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Study of irrigation performance index in Saba irrigation area

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ABSTRACT

Saba Irrigation Area is located in Gerokgak and Seririt District, Buleleng regency, Bali. The assessment of the irrigation performance index is required to maintain the value of irrigation asset function and condition. Some problems occur in the irrigation area from the standard area of 1548 ha, but the productive land is around 889 ha or about 57% of the standard area. The problems were found in the irrigation canal, which hampered the performance of irrigation downstream, where water cannot flow to rice fields. The wet cross-section of the channel is covered by sediment. Even at several locations, the sediment height has the same elevation as the surrounding surface. The purpose of this study is to obtain value in the form of an assessment index on the primary and secondary irrigation systems, which will be classified into their respective components. Furthermore, rehabilitation priority is determined using the decision-making method with the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP). The assessment of irrigation performance index scored 62.94% consisting of physical infrastructure 29.28%; crop productivity 7.24%; supporting facilities 4.95%; personnel organization 10.75%; documentation 3.40%; and water user associations 7.33%. Determining the rehabilitation priority using the AHP method and ANP method showed the same results, i.e. physical infrastructure in rank 1, personnel organization in rank 2, crop productivity in rank 3, water user associations in rank 4, supporting facilities in rank 5, and documentation in rank 6. Determination of the selected rehabilitation in the physical infrastructure aspect is the sub-aspect of irrigation channels. Irrigation channels get the highest score with the worst damage conditions from all sub-aspects.

Keywords: performance index assessment; rehabilitation priority; Saba irrigation area; AHP and ANP methods

1 Introduction

Irrigation has an essential role in increasing agricultural production in achieving national food sovereignty. The success of the performance of the irrigation system is highly dependent on the management of the irrigation system. This is reflected in its ability to support the availability and operation of sufficient irrigation water in the service area of the irrigation area that is conducive to the implementation of the planned cropping pattern [1]. Currently, the development of irrigation infrastructure is included in the National Medium-Term Development Plan (RPJMN) for 2020-2024 in order to strengthen economic resilience [2]. Over time, the performance of the irrigation system has decreased due to the less than the optimal implementation of operation and maintenance activities, human activities, and natural disasters [2, 3]. The decline in the performance of the irrigation system will have a direct impact on farmers. If left without any improvement efforts, it is feared that it will cause social and economic problems [4].

It is essential to evaluate or assess the performance of the irrigation system to monitor the condition and performance of all aspects of the irrigation system [5]. This is implemented by conducting a visual search of the irrigation network accompanied by documentation to report conditions in the field [6, 7]. The irrigation system performance assessment is carried out by the irrigation area managers in accordance with their respective authorities once a year. The value generated from this evaluation will determine the performance of an irrigated area as consideration for carrying out proposed activities in the following year, however, most of the assessments carried out so far still depend on the experience of field officers so that it can cause differences due to the subjective nature of the assessment [8]. The following solution be recommended in handling an irrigation area is maintenance and repair or rehabilitation [6, 9].

Saba irrigation area is one of the largest irrigation areas in Buleleng Regency, Bali Province, which irrigates 13 Subaks. Some problems occur in the irrigation area from the standard area of 1548 ha, but the productive land is around 889 ha or about 57% of the standard area. The problems were found in the irrigation canal, which hampered the performance of irrigation downstream. The wet cross-section of the channel is covered by sediment. Even at several locations, the sediment height has the same elevation as the surrounding surface, which can be found in Berongbong Subak, Tinga-Tinga Subak, Pengulon Subak, and Patas Subak. This condition occurs in almost half of the entire length of the primary and secondary channels. Several activities and human activities are causes for the accumulation of sediment in the channel. Based on interviews with observers, several times during the rainy season, there was an overflow of water from the channel to the surrounding area due to the wet cross-section of the channel that could not accommodate the discharge that entered the channel.

The purpose of this study is to obtain a number in the form of an assessment index on the primary and secondary irrigation systems, which will be classified into their respective components. Furthermore, handling priority is determined using the decision-making method with Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP).

2 Data and Methods

2.1 Data

2.1.1 Study area

The study was conducted in Saba Irrigation Area, which is located in Buleleng Regency, precisely in Gerokgak District and Seririt District as shown in Figure 1. This irrigation area gets water from Saba Weir, which is located in Lokapaksa Village. The coverage area served in this irrigation area reaches seven villages with a potential area of 1548 ha and a functional area of 889 ha. Saba irrigation area consists of 13 Subaks including Umadesa, Tegal Intaran, Ponjok Cukli, Banyumati, Yeh Anakan, Banjar Munduk, Pangkung Kunyit, Tegal Lenge, Tukad Sumaga, Berong Bong, Tinga-tinga, Pengulon, and Patas.

