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Priority Strategy For Improving Dam Operation and Maintenance Performance (Cacaban Dam Case Study)

Ary Aprianto
Institut Teknologi Sepuluh Nopember, Indonesia
Email: aprianto.ary@gmail.com

*Correspondence: aprianto.ary@gmail.com

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ABSTRACT

Dam operation and maintenance activities are critical, so the dam usually works and provides benefits according to plan. Over time, the performance of the Cacaban Dam has decreased significantly. The physical condition of the main building, supporting buildings, and instruments have experienced damage, which could pose a risk to the dam's safety. The main objective of this research is to determine priority strategies for improving operations and maintenance of the Cacaban Dam. Determining priority strategies for improving operations and maintenance in this research uses the DSS (Decision Support System) method with SWOT (Strength, Weakness, Opportunity, and Threat) and QSPM (Quantitative techniques Strategic Planning Matrix). Based on the SWOT analysis results, the resulting strategy is the Diversity Strategy, meaning that the Cacaban Dam is in good internal condition. In contrast, the external condition is not good. The proposed strategy is to minimize external threats/threats with strategic priorities referring to the scoring results using the QSPM method. Meanwhile, from the results of the dam performance assessment, Cacaban Dam obtained an average performance score of 3.45, considered adequate performance. However, if you look at several items of poor performance, there are two items, namely reservoir condition and border and greenbelt conditions, which have poor performance. There are seven components, namely intake buildings, spillway buildings, support hills, dam services, emergency action plans, instrumentation, and surrounding communities, whose performance is quite close to the deficient limit and has the potential for performance to decline. Extra handling is needed to restore the performance of dams and reservoirs.

Introduction

Cacaban Dam, one of the assets of the Regional Government of Tegal Regency, was built in 1952-1958 and planned and implemented by the Dutch East Indies

Government. Cacaban Dam is a homogeneous soil dam with a maximum height of 38 meters (Abbasi, Vahdani, Ahmadi, & Behrouz, 2013). The dam has a length of 168 meters, and the source of Cacaban Reservoir water comes from the Cacaban Wetan River. Cacaban Dam functions as a water reservoir in the rainy season. She irrigates technical irrigation for rice fields covering an area of 17,481 hectares and provides raw water of 0.35 m3/s for the surrounding community (BBWS et al., 2022).

Over time, the performance of the Cacaban Dam has decreased significantly. The physical condition of the main building, supporting buildings, and instruments has suffered damage that could pose a risk to the dam's safety. Problems that occur in the Cacaban Dam at this time include the volume of the reservoir, which was initially 49 million m^3 has decreased by about 50% from the original reservoir, and damage to hydromechanical equipment. The physical condition of the main dam / main dam is also damaged, and it is necessary to check the condition of the structure; besides that, it is necessary to check and evaluate reservoir reservoirs and services (BBWS Pemali Juana, 2021). Sedimentation conditions have also increased which has caused silting of the reservoir bottom, caused by the erosion rate in the Cacaban Dam Watershed (DAS) included in the hefty erosion hazard level (Pramono, Wahyudi, & Soedarsono, 2019).

Based on several problems that occur in the Cacaban Dam, this study will analyze the dam's current condition, which will then produce a priority strategy for improving its performance of the Cacaban Dam. Given the importance of studying the condition of the Cacaban Dam, the author compiled this thesis titled "Priority Strategy for Improving Dam Operation and Maintenance Performance (Case Study of Cacaban Dam, Tegal Regency)."(Pramono et al., 2019)

The study of the current condition of Cacaban Dam is an important effort in understanding the challenges faced by this infrastructure and designing priority strategies to improve its performance. The dam has a long history as a regional government asset and has made significant contributions to technical irrigation and raw water supply for the surrounding community (Pesonen & Horn, 2014).

Built during the period 1952-1958 by the Dutch East Indies Government, Cacaban Dam is a homogeneous soil dam with a maximum height of 38 meters. With a length of 168 meters, the dam relies on the flow of the Cacaban Wetan River as a water source for the Cacaban Reservoir. During the rainy season, Cacaban Dam functions as a water reservoir, providing technical irrigation for 17,481 hectares of paddy fields and supplying raw water at a rate of 0.35 m3/second for the surrounding community (Ghosiyan, Ebadi, & Shojazadeh, 2015).

