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PRIORITY SCALE FOR DETERMINING PHYSICAL MAINTENANCE USING THE AHP METHOD AT KLEGO DAM, BOYOLALI REGENCY

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ABSTRACT

Keywords: Dam; Dam Maintenance; Priority Scale; AHP.

This research aims to evaluate the safety and performance of the Klego Dam in Boyolali, Central Java, using a quantitative descriptive method with primary and secondary data. The research stages involve damage analysis, adjustment of the dam's physical conditions to the research location, and analysis of the current conditions. Maintenance handling is prioritised using the Analytical Hierarchy Process (AHP) method, focusing on spillway channels, turbulent flow, and serrated sections. The physical conditions are analysed to determine the dam's status in 2022. The AHP program prioritises based on performance, safety, cost, damage, and component function. The results of the prioritisation scale for maintenance handling of the Klego Dam are as follows: (1) completing dam instrumentation with a priority matrix value of 0.646; (2) dam infrastructure repair with a value of 0.223; (3) completing the dam's emergency system with a value of 0.132.

Introduction

Dam construction in Indonesia during the current period of President Joko Widodo's administration has increased (Sembiring, 2022). The Ministry of PUPR has infrastructure development targets for 2015-2019, including strengthening connectivity, increasing the number of settlements, and providing housing and water/food security (Juanizar, Suripin, Sriyana, & Suprapto, 2022). One of the targets of infrastructure development in water security is the construction of 65 reservoirs consisting of 16 ongoing dams and 49 new dams (Anryana, Prawitosari, & Achmad, 2019).

The construction, maintenance and operation of dams with their reservoirs will be increasingly influenced by spatial developments, increasing environmental issues, and demands for sustainable development, so legal umbrellas and adjustments to guidelines and regulations are needed that can respond more quickly and definitely to these developments (Al Theeb, Qdais, Qdais, & Habibah, 2022).

Many large dams are generally old, especially the Klego Dam, which was built in 1987 and began operating in 1990. Attention is needed to estimate the level of dam failure, so more precise and rigorous operation and maintenance management to overcome problems with dams is needed.

Klego Dam is administratively located in Bade Village, Klego District, Boyolali Regency, Central Java Province. The geographical location of Klego reservoir is at BT 110□ 42' 15.10" and LS 7□ 21' 43.34". The location of the Klego Dam can be seen in Figure 1.

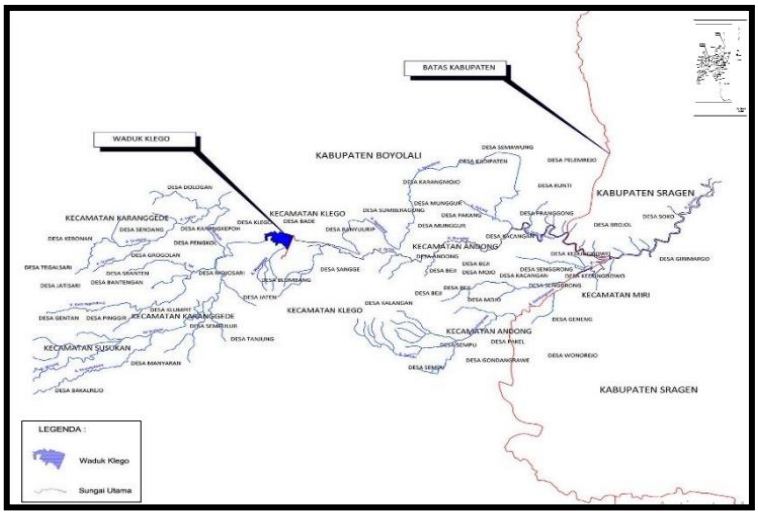


Figure 1 Location of Research Activities

Based on Technical Data, the Klego Dam has a storage volume of 2.33 million m³ used to irrigate an irrigation area of 1353 Ha. As an improvement in the function of Benudngan Klego, an analysis is needed regarding the assessment of dams.