Figure 1. Saba irrigation area map

2.1.2 Data collection

Data collection was carried out to achieve the objectives in this study, which consisted of primary data and secondary data. Primary data were obtained from survey results and irrigation tracing (walkthrough) in the Saba Irrigation Area covering the condition and performance of the irrigation system. Secondary data consists of (1) Saba watershed map obtained from BWS Bali Penida; (2) irrigation networks scheme obtained from BWS Bali Penida; (3) irrigation area map obtained from BWS Bali Penida; (4) organizational structure for irrigation network operation and maintenance data obtained from Observers (Regional Technical Implementation Unit); (5) Subak and water user associations data obtained from Observers; and (6) crop patterns and water distribution data obtained from Observers and Water User Associations (WUAs).

2.2 Methods

2.2.1 Survey and irrigation system inventory

The survey was conducted by tracing the irrigation networks (walkthrough) to determine the condition of all irrigation assets. Irrigation network inventory is carried out to obtain data on the number, type, dimension, condition, and function of all irrigation assets every year, referring to the applicable provisions or guidelines. The implementation of irrigation networks inventory is carried out in a participatory manner through tracing of irrigation networks by officials who have the authority in stages together with Regional Technical Implementation Unit by using the blank irrigation network inventory.

2.2.2 Irrigation performance index assessment

The irrigation system assessment to determine the condition of the irrigation system consists of (1) physical infrastructure; (2) crop productivity; (3) supporting facilities; (4) personnel organization; (5) documentation; and (6) water user associations (WUAs). The assessment is carried out based on the results of an inventory containing the actual conditions in the related irrigation area, which includes (1) intake structure (weir); (2) structures on the channel (regulatory structures, measurement structures, complementary structures); and (3) channels on the primary and secondary irrigation networks. This assessment refers to the regulation of the Minister of Public Works and Public Housing Republic of Indonesia No. 12/PRT/M/2015. The weights value for each aspect is shown in Table 1.

The criteria for evaluating the performance of the irrigation system based on the weight values that have been achieved can be classified into several categories as shown in Table 2.

Table 1. Weight value for each aspect of irrigation system performance assessment

No.	Aspect	Weight Value (%)
1	Physical infrastructure	45
2	Crop productivity	15
3	Supporting facilities	10
4	Personnel organization	15
5	Documentation	5
6	Water user associations	10

Table 2. Weight value and irrigation system performance categories

No.	Weight Value	Performance Categories
1	80 – 100	Excellent performance
2	70 -79	Good performance
3	55 – 69	Less performance and needs to be considered
4	< 55	Poor performance and needs to be considered

2.2.3 Determination of rehabilitation priority

Determination of irrigation treatment priorities aims to rank the components that most require treatment and repair. This calculation uses the Analytic Hierarchy Process (AHP) method and the Analytical Network Process (ANP) method, which is calculated using the Super Decision V2.10 software. These methods use a multilevel modeling structure and a pairwise comparison matrix to calculate the priority value for each element [10]. The difference between these two methods lies in making the stratified structure. In AHP, decision problems are organized into a hierarchy, including objectives, decision criteria, and alternatives. Meanwhile, ANP organizes it into a network [11].

2.2.4 AHP method

The first step is to create a network structure. The network structure of the AHP method is hierarchical, that is, in order from the top, the goals, criteria, and alternatives are listed as shown in Figure 2 [12]. The weight of these values is based on the difference between the condition values of the criteria or alternatives being compared as shown in Table 3. From the results of the comparison matrix calculation, the priority vector value is obtained. The priority vector value is used to calculate the maximum value, consistency index (CI), index ratio (RI) to consistency ratio (CR) [13]. If the result of the CR value < 0.1, it means that the pairwise matrix comparison is consistent or the data is accepted [10].

