secondary, and tertiary canal networks [18-20]. At this stage, the accuracy of water regulation is crucial in ensuring equitable water distribution among farmers.

In addition, operational activities also involve monitoring and evaluation to ensure that water distribution is carried out in accordance with the established plans [21]. When discrepancies arise between planned operations and actual field conditions, adjustments are required to ensure that crop water demands remain fulfilled. Ineffective irrigation network operation may lead to unequal water distribution, conflicts among water users, and a decline in agricultural productivity.

2.3. Irrigation Network Maintenance

In addition to operation, irrigation network maintenance is an equally important aspect in sustaining the performance of irrigation systems. Maintenance aims to preserve the physical condition of the network so that it continues to function in accordance with its design capacity and to prevent more severe damage from occurring. Without adequate maintenance, irrigation networks will gradually experience functional deterioration, which ultimately requires substantial rehabilitation costs [11-12]. The scope of irrigation network maintenance includes inventorying network conditions, maintenance planning, implementation of maintenance activities, as well as monitoring and evaluation of maintenance outcomes [18]. Based on the type and severity of damage, irrigation network maintenance is classified into network safeguarding, routine maintenance, periodic maintenance, and emergency repairs.

Routine maintenance consists of light maintenance activities carried out continuously, such as cleaning canals from debris and sediment, lubricating control gates, and conducting minor repairs on irrigation structures. Periodic maintenance is conducted at regular intervals with a larger scale of work, including repairs to canals, control structures, and supporting facilities. Meanwhile, emergency repairs are carried out in response to severe damage or natural disasters to ensure that irrigation networks can continue to function temporarily before permanent repairs are implemented. Suboptimal maintenance implementation, whether due to budget constraints or limited human resources, has a direct impact on the decline in irrigation network performance and the effectiveness of water service delivery [22].

2.4. Irrigation System Performance Evaluation and IKSI Indicators

To assess the extent to which irrigation networks function optimally, an evaluation of irrigation system performance is required. This evaluation aims to provide a comprehensive overview of the condition and performance of irrigation networks, which can be used as a basis for decision-making in irrigation management and performance improvement [23]. One of the evaluation methods applied is the Irrigation System Performance Index (IKSI), which assesses irrigation network performance based on several key indicators [9]. These indicators include physical infrastructure, crop productivity, supporting facilities, organizational and personnel aspects, documentation, and the institutional condition of Water User Associations (WUAs/P3A). The physical infrastructure indicator evaluates the condition of irrigation structures and canals, while the crop productivity indicator reflects the effectiveness of the irrigation system in meeting crop water requirements [24].

Indicators related to supporting facilities, organizational and personnel aspects, and documentation represent the readiness of supporting resources in irrigation management [25]. In addition, the institutional condition of WUAs is assessed to determine the level of farmer participation in the management and maintenance of irrigation networks [26]. A comprehensive IKSI assessment enables a more focused and objective identification of existing problems. The use of the ePAKSI application supports the IKSI evaluation process through digital field data recording, thereby enhancing the accuracy, measurability, and systematic documentation of evaluation results [27-28].

2.5. P3A Institutions and Farmer Participation

The success of irrigation network management is determined not only by physical and technical conditions but also by institutional roles and farmer participation. Water User Associations (WUAs/P3A) are institutions established to support irrigation water management at the tertiary level and to serve as a coordination platform among farmers [24].

Active participation of WUAs in the operation and maintenance of irrigation networks plays an important role in maintaining network conditions and improving water distribution efficiency [11]. However, in practice, the role of WUAs is often not yet optimal due to limited institutional capacity, insufficient training, and weak coordination with local governments. These conditions result in low levels of farmer involvement in irrigation network maintenance and contribute to increasing rates of network deterioration.

2.6. SWOT Analysis for Improving Operation and Maintenance Performance

Efforts to improve the performance of irrigation network operation and maintenance require an analytical approach capable of identifying the internal and external conditions of the irrigation system. One such approach is SWOT analysis, which examines the strengths, weaknesses, opportunities, and threats that influence irrigation network performance. SWOT analysis enables the formulation of performance improvement strategies based on the existing condition of irrigation networks and their management environment [29-30]. Through this approach, the proposed strategies are expected to leverage available opportunities to address internal weaknesses while minimizing threats that may hinder the sustainability of irrigation network management.