Based on the source of BBWS Pemali Juana data, the condition of the Klego Dam has suffered several damages, ranging from the main building to complementary buildings/facilities and infrastructure that support the dam's operation.

The problems in Klego Dam are reviewed from:

1. The body of the Klego Dam has cracks and deformation.
2. The intake building has holes that are broken into by residents so that the water that comes out is not by the SOP
3. In the Spillway Building, there is no reject pond at the downstream end of the sewer so that runoff runs directly into people's land.
4. The top of the dam is used as an access road or main road; this can affect the stability of the dam and can endanger the safety of the Klego Dam
5. The intake door does not function optimally because the sedimentation conditions in the reservoir are high enough to affect the performance of the reservoir and agricultural conditions downstream of the dam.

Considering the problems described above, maintenance and rehabilitation measures are needed to handle the problems of the Klego Dam, primarily to support its optimal function (Aldi, Alkatiri, Latif, & Amalia, 2023). Through the State Budget, the government provides a Special Allocation Fund (DAK) that can be used for rehabilitation activities to improve dam buildings' function and physical condition (Triyani & Yulistika Chandra Ayu P, 2022). However, with this limited DAK allocation, the implementation of maintenance must be carried out gradually and continuously, so an analysis is needed to determine the priority of dam maintenance. Analysis of Dam maintenance priorities is critical to be carried out before maintenance is carried out. This aims to determine the priority scale of handling and damage to Dam components so that handling steps can be determined to overcome problems at the Klego Dam (Andriawan, 2022).

In dam management, maintenance is an effort to maintain and improve the condition and function of irrigation networks. The type of maintenance is determined based on the physical condition of the dam (Hartono, Saparudin, & Sugiyarto, 2017) (Government Regulation of the Republic of Indonesia Number 37 of 2010). Dam damage can be caused by operating errors and natural conditions that impact the deterioration of the condition and function of the dam. Dam damage is followed up through rehabilitation activities to restore the condition and function of the dam. Rehabilitation is a type of activity with a large volume of work. Therefore, the activity is carried out programmatically based on the priority value of handling (Setiawan & Khusnudin, 2021).

In this study, dam handling priorities will be determined through a maintenance priority number determination model based on an assessment of the condition and function of dam components based on the Analytical Hierarchy Process (AHP) method. The advantage of applying the AHP method is that it considers the weight of asset criteria based on the importance of components. The dam criteria will be analysed using the AHP (Analytic Hierarchy Process) method, which is then applied to the Klego Dam. The results obtained later can show which components are priorities in handling repairs. The components reviewed in this study are from the condition of the Reservoir, Dam Structure, Auxiliary Buildings and Instrumentation on the Klego Dam, which will be analysed in more detail later.

Research Methods

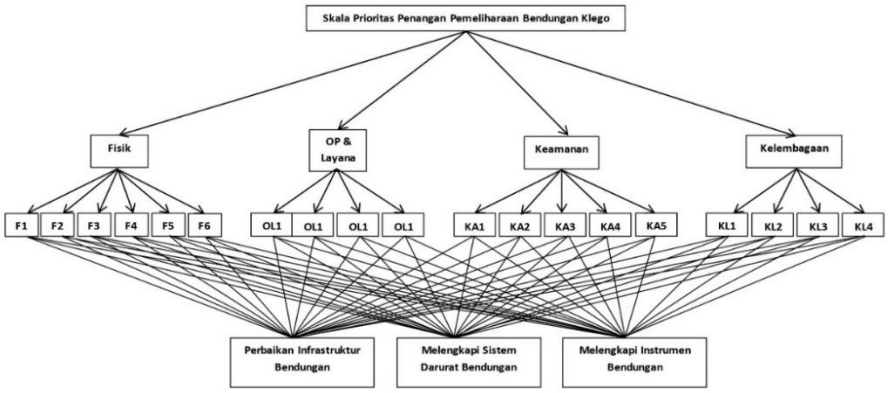
The concept carried out in this research is descriptive research, which aims to collect information and actual data in detail that describes existing conditions and symptoms, identify problems or examine applicable conditions and practices. In this study, the identification of problems that occurred in the Klego Dam was carried out, and the value of the function and performance of the Klego Dam was then determined. With the knowledge of the problems and performance functions of the Klego Dam, it can then be determined the accuracy of rehabilitation actions on the Klego Dam according to the priority scale of rehabilitation related to the function and level of dam safety to maintain the optimal function of the Klego Dam.