However, over time, the performance of Cacaban Dam has significantly declined. The physical condition of the main building, supporting structures, and equipment has deteriorated, posing risks to dam safety. Several issues include a 50% decrease in reservoir volume from its original capacity, damage to hydromechanical equipment, and physical deterioration of the main dam structure. Sedimentation levels have also increased, leading to siltation of the reservoir bottom due to erosion rates in the Cacaban Watershed, classified as having a high erosion hazard level (Pramono et al., 2019)

This study aims to analyze the current condition of Cacaban Dam and develop priority strategies to enhance its performance. Recognizing the importance of researching the condition of Cacaban Dam, the author has compiled a thesis entitled "Priority Strategy for Improving Dam Operation and Maintenance Performance (Case Study of Cacaban Dam, Tegal Regency)."

In-depth analysis of the physical, hydromechanical, and sedimentation conditions will be the primary focus of this research. Taking into account these aspects, priority strategies will be formulated to address the performance issues of Cacaban Dam, ensuring the continuity of irrigation functions and water supply for the community while minimizing risks to dam safety (Maulida et al., 2021).

The novelty of the "Priority Strategy for Improving Dam Operation and Maintenance Performance (Cacaban Dam Case Study)" lies in its innovative approach to addressing the challenges specific to Cacaban Dam. By integrating methodologies such as SWOT analysis and the Quantitative Strategic Planning Matrix (QSPM) method, this study offers a fresh perspective on strategic decision-making in dam management. Unlike conventional approaches that provide generic solutions, this study emphasizes the development of priority strategies tailored to the unique needs and circumstances of Cacaban Dam. Moreover, the study's reliance on empirical data ensures that proposed solutions are grounded in real-world evidence, enhancing their practicality and effectiveness. By prioritizing safety and sustainability alongside operational efficiency, this study sets a precedent for future research in dam management and infrastructure maintenance, paving the way for innovative solutions in the field.

Research Methods

This research method begins with the collection of primary data and secondary data. The output expected to appear in the data collection stage is the data collection needed in research and can support the strategy analysis and prioritization stages. Primary data in the study area were obtained from the results of physical observations of the dam by the authors, questionnaires, and direct interviews with related parties. Secondary data in the form of existing condition data in the form of research location maps, supporting data, related studies, books, and related journals are reference sources for the preparation of this research. Data sources were obtained from external parties, including the Pemali Juana River Basin Center (BBWS) as the manager (Sugiyono, 2016).

Technical data analysis in this study uses the SWOT method. SWOT analysis has become one of the most valuable tools in the construction world. However, it does not rule out the possibility of being used as an application of decision-making tools in the analysis of "Priority Strategy for Improving Dam Operation and Maintenance Performance (Cacaban et al. Study)." Strategy prioritization using the QSPM method utilizes internal and external factors in the SWOT analysis (Rangkuti, 2015).

Results and Discussion

The results of the visual examination can be concluded that the physical condition of the Cacaban Dam is not good because there are activities in the dam environment that can reduce the function of the dam, activity waste, and plant waste from the green belt area that covers the reservoir, the number of green belt locations that change functions, for the physical dam several parts such as launchers, oak ponds, left and right walls/pedestals, Hydromechanical equipment, and irrigation canals are already damaged, which can disrupt the function of the dam (Dyson, 2004).

In April 2023, dam performance measurements will be measured with questionnaires to the Cacaban Dam Management Unit. The results of the questionnaire with assessment criteria entered into the value column are analyzed by the dam performance review procedure referring to the Dam Performance Assessment Technical Guidelines issued by the Directorate of Operation and Maintenance, Directorate General

of Water Resources, Ministry of Public Works and Public Housing, it is concluded that the condition of the Cacaban Dam with the average assessment criteria is good, but if we look back at the details on the components there are two items, namely reservoir conditions and boundary &; greenbelt conditions are in less performance. There are seven components, namely retrieval buildings, spillway buildings, pedestal hills, dam services, emergency action plans, instrumentation, and surrounding communities, in performance quite close to the limit of less. In the sub-component, there are nine items, namely RTD preparedness, RTD communication system, water level elevation instrumentation, reservoir water quality, reservoir cleanliness, reservoir sedimentation, border and greenbelt conditions, border and greenbelt conservation efforts, and community activities in poor performance. Seeing this condition was assisted by discussions with Cacaban Dam experts or supervisors from UPB Cacaban Dam. Cacaban Dam's extra handling is needed to restore dam performance, especially so that it can better meet downstream needs (Beloborodko et al., 2015).