3. Research Method

This study employs a descriptive approach using a mixed-methods design that combines quantitative and qualitative methods to analyze the performance of irrigation network operation and maintenance in Solok Regency [31]. Data were collected through field observations, interviews, and documentation studies conducted in several irrigation areas within Solok Regency. Performance evaluation was carried out using the ePAKSI application to obtain the Irrigation System Performance Index (IKSI), while strategies for performance improvement were formulated using SWOT analysis supported by IFAS and EFAS analyses.

Data analysis was conducted in two main stages. The first stage involved evaluating irrigation system performance using the IKSI framework with the assistance of the ePAKSI application to obtain objective and measurable performance scores and categories. The second stage applied SWOT analysis to identify internal and external factors affecting the performance of irrigation network operation and maintenance, and to formulate appropriate performance improvement strategies based on existing conditions. The results of these analyses served as the basis for developing recommendations to enhance the management of irrigation network operation and maintenance in the study area.

The research was conducted in several irrigation areas in Solok Regency that are registered in the ePAKSI application as part of the irrigation system performance assessment database. Spatial information and irrigation area identities were obtained from location maps available in the ePAKSI application, which were subsequently used to describe the study objects and to define the scope of analysis for irrigation network operation and maintenance performance.

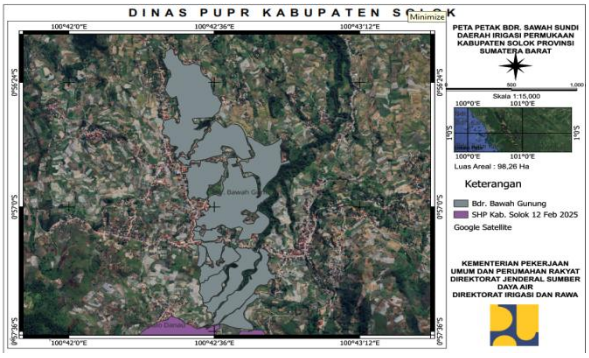

Fig. 1. Map of the Bdr. Bawah Gunung Irrigation Area (ID ePAKSI: 13030012)

This irrigation area is one of the study objects analyzed to assess the performance of irrigation network operation and maintenance based on the IKSI framework.

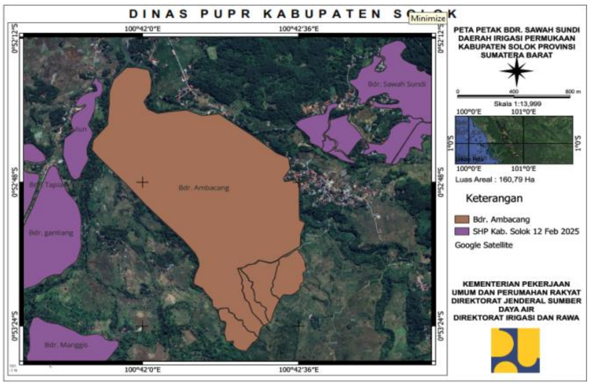

Fig. 2. Map of the Bdr. Ambacang (ID ePAKSI: 13030204)

These location data are used as the basis for identifying the condition of the irrigation network and the coverage of irrigation services within the study area.

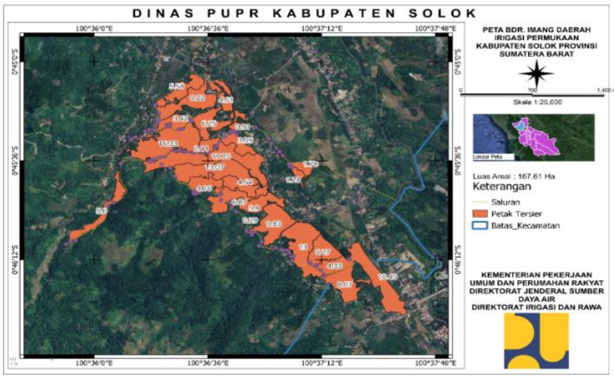

Fig. 3. Map of the Bdr. Imang (ID ePAKSI: 13030028)

Although sharing the same name, differences in identification codes indicate that these irrigation areas represent distinct network units and are therefore analyzed separately. All irrigation areas included in the study were evaluated individually using the Irrigation System Performance Index (IKSI), based on field data documented in the ePAKSI application. The performance evaluation results for each irrigation area were subsequently used as the basis for analysis and discussion in the results section.