The method to obtain the percentage of the performance of each dam component used in this study is to use questionnaires and interviews with employees involved in the UPB (Dam Management Unit) of the Klego Dam and a team of experts in dam management and maintenance. The determination of the sample uses purposive sampling/Judgment Sampling, which is a non-probability sampling; the sample in this study is determined by the researcher, considering that the sample can provide accurate and actual information.

Results and Discussion

This research refers to the method used by Andriawan, A. (2020). Decision-making techniques on determining the priority scale of maintenance of the condition of the Klego Dam with the application of the Analytical Hierarchy Process and Software Expert

Choice 11 To produce handling strategies and priority order in the maintenance of the Klego Dam to improve dam performance. The condition assessment results became the basis for further analysis by determining the priority scale for handling maintenance of the Klego Dam (Wijayanti, 2015). Priority handling uses the Analytical Hierarchy Process (AHP) Method because it represents all calculated aspects (Andriawan, 2020). The AHP modelling at the Klego Dam is described as follows:



Picture 2 AHP Modeling in the Klego Dam

The weight of criteria, sub-criteria and alternatives is assessed by conducting a questionnaire distribution survey to experts and stakeholders. Each respondent was asked to provide an assessment or perception of the importance of each element compared using the Saaty scale with values between 1 and 9. The assessment carried out by four respondents indeed produces different opinions or values, while the AHP method only requires a single answer to the pairwise comparison matrix. Therefore, the four respondents' assessment results are combined to produce the average value or geomean. The following is an example of geomean figures between alternatives obtained by combining the assessment results of the four respondents shown in Figure 3 (Expert Choice) and Figure 4 (Ms. Excell, 2013).

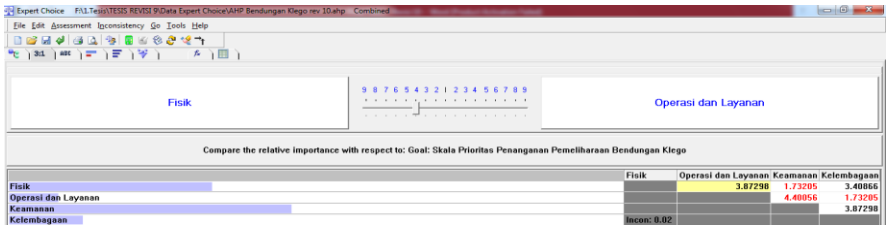
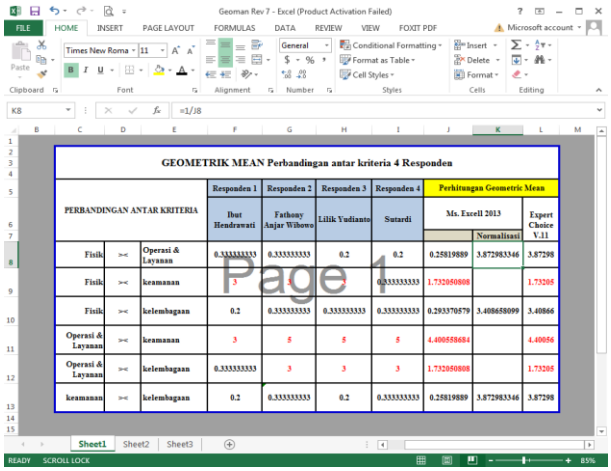