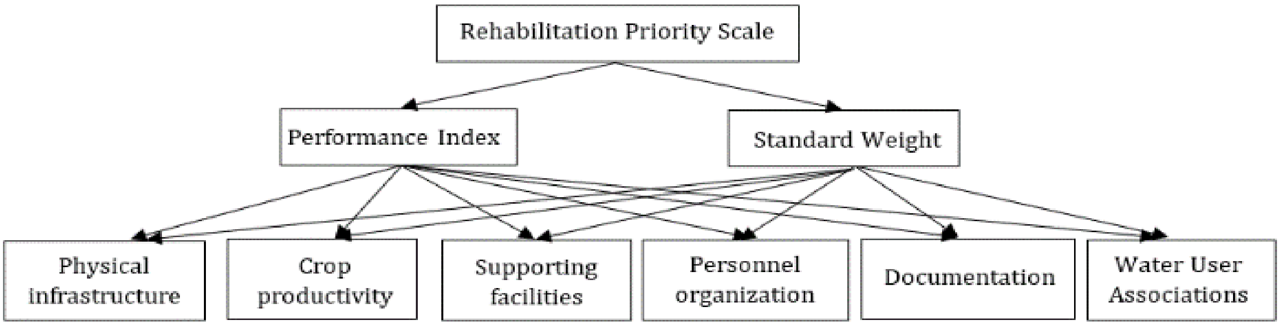


Figure 2. AHP method network structures

Table 3. Description of the standard weight comparison difference

Difference	Weight	Description
1 to 5	2	A little more important
6 to 10	3	↓
11 to 15	4	
16 to 20	5	
21 to 25	6	
26 to 30	7	
31 to 35	8	
36 to 40	9	Very important

2.2.5 ANP method

The first step in this method is to create a network structure that can be seen in Figure 3. The network structure of the ANP method is different from the AHP method which considers the dependence of elements in the network structure, there are loop and feedback lines [14]. The objectives, criteria, and alternatives are the same as the AHP method. The difference is there is a backline (loop). The loop line in question is contained in the criteria. The line shows a self-calculation in each criterion to criteria.

The feedback line on the criteria and alternatives shows alternative calculations to criteria (not hierarchical) [15]. The parameter difference in the comparison of the condition values used for the calculation of the pairwise comparison matrix is the same as the AHP method, and the difference is that in the ANP method, there is a pairwise comparison matrix calculation of each criterion against the criteria and alternatives to the criteria. The matrix in this calculation is the same as the matrix used in the irrigation priority calculation method, the AHP method [14], [15].

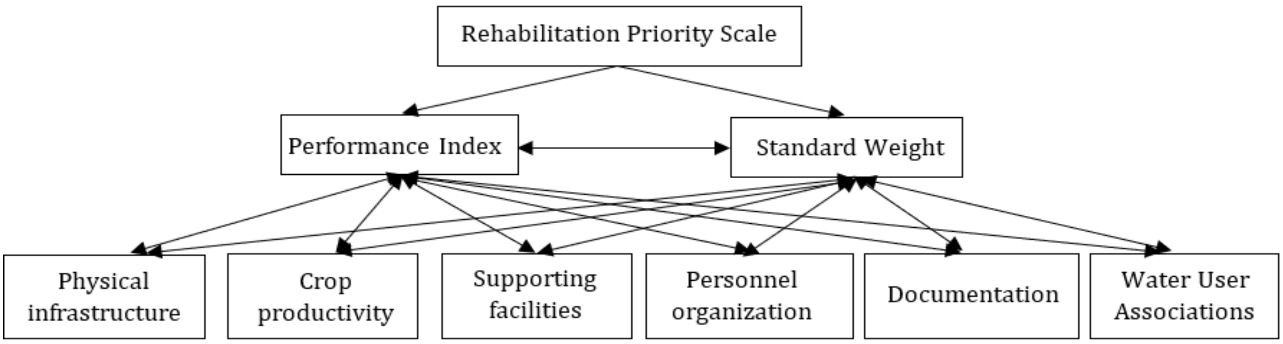


Figure 3. ANP method network structures

3 Results and Discussion

3.1 Irrigation performance index result

Based on the survey results or tracing the irrigation networks using irrigation scheme data as reference, the condition of aspects with various scores is obtained. The lowest score is 35%, categorized as poor performance and needs to be considered, found in aspects of physical infrastructure and supporting facilities. The highest rating is 100%, categorized as excellent performance, found in the WUAs aspect.

The irrigation performance index in the Saba irrigation area of each aspect is detailed in Appendix.

3.2 Results of irrigation performance index of each aspect

3.2.1 Physical infrastructure

Assessment of the condition of the building has different aspects depending on the type of structure. Based on the performance index assessment, physical infrastructure scored 29.28% of the maximum of 45%. The results consist of several assessments i.e. (1) intake structure (weir) scored 8.78% from a maximum of 13%; (2) irrigation channels scored 5.54% of the maximum of 10%; (3) structures on the channel scored of 5.61% of the maximum of 9%; (4) drainage channel and structures scored 3.05% of the maximum of 4%; (5) entrance or inspection roads scored 3.35% of the maximum of 4%; and (6) offices, housing, and warehouses scored 2.95% of the maximum of 5%.

The intake structure (weir) scored 8.78% was obtained from the weight of the section consisting of (1) weir by 2.74%; (2) sediment gate and gears by 4.4%; and (3) sediment trap and drain gate by 1.64%. The irrigation channel scored 5.54%, obtained from the condition of all segments of the irrigation network. Aspects that become part weight are (1) the capacity of each channel by 3.35%; (2) the embankment stability and height by 1.14%; and (3) channel rehabilitation by 1.05%.