4. Result

In recent years, the sustainability of irrigation systems has become a critical issue in the management of agricultural water resources, particularly in major rice-producing areas that are highly dependent on the availability of irrigation water [32]. Although irrigation networks have been developed to support increased agricultural productivity, in practice many irrigation systems continue to experience performance deterioration due to limited maintenance, weak operational management, and low levels of water user participation [33]. These conditions result in suboptimal water distribution and may hinder the sustainability of agricultural production. Therefore, evaluating the performance of irrigation network operation and maintenance is essential as a basis for formulating more effective and sustainable management improvement strategies.

Field observations indicate that, in general, the condition of irrigation networks in Solok Regency remains capable of supporting agricultural activities, although performance degradation was identified in several segments, particularly within tertiary networks. In the Bdr. Ambacang Irrigation Area, the condition of the weir remains in very good condition following rehabilitation works carried out in the 2024 fiscal year. This condition indicates that the rehabilitation efforts have been effective in maintaining the function of the weir as the main structure regulating irrigation water flow.

Fig. 4. Weir of the Bdr. Ambacang Irrigation Area

Fig. 5. Condition of Primary and Secondary Canals in the Bdr. Ambacang Irrigation Area

Based on the figure, the weir structure is shown to be functioning properly and is capable of supporting the operation of the irrigation network within the service area. Although the condition of the weir is relatively good, several issues were identified in the primary and secondary canals of the Bdr. Ambacang Irrigation Area. These issues include the growth of wild vegetation and sediment accumulation, which have the potential to reduce flow capacity and disrupt the smooth distribution of irrigation water. This condition indicates that routine maintenance of the canals has not yet been carried out optimally.

The presence of sediment and vegetation within the canals indicates the need to increase maintenance intensity to ensure that flow capacity remains in accordance with the design specifications [6]. More concerning irrigation network conditions were identified in the Bdr. Bawah Gunung Irrigation Area. At this location, the weir structure is in poor condition, as indicated by damage to the crest and the stilling basin. Such damage has the potential to disrupt the function of the weir in regulating and distributing irrigation water to the conveyance canals. The condition of the weir in the Bdr. Bawah Gunung Irrigation Area is shown in the following figure.

Fig. 6. Weir of the Bawah Gunung Irrigation Area

Based on the figure, it is evident that the weir structure requires maintenance and repair to restore its optimal functionality. Significant issues were also observed in the Bdr. Imang Irrigation Area. In several segments of the network, irrigation channels are no longer flowing with water and are obstructed by debris and overgrown vegetation. These conditions indicate that the irrigation network is not only suffering from physical damage but also lacks adequate attention in routine maintenance activities.

Fig. 7. Condition of the Irrigation Channels in Bdr. Imang

The presence of debris and overgrown vegetation in the channels accelerates the decline of the network's functionality and has the potential to cause failures in water distribution to agricultural lands [11]. From the perspective of irrigation network operation, water distribution generally follows the established cropping patterns. However, during the dry season, water availability is not yet sufficient to meet crop requirements evenly. This situation is exacerbated by the limited number of operation and maintenance personnel, as well as the lack of supporting facilities, which prevents optimal water allocation [6][11][12]. Furthermore, irrigation network maintenance is still carried out reactively rather than on a scheduled basis, causing minor damages to often develop into more serious issues. This finding aligns with Silahooy et al. [34], who stated that weak routine maintenance accelerates the degradation of irrigation network functionality and increases rehabilitation costs.