Figure 3 Example of Geometric Mean Between Alternative Combinations of 4 Respondents using Expert Choice



GEOMETRIK MEAN Perbandingan antar kriteria 4 Responden

PERBANDINGAN ANTAR KRITERIA			Responden 1	Responden 2	Responden 3	Responden 4	Perhitungan Geometric Mean		
			Ibut Hendrawati	Fathony Anjar Wibowo	Lilik Yudianto	Sutardi	Ms. Excell 2013	Normalisasi	Expert Choice V.11
Fisik	><	Operasi & Layanan	0.333333333	0.333333333	0.2	0.2	0.25819889	3.872983346	3.87298
Fisik	><	keamanan	3	3	0.333333333	0.333333333	1.732050808		1.73205
Fisik	><	kelembagaan	0.2	0.333333333	0.333333333	0.333333333	0.293370579	3.408658099	3.40866
Operasi & Layanan	><	keamanan	3	5	5	5	4.400558684		4.40056
Operasi & Layanan	><	kelembagaan	0.333333333	3	3	3	1.732050808		1.73205
keamanan	><	kelembagaan	0.2	0.333333333	0.2	0.333333333	0.25819889	3.872983346	3.87298

Figure 5 Example of Geometric Mean Between Alternative Combinations of 4 Respondents using Ms. Excel

The geometric alignment values in Figure 3 are shown in the lower right corner. Figure 4 compares manual calculations with Ms Excell and expert choice; the results are the same. In Figure 3 of the matrix, the CR value of the combination result is 0.00 so that the value can be accepted and considered consistent. The red number indicates that the scale rater is more inclined to choose on the right than on the left, while the black number indicates that the scale rater is more inclined to choose on the left than on the right.

Furthermore, in the combined assessment will also appear the overall weighting as follows:

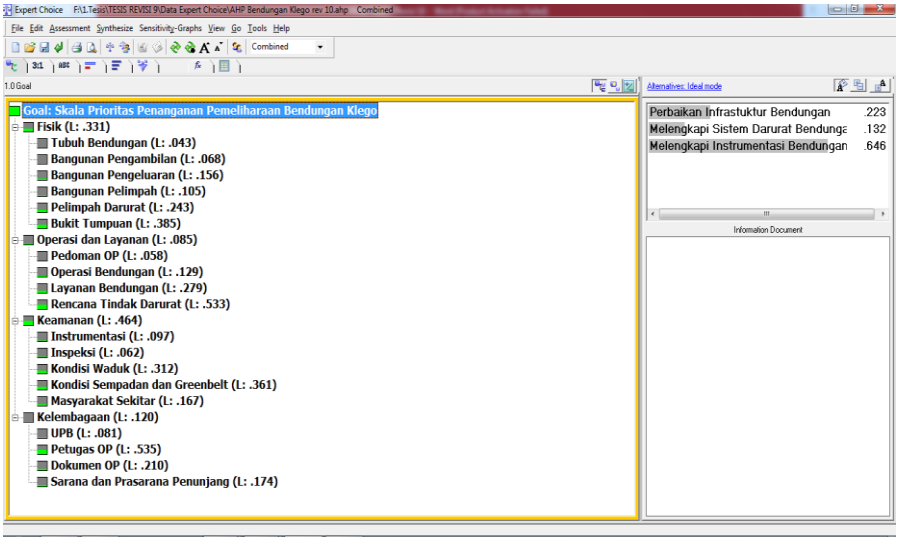


Figure 5 Combination Weighting Results

Figure 5 above shows the results of pairwise comparison weighting, a normalisation of a paired comparison matrix between research elements from all respondents. The weighting above is displayed comprehensively, starting from the weighting between

criteria against the objective, the weighting of the sub-criteria against the parent criteria, to the alternative weighting of the objective (Susila & Munadi, 2007).