The assessment of structure on the channel scored 5.61% obtained (1) regulatory structures by 1.2%; (2) regulatory structures on the primary and secondary irrigation network by 0.7%; (3) regulatory structures on the tertiary irrigation network by 0.7%; (4) measurement structures on the intake structures by 0.8%; (5) measurement structures on the regulatory structures by 0.38%; (6) complementary structures by 0.48%; (7) complementary structure on the siphons, culverts, bridges, gutters, cross-drains by 0.72%; (8) rehabilitation on the regulatory structures by 0.5%; and (9) rehabilitation on the complementary structures by 0.13%.

The aspect of drainage channel and structures scored 3.05% consisting of (1) rehabilitation of drainage channels and structures scored by 2.4%, and (2) flood problems by 0.65%. The aspect of entrance or inspection roads scored 3.35% consisting of (1) entrance to intake structure by 1.8%; (2) inspection roads and trails along the channel by 0.8%; and (3) inspection roads to maintenance structures by 0.75%. Most of the entrance and inspection roads on Saba irrigation networks are located not near district or village roads, but it takes walking to reach them.

The aspects of the office, housing, and warehouse scored 2.95% consisting of (1) observer office by 0.7%; (2) weir operational officer by 0.7 %; (3) housing for observers by 0.35%; (4) warehouse for observer office by 0.65%; (5) warehouse for intake structure (weir) by 0.3%; and (6) beams and other fixtures by 0.25%.

3.2.2 Crop productivity

The assessment for crop productivity aspect scored 7.24% of the maximum value of 15%. The assessment consists of the weight of parts (1) water resources availability scored 5.4% of the maximum value of 9%; (2) realization of the planting area by 1.38% of the maximum value of 4%; and (3) crop productivity of 0.46% of the maximum value of 2%.

The water resources availability in the Saba irrigation area was obtained from calculating the K factor as a function of comparing the availability discharge and the demand discharge for three planting season periods (I, II, and III) for the entire year of 2020. The water resources availability scored 5.4 % or can be classified into conditions of poor performance and need needs to be considered with a weight value of 60.

The assessment for the realization of planting scored 1.38%, which is obtained by calculating the planting intensity and crop productivity for all periods in the same year. From the calculation of cropping intensity, the average planting season I was 31.74%, planting season II was 40.33% and planting season III was 31.74%. The assessment for paddy productivity scored 0.46%, which is obtained by comparing the actual paddy production with the average paddy production. Paddy production in the Saba Irrigation Area is 1.40 tons/ha, which is compared to the national average of 6.13 tons/ha.

3.2.3 Supporting facilities

Based on the performance index assessment, the supporting facilities aspect scored 4.95% of the maximum value of 10%. The results consist of several assessments consisting of (1) operation and maintenance equipment scored 1.98% from a maximum value of 4%; (2) transportation scored 0.83% from a maximum value of 2%; (3) observers equipment scored 1.05% of the maximum value of 2%, and (4) communication equipment scored 1.1% of the maximum value of 2%.

Aspects of operation and maintenance equipment scored 1.98% consisting of (1) essential equipment for routine maintenance by 1.2%; (2) operation equipment by 0.25%; and (3) heavy equipment for mud cleaning and embankment maintenance by 0.53%. Operation and maintenance equipment, especially heavy equipment is in poor performance condition and needs attention. There is still no heavy equipment that can support the operation and maintenance of the Saba irrigation area. The index assessment for transportation aspect scored 0.83% consisting of (1) transportation used by observers at Regional Technical Implementation Unit by 0.5%, and (2) transportation used by weir operational officer by 0.33%. In supporting the mobility of existing equipment, there are versatile motorcycles available. As for transportation, the personnel still use private transportation modes.

The office equipment aspect scored 1.05% consisting of (1) basic furniture for the office by 0.4%; and (2) work equipment in the office by 0.65%. Work equipment in the office that can support personnel performances such as desks, chairs, computers, printers, filing racks, whiteboards, and stationery are not complete.

The communication equipment scored 1.1%. Communication equipment that can support the operation and maintenance used, such as radio transmitters, telephones, handy talkies, and mobile phones are still not fulfilled or incomplete. Personnel in the field still use personal communication equipment to communicate.

3.2.4 Personnel organization

Based on the performance index assessment, the personnel organization aspect scored 10.75% of the maximum value of 10%. The results consist of several assessments consisting of (1) operation and maintenance organization by 4%; and (2) personnel by 6.75%.