Performance evaluation of the irrigation system using the ePAKSI application yielded the Irrigation System Performance Index (ISPI), which indicates that the operation and maintenance performance of irrigation networks in Solok Regency remains below optimal conditions. Based on the ISPI calculation for 2025, the three studied irrigation areas recorded values below 55%, which represents the minimum threshold, indicating that the performance of the irrigation networks is still insufficient and requires serious attention. The results of the ISPI calculations and their summary are presented in the following table:

Table 3. Physical Infrastructure Assets of the Bdr. Ambacang Irrigation Area

No.	Structure Name	Quantity/Length	Unit
1.	Weir	1	Unit
	Scouring Gate	-	
	Intake Gate	-	
2.	Regulating Structures (Division / Division Intake / Intake Structures)	7	Unit
3.	Appurtenant Structures	3	Unit
4.	Office	-	-
5.	Warehouse	-	-
6.	Primary Canal	0.04	Km
7.	Secondary Canal	0.62	Km

Source: ePAKSI Apps 2025

The Table 3 presents the number of structures in the Bdr. Ambacang Irrigation Area following the ePAKSI assessment, based on the Irrigation System Performance Index (ISPI) evaluation for 2025. Overall, the physical infrastructure is still in a fairly good condition, particularly the main structures that have undergone repairs. However, several channel components and auxiliary structures continue to show signs of deterioration due to sedimentation and vegetation growth, which may reduce flow capacity and affect the smooth distribution of water. A similar condition is also observed in the irrigation infrastructure of the Bdr. Bawah Gunung Irrigation Area, as shown in the following table:

Table 4. Physical Infrastructure Assets of the Bdr. Bawah Gunung Irrigation Area

No.	Structure Name	Quantity/Length	Unit
1.	Weir	1	Unit
	Scouring Gate	-	Unit
	Intake Gate	1	
2.	Regulating Structures (Division / Division Intake / Intake Structures)	12	Unit
3.	Appurtenant Structures	9	Unit
4.	Office	-	-
5.	Warehouse	-	-
6.	Primary Canal	0.36	Km
7.	Secondary Canal	2.13	Km

Source: ePAKSI Apps 2025

The Table 4 shows that the physical infrastructure assets of the Bdr. Bawah Gunung Irrigation Area include intake gates, control structures, auxiliary structures, primary channels, and secondary channels, based on the 2025 Irrigation System Performance Index (ISPI) assessment. The condition of the physical infrastructure in this irrigation area is relatively lower compared to the Bdr. Ambacang Irrigation Area, particularly in the weir structures and main conveyance channels. Damage to certain structural components, along with poorly maintained channels, indicates a significant decline in network functionality. This condition suggests that the irrigation network in Bdr. Bawah Gunung requires greater attention in operation and maintenance activities to improve its performance. A similar situation is also observed in the Bdr. Imang Irrigation Network.

Table 5. Condition of the Bdr. Imang Irrigation Network

No.	Structure Name	Quantity/Length	Unit
1.	Weir	2	Unit
	Scouring Gate	-	
	Intake Gate	-	
2.	Regulating Structures (Division / Division Intake / Intake Structures)	25	Unit
3.	Appurtenant Structures	85	Unit
4.	Office	2	Unit
5.	Warehouse	-	-
6.	Primary Canal	-	-
7.	Secondary Canal	2.02	Km

Source: ePAKSI Apps 2025

Based on the Table 5, it can be seen that the assets in the Bdr. Imang Irrigation Area consist of weirs, control structures, auxiliary structures, sedimentation basins, primary channels, and secondary channels, according to the 2025 Irrigation System Performance Index (ISPI) assessment. Several segments of the irrigation network are in poor condition, characterized by channels that do not function optimally and are not flowing with water. Furthermore, issues such as debris accumulation and overgrown vegetation in the channels indicate weak routine maintenance activities. These conditions directly impact the low performance of the irrigation network and have the potential to hinder water distribution to agricultural lands.

Overall, the data in these tables indicate that performance problems are not only related to physical aspects but also to supporting factors. Low ISPI values are particularly influenced by non-technical indicators, such as personnel organization, documentation, and the institutional capacity of the Water Users Association (P3A). Interviews and observations show that P3A participation in irrigation network maintenance remains limited, especially in tertiary networks, causing these networks to deteriorate more rapidly. This finding aligns with the results of Uphoff (1986) and Sutrisno and Heryani (2016), who emphasized that active farmer involvement is a key factor in the successful management of irrigation systems.