1. AHP Weighting Results

In this step, the presentation of the AHP weighting is displayed in more detail for each element assessed. The following are the weighting results of each element of the study:

Table 1
Recap of Priority Weight of Criteria/Sub-Criteria

No	Criterion	Weight	Sub Criteria	Weight
1	Physical	0.331	Dam Body	0.043
			Picking Building	0.068
			Production Building	0.156
			Overflow Building	0.105
			Emergency Spillover	0.243
			Highlight Hill	0.385
2	Operation & Service	0.085	Operating Guidelines	0.058
			Dam Operations	0.129
			Dam Services	0.279
			Emergency Action Plan	0.533
3	Security	0.464	Instrumentation	0.097
			Inspection	0.062
			Reservoir Conditions	0.312
			Border and Greenbelt Conditions	0.361
			Surrounding Community	0.167
4	Institutional	0.120	Upwards	0.081
			Operations Officer	0.535
			Operating Documents	0.210
			Supporting Facilities and Infrastructure	0.174

From the results of overall data processing with expert choice v.11, the highest priority weight for all criteria was obtained, namely the Security criterion with a weight of 46.4%. The weight of each criterion and sub-criteria based on the ranking and the amount of score obtained can be seen in the Table above.

2. Alternative weighting of research goals

The priority weighting of each alternative against each of the Physical sub-criteria, Operations and Services sub-criteria, Security sub-criteria, and Institutional sub-criteria can be obtained from the results of data processing with expert choice v.11 with the results as shown in Table 2.

Table 1

Priority Weight of Criteria/Sub-Criteria

No.	Criteria/Sub-criteria	Relative Importance Weighting		
		Dam Infrastructure Repair	Equipping the Dam Emergency System	Equipping Dam Instrumentation

1	Physical			
1a	Dam Body	0.212	0.135	0.654
1b	Picking Building	0.258	0.105	0.637
1c	Production Building	0.170	0.170	0.659
1d	Overflow Building	0.226	0.117	0.657
1e	Emergency Spillover	0.258	0.105	0.637
1f	Spotlight Hill	0.212	0.135	0.654
2	Operations and Services			
2a	Operating Guidelines	0.244	0.124	0.632
2b	Dam Operations	0.212	0.135	0.654
2c	Dam Services	0.170	0.170	0.659
2d	Emergency Action Plan	0.258	0.105	0.637
3	Security			
3a	Instrumentation	0.244	0.124	0.632
3b	Inspection	0.258	0.105	0.637
3c	Reservoir Conditions	0.212	0.135	0.654
3d	Matching Conditions and Greenbelt	0.258	0.105	0.637
3e	Surrounding Community	0.148	0.194	0.657
4	Institutional			
4a	Dam Management Unit	0.207	0.126	0.667
4b	Operations Officer	0.202	0.168	0.629
4c	Operation Documentation	0.212	0.135	0.654
4d	Supporting Facilities and Infrastructure	0.258	0.105	0.637

Next is the weighting of alternatives to the objectives or objectives of the study. The following are the combined weighting results of 4 alternative treatments at the Klego Dam:

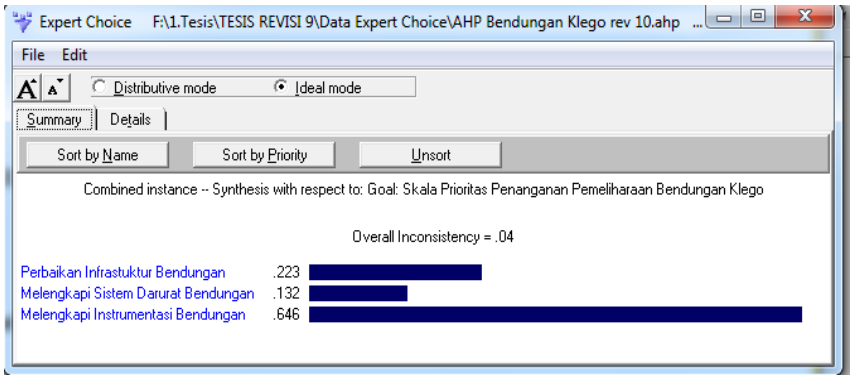


Figure 7 Alternative Weighting Results (Combination)