The results of the dam performance assessment based by the Director General of Water Resources of the Ministry of PUPR in 2017, namely all parts of the Cacaban Dam from the upstream, middle, and downstream areas, are a picture that can be interpreted as the ability of the Cacaban Dam related to its function as a multipurpose dam that we have obtained in the previous stage, analyzed and sorted assisted by a discussion with Cacaban Dam experts or supervisors from UPB Cacaban Dam, become "key factors," namely components of internal factors, namely and external factors, namely strength, weakness; and external factors, namely opportunity, threat. The "key factor" mapping results show that the amount of strength is more than weakness, and external threat factors are more than opportunity. This shows qualitatively that the Cacaban Dam has many advantages but also many threats from outside (Ginting, 2006).

Qualitative internal and external factor data will be converted into quantitative through the calculation of SWOT Analysis with data taken in May 2023 so that the value or weight or rating of each factor is known; the results of internal and external factor analysis can be seen in Table 1

Table 1 Results of Internal and External Factor Analysis Questionnaire

No	*Key Factor*	*Weight*	*Rank*	*Weighted Score*
A	***B***	***C***	***D***	***E= (CxD)***
	Internal Factors Evaluation			
	Strength			
1	Availability of basic or critical infrastructure	0,11	3,57	0,39
2	Availability of Dam Management units	0,08	4,00	0,32
3	OP Officer Availability	0,10	4,09	0,41
4	OP Document Availability	0,09	4,64	0,42
5	Availability of Supporting Infrastructure Facilities	0,10	4,64	0,46
6	The only large reservoir in Tegal	0,11	4,00	0,44
7	Relatively constant availability of reservoir inflow	0,09	4,55	0,41
8	Quite good reservoir water quality	0,09	2,73	0,25
9	Availability of guidance in emergency conditions (Dam collapse)	0,07	4,00	0,28
10	Good competence of UPB officers	0,08	4,36	0,35

No	*Key Factor*	*Weight*	*Rank*	*Weighted Score*
A	***B***	***C***	***D***	***E= (CxD)***
	Internal Factors Evaluation			
11	Good UPB office conditions	0,08	4,82	0,39
	Total	**1,00**		**4,11**
	Weakness/Weakness			
1	Damage to some infrastructure	0,15	3,06	0,46
2	Guidelines for flood early warning systems that do not yet exist	0,22	2,45	0,54
3	Damage to dam instruments	0,28	2,75	0,77
4	Aged Hydromechanical Equipment	0,07	3,00	0,21
5	There are deposits of garbage, sedimentation, and residues of rice plant residues on the tidal land of reservoirs	0,15	3,00	0,45
6	Irrigation outlet canals are damaged and perforated, causing loss of irrigation supply water	0,05	3,00	0,15
7	Communication equipment is not sufficient in times of emergency	0,03	2,45	0,07
8	Incomplete recording of dam behavior	0,05	3,36	0,17
	Total	**1,00**		**2,82**
	Strength - Weakness			**1,29**
	External Factors Evaluation			
	Opportunity/Opportunity			
1	Availability of periodic inspection measures	0,15	3,48	0,52
2	Good communication with the dam community	0,11	3,18	0,35
3	There is satisfaction from irrigation services	0,11	2,82	0,31
4	Tourism potential in Cacaban reservoir	0,18	3,00	0,54
5	Measurement of reservoir water quality	0,17	2,00	0,34
6	There are conservation efforts on borders and greenbelts	0,13	3,00	0,39
7	There is community involvement in maintaining the sustainability of reservoirs	0,15	1,82	0,27
	Total	**1,00**		**2,73**
	In threat/shock			
1	Socialization related to disaster preparedness has not been carried out	0,09	4,00	0,45
2	Damage to Border Conditions and Green Belt	0,16	2,55	0,41
3	Existence of Surrounding Community Activities	0,15	2,55	0,38
4	Cross-institutional existence in dam maintenance	0,07	3,27	0,23
5	When the inundation of the reservoir recedes, rice is planted by farmers around the	0,08	3,00	0,24

No	*Key Factor*	*Weight*	*Rank*	*Weighted Score*
A	***B***	***C***	***D***	***E= (CxD)***
	Internal Factors Evaluation			
	reservoir, which has the potential to cause pollution of the reservoir's water quality			
6	The potential of aquatic vegetation in reservoirs is quite a lot	0,08	2,55	0,20
7	The presence of garbage in the reservoir	0,06	4,00	0,24
8	Absence of sediment measurements at the bottom of the reservoir	0,13	2,73	0,35
9	There have been no preventive efforts to overcome reservoir sedimentation	0,11	3,00	0,33
10	The use of reservoir water for irrigation, residents, and raw water	0,07	4,00	0,28
	Total	**1,00**		**3,03**
	Opportunity - Threat			**-0,30**

Mapping with a SWOT diagram is done by subtracting the total number of factors S from W and O from T. The acquisition of numbers (S-W) then becomes the value or point on the X axis, while the acquisition of numbers (O-T) then becomes the value or point on the Y axis (Table 1).(Gao & Peng, 2011)

Based on the strategy diagram, it is known that the application of the strategy on the respondent's contribution in providing the perception of the existence of the Cacaban Dam is as follows (Sumiarsih, Legono, & Kodoatie, 2018).