The operation and maintenance organization consists of (1) observers or Regional Technical Implementation Unit organization by 1.6%; (2) weir operational organization by 1.6%; and (3) sluice guards by 0.8%. Based on the interviews conducted with the observers, sluice guards, and weir operation officers, the meetings held to discuss operation and maintenance activities were irregular and incidental. In practice, no operation and maintenance manual can be used by sluice guards so that the operation and maintenance of the door are not based on what it should be.

For the personnel aspect consisting of (1) weir operational officer quantity by 0.7%; (2) sluice guards quantity by 2.1%; (3) sluice guards for civil servants by 1%; (4) observers or Regional Technical Implementation Unit personnel who already understand operation and maintenance by 0.75%; (5) weir operational officer who already understand operation and maintenance by 1.5%; and (6) sluice guards personnel who already understand operation and maintenance by 0.7%. For the needs of one weir operational officer, one observer, and three sluice guards, it is as needed.

Weir operational officer has the status of a civil servant, but the sluice guards are not yet civil servants and still contract employees. To assess the understanding of the tasks and functions of Regional Technical Implementation Unit personnel, weir operational officer, and sluice guards, direct interviews were conducted regarding the knowledge of operations and maintenance with several questions.

The implementation and training of personnel development have not yet been implemented. Completing reports is carried out in an orderly, correct, and valid manner for Regional Technical Implementation Unit personnel and weir operational officer, while the personnel assessment is obtained from the accumulation of understanding of tasks and functions.

3.2.5 Documentation

From the survey results, the documentation aspect was found complete enough, consisting of irrigation area data book, as-built drawings and maintenance maps, and irrigation network schemes. But only several available documentation data were obtained for the current condition, others have not been updated. There was still no printed documentation data on the office wall.

Assessment for documentation aspect scored 3.4% out of the maximum of 5% consisting of (1) irrigation area data books by 1.4%; (2) maps and figures by 0.7%; (3) as-built drawings and maintenance maps by 0.5%; and (4) irrigation network scheme by 0.8%.

3.2.6 Water user associations (WUAs)

The performance index assessment for WUAs scored 7.33% of the maximum value of 10%. The assessment consists of the weight of parts i.e. (1) legal entity of WUAs by 1.13%; (2) WUAs institutional condition by 0.3%; (3) meeting activities by 0.8%; (4) participation in surveys or network tracing by 1%; (5) participation in network rehabilitation and natural disaster management by 2%; (6) fee contribution for network rehabilitation; and (7) participation in planting planning and water allocation by 0.7%. The alliance of WUAs condition is currently developing.

The technical division in this irrigation area holds meetings but not regularly. WUAs actively participate in surveys or network searches and participate in both in-network rehabilitation. WUAs also play a role in network improvement using fee contribution and are active in planting planning. The water allocation in the intake structure is handed over to the alliance of WUAs, while in the regulatory structures, it is handed over to each WUAs.

3.2.7 Summary of irrigation performance index

Based on the assessment for all aspects, the total performance index for the Saba irrigation area is 62.94% as shown in Table 4. This value is included in the condition “less performance and needs to be considered” (55-69%).

Table 4. Saba irrigation performance index

No.	Aspect	Performance Index
1	Physical infrastructure	29.28%
2	Crop productivity	7.24%
3	Supporting facilities	4.95%
4	Personnel organization	10.75%
5	Documentation	3.40%
6	Water User Associations	7.33%
	Total	62.94%

3.3 Irrigation rehabilitation priority

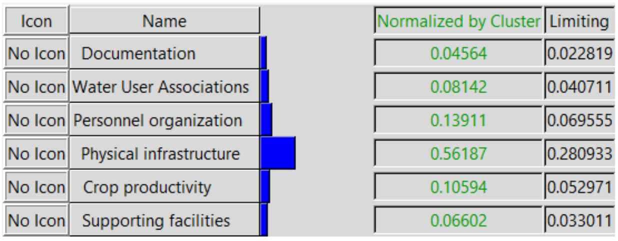
3.3.1 Irrigation rehabilitation priority with AHP

Based on Figure 2, it can be seen that the rehabilitation priority scale is the goal. The results of the performance index value as criteria. Aspects on the assessment of the performance index of the irrigation system as an alternative.

After creating the structure, the next step is to calculate the pairwise comparison matrix between criteria. In calculating the pairwise comparison matrix, each criterion is given a weight according to its level of importance which is shown in Table 3.

Next is the calculation of the pairwise comparison matrix of criteria to alternatives shown in Table 5 and Table 6. After all pairwise comparison matrices are calculated and the CR < 0.1, it can be said that the data are consistent. This shows that the weighting for both criteria to alternative is correct.