Based on the results of the alternative weighting above, it can be seen that the alternative order of maintenance handling at the Klego Dam is to complete the dam instrumentation with a weight of 64.6%, followed by repairing the dam infrastructure with a weight of 22.3%, completing the dam emergency system 13.2%.

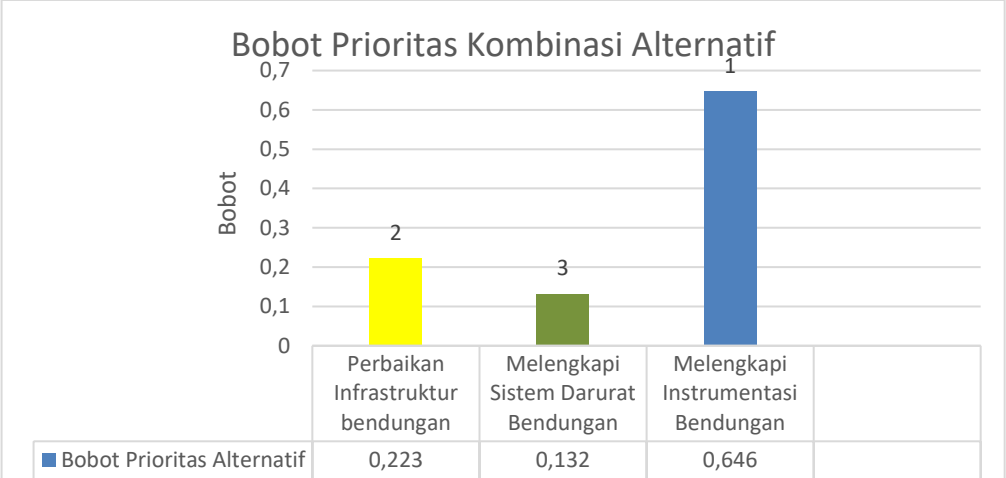


Diagram 1 Alternative Combination Priority Weights

This sensitivity testing is essential to see the consistency of results and the strength of priority ratings on alternatives. Graph performance is obtained based on scenarios or assumptions made differently. In this study, the scenario was created by assuming the weight on the criteria increased or decreased by 50% of the original weight. Sensitivity testing is performed by shifting the sensitivity scale towards the right and left. If shifted to the right, the weight on the criteria tested for sensitivity will increase and vice versa. Here are the sensitivity test results:

Table 3
Sensitivity Test Results

No	Criterion	Alternative	Sensitivity Test Weight Presentation			Sensitivity Test Results
			Normal	93%	3%	
1	Physical	Dam Infrastructure Improvement	22.3%	22.2%	22.3%	No changes to the priority order of handling
		Equipping the Dam Emergency System	13.2%	12.9%	13.3%	
		Completing Dam Instrumentation	64.6%	64.9%	64.4%	
2	Operations and Services	Dam Infrastructure Improvement	22.3%	22.7%	22.2%	No changes to the priority order of handling
		Equipping the Dam Emergency System	13.2%	12.8%	13.2%	
		Completing Dam	64.6%	64.5%	64.6%	