Coordinate Position in quadrant :

X = Total Skor Strength - Total Skor Weakness = 4,11 – 2,82 = 1,29

Y = Total Skor Opportunity - Total Skor Threat = 2,73 – 3,03 = -0,30

The coordinates (X, Y) in the SWOT diagram are (1.29;-0.30), plotted in the diagram below.

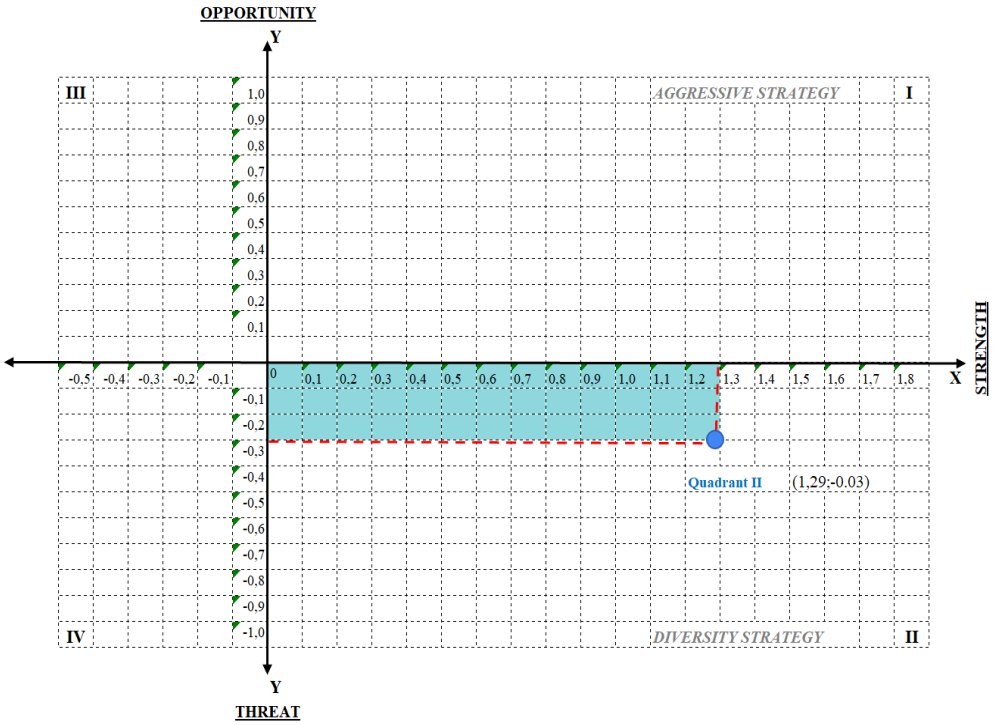

Figure 1 Coordinate points on a SWOT diagram.

The plotting results obtained by the diagram are in quadrant II, with the resulting strategy being the Diversity Strategy, meaning that the Cacaban Dam must utilize its strength to take advantage of long-term opportunities (Wardoyo, 2011).

The SWOT matrix is derived from external and internal strategic factors as described in the External Factor Evaluation and Internal Factor Evaluation (EFE and EFI) tables by transferring opportunities and threats from the EFE table and strengths and weaknesses from the EFI table into the corresponding cells in the SWOT matrix. Then, the data was discussed with representatives of the Cacaban Dam Maintenance Unit and questionnaire participants, following the SWOT Matrix shown in Figure 1.