Next is the final result of the priority scale order by determining the priority order based on the total value of AHP (Limiting). The priority order for handling the AHP method can be seen in Figure 4. The result of the AHP method shows that physical infrastructure in rank 1, personnel organization in rank 2, crop productivity in rank 3, water user associations in rank 4, supporting facilities in rank 5, and documentation in rank 6.



Icon	Name		Normalized by Cluster	Limiting
No Icon	Documentation		0.04564	0.022819
No Icon	Water User Associations		0.08142	0.040711
No Icon	Personnel organization		0.13911	0.069555
No Icon	Physical infrastructure		0.56187	0.280933
No Icon	Crop productivity		0.10594	0.052971
No Icon	Supporting facilities		0.06602	0.033011

Figure 4. Rehabilitation priority order of the AHP method

Table 5. Pairwise comparison matrix of standard weight criteria to alternatives

Standard Weight	Physical infrastructure	Crop productivity	Supporting facilities	Personnel organization	Doc.	Water user as.
P. infrastructure	1	7	8	7	9	8
Crop productivity	1/7	1	2	1	3	2
Supporting facilities	1/8	1/2	1	1/2	2	1
P. organization	1/7	1	2	1	3	2
Documentation	1/9	1/3	1/2	1/3	1	1/2
Water user as.	1/8	1/2	1	1/2	2	1

Table 6. Pairwise comparison matrix of performance index criteria to alternatives

Standard Weight	Physical infrastructure	Crop productivity	Supporting facilities	Personnel organization	Doc.	Water user as.
P. infrastructure	1	6	6	5	7	6
Crop productivity	1/6	1	2	1/2	2	1
Supporting facilities	1/6	1/2	1	1/3	2	1/2
P. organization	1/5	2	3	1	3	2
Documentation	1/7	1/2	1/2	1/3	1	1/2
Water user as.	1/6	1	2	1/2	2	1

3.3.2 Irrigation rehabilitation priority with ANP

The first step is the calculation of the Unweighted Supermatrix obtained from the priority vector values of each element, which can be seen in Table 7. After the Unweighted Supermatrix is obtained, the next step is the calculation of the Weighted Supermatrix which is obtained from the result of multiplying the value of the Weighted Supermatrix with the priority weight of each criterion and alternative, which can be seen in Table 8.

The last supermatrix calculation is the Limited Supermatrix obtained by multiplying the supermatrix by the supermatrix itself until the same value is obtained for each criterion and alternative which can be seen in Table 9.

The results of Limited Supermatrix can determine the rehabilitation priority order which can be seen in Figure 5. The result of the ANP method shows that physical infrastructure in rank 1, personnel organization in rank 2, crop productivity in rank 3, water user associations in rank 4, supporting facilities in rank 5, and documentation in rank 6.

Table 7. Unweighted Supermatrix

Cluster Node Labels		Alternative						Criteria	
		Crop product	Doc.	P. organization	P. infrastructure	S. facilities	Water user as.	P. index	S. weight
Alternative	Crop product	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0966	0.1153
	Doc.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0503	0.0410
	P. organization	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1630	0.1153
	P. infrastructure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5277	0.5960
	S. facilities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0658	0.0662
	Water user as.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0966	0.0662
Criteria	P. index	0.2500	0.3333	0.3333	0.1667	0.3333	0.3333	0.0000	1.0000
	S. weight	0.7500	0.6667	0.6667	0.8333	0.6667	0.6667	1.0000	0.0000

Table 8. Weighted Supermatrix

Cluster Node Labels		Alternative						Criteria	
		Crop product	Doc.	P. organization	P. infrastructure	S. facilities	Water user as.	P. index	S. weight
Alternative	Crop product	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0483	0.0576
	Doc.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0251	0.0205
	P. organization	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0815	0.0576
	P. infrastructure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2638	0.2980
	S. facilities	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0329	0.0331
	Water user as.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0483	0.0331
Criteria	P. index	0.2500	0.3333	0.3333	0.1667	0.3333	0.3333	0.0000	0.5000
	S. weight	0.7500	0.6667	0.6667	0.8333	0.6667	0.6667	0.5000	0.000

Table 9. Limited Supermatrix

Cluster Node Labels		Alternative						Criteria	
		Crop product	Doc.	P. organization	P. infrastructure	S. facilities	Water user as.	P. index	S. weight
Alternative	Crop product	0.0359	0.0359	0.0359	0.0359	0.0359	0.0359	0.0359	0.0359
	Doc.	0.0149	0.0149	0.0149	0.0149	0.0149	0.0149	0.0149	0.0149
	P. organization	0.0449	0.0449	0.0449	0.0449	0.0449	0.0449	0.0449	0.0449
	P. infrastructure	0.1893	0.1893	0.1893	0.1893	0.1893	0.1893	0.1893	0.1893
	S. facilities	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220
	Water user as.	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262	0.0262
Criteria	P. index	0.2733	0.2733	0.2733	0.2733	0.2733	0.2733	0.2733	0.2733
	S. weight	0.3934	0.3934	0.3934	0.3934	0.3934	0.3934	0.3934	0.3934