Based on the performance evaluation and assessment of existing conditions, a SWOT analysis was conducted to formulate strategies for improving the operation and maintenance of the irrigation network. The IFAS and EFAS calculations indicate that the irrigation management strategy position in Solok Regency falls within Quadrant III (W–O).

This position indicates that, although internal weaknesses are relatively dominant, irrigation management still has external opportunities that can be leveraged to improve performance. Considering the results of the SWOT analysis, the recommended strategies focus on utilizing external opportunities to address internal weaknesses. These include increasing funding for operation and maintenance, strengthening human resource capacity, implementing a more structured maintenance system, and enhancing the role and participation of the Water Users Association (P3A) (29–30). This strategy is expected to gradually and sustainably improve the operation and maintenance performance of the irrigation network, ensuring that the network continues to support food security in Solok Regency.

5. Discussion

The evaluation of operation and maintenance (O&M) performance of irrigation networks in Solok Regency indicates that the systems remain functional but have not achieved optimal performance. This is reflected in the Irrigation System Performance Index (ISPI) values across all studied irrigation areas, which fall below the minimum threshold of 55%. Although the networks are still operational, several fundamental issues limit their long-term sustainability.

From a physical perspective, infrastructure conditions vary among irrigation areas. In the Bdr. Ambacang Irrigation Area, the weir structures are relatively well maintained due to recent rehabilitation, enabling effective water distribution. However, sedimentation and vegetation growth in primary and secondary canals reduce flow capacity, highlighting the importance of routine channel maintenance beyond maintaining main structures. In contrast, the Bdr. Bawah Gunung and Bdr. Imang Irrigation Areas exhibit more severe physical deterioration, including damaged weirs, non-functional canals, and debris-clogged channels. These conditions indicate inconsistent maintenance practices, allowing minor damage to escalate and reduce overall system performance, consistent with Arsyad (2010).

Operationally, water distribution generally follows established cropping patterns, but inequities occur during the dry season. This reflects challenges in balancing water availability with field demand, potentially affecting equitable distribution and agricultural productivity. Beyond physical and operational factors, ISPI results reveal that non-technical aspects particularly personnel organization, documentation, and the institutional capacity of the Water Users Association (P3A) contribute significantly to low performance. Limited farmer participation in tertiary network maintenance accelerates infrastructure deterioration. This finding aligns with Uphoff (1986) and Sutrisno and Heryani (2016), who emphasize the critical role of water user institutions in sustaining irrigation systems.

The SWOT analysis places irrigation O&M management in Quadrant III (W–O), indicating the presence of internal weaknesses alongside external opportunities. Accordingly, improvement strategies focus on leveraging these opportunities to address weaknesses through strengthened O&M management and institutional reinforcement of P3A. Key strategies include implementing planned and periodic maintenance to prevent progressive infrastructure damage, particularly in conveyance channels; enhancing P3A capacity through training and guidance to increase farmer participation; optimizing the use of information technology, such as ePAKSI, for objective performance monitoring; and improving coordination between irrigation agencies and P3A to ensure clear institutional roles. Overall, irrigation management challenges in Solok Regency extend beyond physical infrastructure to operational and institutional dimensions. Strengthening O&M management, reinforcing water user institutions, and utilizing technological support are essential to improving system effectiveness and ensuring sustainable agricultural production and regional food security.

6. Conclussion

Based on the evaluation of the operation and maintenance performance of irrigation networks in Solok Regency, it can be concluded that the existing irrigation systems generally still function to support agricultural activities, but have not yet achieved optimal performance. This is reflected in the Irrigation System Performance Index (ISPI) values for all studied irrigation areas, which remain below the minimum threshold, as well as in the various issues identified in physical infrastructure, network operations, and non-technical aspects, such as the institutional capacity of the Water Users Association (P3A). The SWOT analysis indicates that the management of operation and maintenance falls within Quadrant III (W–O), suggesting that performance improvement strategies should focus on enhancing the existing system management through more planned and structured operation and maintenance activities, strengthening the role of P3A institutions, optimizing the use of supporting technologies, and improving coordination among stakeholders. The implementation of these strategies is expected to gradually and sustainably improve the performance of the irrigation networks, thereby supporting the continuity of agricultural production and regional food security.

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