No	Criterion	Alternative	Sensitivity Test Weight Presentation			Sensitivity Test Results
			Normal	93%	3%	
		Instrumentation				
3	Security	Dam Infrastructure Improvement	22.3%	22.4%	22.1%	No changes to the priority order of handling
		Equipping the Dam Emergency System	13.2%	13.1%	13.3%	
		Completing Dam Instrumentation	64.6%	64.5%	64.6%	
3	Institutional	Dam Infrastructure Improvement	22.3%	21.5%	22.3%	No changes to the priority order of handling
		Equipping the Dam Emergency System	13.2%	14.6%	13.0%	
		Completing Dam Instrumentation	64.6%	63.9%	64.6%	

Based on the tabulation of sensitivity test results, it can be seen that although the weight of the criteria affects each other, the change in the weight of the criteria will still result in the same handling priority. The above test does not change the order of its alternative priority scales. Equipping dam instrumentation remains a top priority in handling maintenance at the Klego Dam.

Based on the results of data processing using the Expert Choice V.11 application which is divided into four aspects of criteria, namely Physical, Operation and Service, Security, and Institutional criteria, the lowest weight of handlers is obtained namely Operation and Service criteria with a priority weight value of 0.85, followed by institutional criteria with a weight value of 0.120, followed by Physical criteria with a priority weight value of 0.331, and finally with the highest priority weight, namely the Security criterion with a value of 0.85 priority, followed by institutional criteria component weight 0.464. From these results, the priority of handlers can be found in the Security criteria. These four conditions indicate a decline in function from the initial condition of the dam, so priority in handling repairs is needed according to the level of damage. (Hugging, 2020).

The results of the synthesis of data processing among research alternatives obtained the global priority weight of each alternative from the largest to the smallest. Based on the maintenance priority rating of the Klego Dam:

1. In the first order, the priority for maintenance is to complete the dam instrumentation with a priority matrix value of 0.646. Dam instrumentation plays a vital role in dam security performance because Green belt border conditions and reservoir conditions can affect reservoir orientation, vegetation conditions and water quality measurements; this can be a reference for priority maintenance decisions on Klego dams (Murti, 2018).
2. In the second place, there is a form of maintenance, namely the improvement of dam infrastructure, with a priority matrix value of 0.223. This is related to the dam's physical performance, which is also essential. The physical condition of the dam can be a benchmark for the feasibility of other aspects, meaning that if the physical condition of the dam is declared feasible, the performance of other aspects can run well. Let us look back at the results of the assessment of the physical condition of the Klego Dam. The improvement of building infrastructure can be aimed at the pedestal hill and emergency spillway buildings with a "less" assessment category compared to other parts (Muslim & Kurniawan, 2020).
3. In the last order, the priority for handling maintenance that needs to be done is to complete the dam emergency system with a priority matrix value of 0.132. This is included in the emergency action plan component in the operation and service aspects of the Klego Dam. The emergency system in question is mutually continuous with dam instrumentation, where when the system detects a signal, dangerous conditions can be prevented as early as possible in the hope that dam operations and services can be maintained and maintained correctly (Orfa & Amal, 2023).

Conclusion

Based on the performance assessment of the Klego Dam by referring to the Technical Guidelines for Dam Performance Assessment issued by the Directorate of Operation and Maintenance, Ministry of Public Works and Public Housing, there are four aspects evaluated, namely physical aspects, aspects of dam operation and service, dam safety aspects, and institutional aspects of dams. Of the four aspects, the physical and institutional aspects have a damage rate above 30% and are in the "Sufficient" criteria, while the operation and service aspects are in the "Good" criteria with a damage rate above 20%. The security aspect is in the "Less" criteria, with a damage rate below 30%. Furthermore, four criteria with 19 sub-criteria were assessed to determine the priority scale for handling maintenance. The results resulted in three alternative maintenance treatments: repairing dam infrastructure, completing the dam emergency system, and completing dam instrumentation. Of the three alternatives, the priority order for handling maintenance of the Klego Dam is to complete the dam instrumentation with a priority matrix value of 0.646, followed by dam infrastructure improvement with a value of 0.223, and complete the dam emergency system with a value of 0.132.

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