Icon	Name	Normalized by Cluster	Limiting
No Icon	Documentation	0.04480	0.014934
No Icon	Water User Associations	0.07868	0.026227
No Icon	Personnel organization	0.13481	0.044938
No Icon	Physical infrastructure	0.56802	0.189341
No Icon	Crop productivity	0.10762	0.035874
No Icon	Supporting facilities	0.06606	0.022019

Figure 5. Rehabilitation priority order of the ANP method

3.3.3 Determination of physical infrastructure aspects rehabilitation priority

In calculations using the AHP and ANP methods, the rehabilitation priority aspect shows the same result as rank 1, i.e. the physical infrastructure aspect. The AHP method scored 0.56187 and the ANP method scored 0.56802. Furthermore, calculations will be carried out to determine the sub-aspects that become a priority in the physical infrastructure aspect. The results of the performance index and standard weight for each sub-aspect of physical infrastructure are shown in Table 10.

Table 10. Physical infrastructure aspect performance index

No.	Sub-aspect	Performance Index	Standard Weight
1	Intake structure (weir)	8.78%	13.00%
2	Irrigation channels	5.54%	10.00%
3	Structure on the channel	5.61%	9.00%
4	Drainage channel and structures	3.05%	4.00%
5	Entrance and inspection roads	3.35%	4.00%
6	Offices, housing, and warehouses	2.95%	5.00%

Determining the rehabilitation priority from the physical infrastructure aspect is carried out by looking for the worst damage conditions (highest score) from all sub-aspects [16]. From the assessment of the performance index that has been carried out, it can be calculated the reached condition and damaged condition for each sub-aspect.

The value for the damaged condition is obtained from the maximum value minus the reached conditions (existing) as shown in Table 11. So that the value of the highest damage condition is obtained in the irrigation channel by 44.6%.

The irrigation channels sub-aspect becomes the first order in determining the rehabilitation priority in the Saba irrigation area. These results are in accordance with the condition or problem found in the irrigation networks.

The rehabilitation that can be done is sediment dredging that settles in the cross-section of irrigation channels. The presence of a pile of sediment in irrigation channels affects the water supply performance to the area to be drained to be less than optimal.

Table 11. Comparison of reached condition and damage condition

No.	Sub-aspect	Reached condition (existing)	Damage condition
1	Intake structure (weir)	67.53	32.47
2	Irrigation channels	55.40	44.60
3	Structure on the channel	62.29	37.71
4	Drainage channel and structures	76.25	23.75
5	Entrance and inspection roads	83.75	16.25
6	Offices, housing, and warehouses	59.00	41.00

4 Conclusion

The assessment of irrigation performance index in Saba Irrigation Area scored 62.94% consisting of physical infrastructure 29.28%; crop productivity 7.24%; supporting facilities 4.95%; personnel organization 10.75%; documentation 3.40%; and water user associations 7.33%.

Determining the rehabilitation priority using the AHP method and ANP method showed the same results, i.e. physical infrastructure in rank 1, personnel organization in rank 2, crop productivity in rank 3, water user associations in rank 4, supporting facilities in rank 5, and documentation in rank 6.

Determination of the selected rehabilitation in the physical infrastructure aspect is the sub-aspect of irrigation channels. Irrigation channels get the highest score with the worst damage conditions from all sub-aspects.

One of the rehabilitation that can be done in the Saba Irrigation Area is sediment dredging in irrigation channels. Furthermore, it is possible to conduct further research to obtain the real costs incurred.

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Appendix: Irrigation performance index of each aspect

Aspect	Weight Score (%)	Performance Index	
		Condition (%)	Categories
I. PHYSICAL INFRASTRUCTURE	29.28		
1 Intake structure	8.78		
1.1 Weir	2.74		
a. Crest	0.60	75.5	GP
b. Wing	0.39	65	LP
c. Impervious floor	0.40	50	PP
d. Dyke	0.60	75	GP
e. Bridge	0.11	53	PP
f. Operational board	0.36	90	EP
g. Water level meter	0.12	60	LP
h. Safety fence	0.16	82	EP
1.2 Sediment gate and gears	4.40		
a. Intake gate	2.80	80	EP
b. Sluice gate	1.60	80	EP
1.3 Sediment trap and drain gate	1.64		
a. Good condition of sediment trap	0.60	85	EP
b. The sediment trap has been cleaned	0.48	80	EP
c. Drain gate & gear of sediment trap can operate	0.56	80	EP
2 Irrigation Channels	5.54		
2.1 Capacity of each channel	3.35	67	LP
2.2 Embankment stability and height	1.14	57	LP
2.3 Channel rehabilitation has been done	1.05	35	PP
3 Structures on the channel	5.61		
3.1 Regulatory structures	1.20	60	LP
a. On the primary & secondary channels	0.70	70	GP
b. On the tertiary irrigation channels	0.70	70	GP
3.2 Discharge measurement			
a. On the intake structures	0.80	80	EP
b. On the regulatory structures	0.38	50	PP
c. On the tertiary structures	0.00	0	-
3.3 Complementary structures			
a. On the primary & secondary channels	0.48	60	LP
b. On the siphons, culverts, bridges, gutters, cross-drains	0.72	60	LP
3.4 Rehabilitation has been done			
a. On the regulatory structures	0.50	40	PP
b. Water level meter	0.00	0	-
c. Operational board	0.00	0	-
d. On the complementary structures	0.13	35	PP
4 Drainage channel and structures	3.05		
4.1 Rehabilitation of drainage channels and structures	2.40	80	EP
4.2 Flood problems	0.65	65	LP
5 Entrance or inspection roads	3.35		
5.1 Entrance to the intake structure	1.80	90	EP
5.2 Inspection roads and trails along the channels	0.80	80	EP
5.3 Each structure and channels	0.75	75	GP
6 Offices, housing, and warehouses	2.95		
6.1 Adequate office for:			
a. Observer office	0.70	70	GP
b. Weir operational officer	0.70	70	GP
6.2 Adequate housing for:			
a. Observers	0.35	70	GP
b. Weir operational officer	0.00	0	-
6.3 Adequate warehouse for:			
a. Observer office	0.65	65	LP
b. Intake structure (weir)	0.30	60	LP

	Aspect	Weight Score (%)	Performance Index	
			Condition (%)	Categories
	c. Beams and other fixtures	0.25	50	PP
II.	CROP PRODUCTIVITY	7.24		
1	Water resources availability	5.40	60	LP
2	Realization of planting area	1.38	34.61	PP
3	Crop productivity	0.46	22.89	PP
III.	SUPPORTING FACILITIES	4.95		
1	Operation and maintenance equipment	1.98		
	1.1 Essential equipment for routine maintenance	1.20	60	LP
	1.2 Operation equipment	0.25	50	PP
	1.3 Heavy equipment for mud cleaning and embankment maintenance	0.53	35	PP
2	Transportation	0.83		
	2.1 Transportation used by observers at Regional Technical Implementation Unit	0.50	50	PP
	2.2 Transportation used by weir operational officer	0.33	65	LP
	2.3 Transportation used sluice guards	0.00	-	
3	Observers equipment	1.05		
	3.1 Basic furniture for the office	0.40	40	PP
	3.2 Work equipment in the office	0.65	65	LP
4	Communication equipment			
	4.1 Communication equipment that can support operation and maintenance	1.10	55	LP
IV.	PERSONNEL ORGANIZATION	10.75		
1	Operation and maintenance organization	4.00		
	1.1 Observers or Regional Technical Implementation Unit	1.60	80	EP
	1.2 Weir operational	1.60	80	EP
	1.3 Sluice guards	0.80	80	EP
2	Personnel	6.75		
	2.1 Quantity according to requirement			
	a. Weir operational officer	0.70	70	GP
	b. Sluice guards	2.10	70	GP
	2.2 Sluice guards for civil servants	1.00	50	PP
	2.3 Personnel who already understand operation and maintenance			
	a. Observers or Regional Technical Implementation Unit	0.75	75	GP
	b. Weir operational officer	1.50	75	GP
	c. Sluice guards	0.70	70	GP
V.	DOCUMENTATION	3.40		
1	Irrigation area data books	1.40	70	GP
2	Maps and figures			
	2.1 Data displayed on the office wall	0.70	70	GP
	2.2 As-built drawings and maintenance maps	0.50	50	PP
	2.3 Irrigation network scheme	0.80	80	EP
VI.	WATER USER ASSOCIATIONS	7.33		
1	The legal entity of WUAs	1.13	75	GP
2	WUAs institutional condition	0.30	60	LP
3	Meeting activities	0.80	40	PP
4	Participation in surveys or network tracing	1.00	100	EP
5	Participation in network rehabilitation and natural disaster management	2.00	100	EP
6	Fee contribution for network rehabilitation	1.40	70	GP
7	Participation in planting planning and water allocation	0.70	70	GP

Notes: EP = Excellent performance (80–100), GP = Good performance (70 –79), LP = Less performance and needs to be considered (55–69), PP = Poor performance and needs to be considered (<55)