Internal Factors / External Factors	Strength
	1. Availability of basic or main Infrastructure 2. Availability of dam management unit 3. Availability of OP officer 4 availability of OP document 5 Availability Of Supporting Infrastructure 6 The only big reservoir in Tegal 7 availability of relatively constant reservoir inflow 8 reservoir water quality is quite good 9 availability guide in emergency conditions (collapse dam) 10 competencies of a good UPB officer 11 good condition of UPB office
Threat	
I Not doing socialization related disaster preparedness	1). The existence of guidance documents on emergency conditions at the dam, must be refined with socialization related warning system when there is a disaster detected in dams, so that disaster mitigation is more structured and does not cause casualties. community spirit downstream of the dam.
II there is damage to boundary conditions and Green belt	2). OP document containing the rules of operation and maintenance of the dam and surrounding areas shall be implemented, including maintenance efforts to maintain boundary conditions and greenbelt reservoirs so as not to be damaged and utilized for illegal buildings that do not fit the rules.
III the existence of community activities around	3). Cacaban reservoir is the only large reservoir in Tegal, so that people many take advantage of the presence of reservoirs for livelihoods and tourism. However, community activities need to be limited, especially not to be in the area dam to maintain water quality and parts of the dam.
IV the existence of cross-institutional maintenance dam	4). Water quality and sedimentation in the reservoir is strongly influenced by water from downstream, while the ownership of border and green belt locations under the auspices of DLH, perhutani and also ownership of citizens, so there needs to be help from the government local to facilitate cross-institutional maintenance is because the dam cacaban is the only large reservoir in Tegal.
V At the time of inundation of the reservoir receded, planted with rice by the farmers around the reservoir, which potential to cause water quality pollution reservoirs	5). Regarding the good competence of UPB officers, a socialization program was created to local residents to be able to maintain the upstream condition of many reservoirs vegetation that can be garbage dam and do the cleaning at least a 2-week period.
VI the potential of aquatic vegetation in the reservoir is quite a lot	6). With a sufficient number of OP officers, the OP activities can be made more structured by always doing the cleaning of vegetation waste on dams and reservoirs continuously, if still not possible can be evaluated by adding personnel and increasing cleaning time.
VII the presence of waste in the reservoir	7). The amount of waste due to the large number of activities in the reservoir, with sufficient infrastructure reliable and the only large dam must have been the attraction of the reservoir is very strong, the population who come can be used to bring in the manager of the tourist area professionals working with local authorities whose results can help in preserving the dam.
VIII there is no sediment measurement on the bottom reservoirs	8). The UPB also plays a role in efforts to prevent sedimentation into reservoir, one of them by also monitoring the rate of sedimentation amount is appropriate with the plan or not and keep the upstream area of the reservoir so as not to be erosion and impact. sedimentation rate at the bottom of the reservoir.
IX there has been no preventive effort to tackling reservoir sedimentation	9). Communities around the reservoir, especially in downstream areas also take advantage of the reservoir inflow relatively stable, average for household and agricultural consumption. It is necessary note that the utilization of it dak too excessive, with the aim of maintaining inflow water, and to maintain stability.
X Use of reservoir water for irrigation, local residents and raw water.	10). Need for routine maintenance by users and managers in irrigation canals cacaban dam to lose water in irrigation canals ti Dak getting bigger.

Figure 2 SWOT Matrix

The next stage of strategy analysis is decision-making; in this stage, the method used is QSPM (Maulida et al., 2021).

From the QSPM matrix on the Cacaban Dam Infrastructure component, the priority of alternative strategies is as follows:

1) Cacaban Reservoir is the only large reservoir in Tegal, so many people use the existence of the reservoir for livelihood and tourism. However, community activities need to be limited, especially not in the dam area, to maintain water quality and parts of the dam. (ST 3)
2) OP documents containing rules for the operation and maintenance of dams and

surrounding areas must be implemented, including maintenance efforts to maintain the condition of the boundaries and greenbelt of reservoirs so that they are not damaged and used for illegal buildings that are not by the rules correctly. (ST 2)

3) The existence of UPB also plays a role in efforts to prevent sedimentation from entering the reservoir, one of which is by monitoring the rate of sedimentation, whether according to plan or not, and keeping the upstream area of the reservoir from becoming erosion and impacting the sedimentation rate at the bottom of the reservoir. (ST 8)
4) The amount of garbage due to the many activities in the reservoir, with reliable infrastructure and the only large dam must be the attraction of the reservoir is very strong, the population that comes can be used to bring professional tourism area managers in collaboration with the local government whose results can help in maintaining the sustainability of the dam. (ST 7)
5) The existence of guidance documents on emergency conditions at dams must be enhanced by socialization related to the warning system when a disaster is detected at the dam so that disaster mitigation is more structured and does not cause casualties to people downstream of the dam. (ST 1)
6) Communities around reservoirs, especially in downstream areas, also take advantage of relatively stable reservoir inflows, on average, for household and agricultural consumption. This needs to be considered so that utilization is not too excessive, with the aim of maintaining reservoir inflow and maintaining the reservoir's stability. (ST 9)
7) Water quality and sedimentation in reservoirs are strongly influenced by water from downstream. At the same time, the ownership of border and greenbelt locations under the auspices of DLH, forestry, and also community ownership, so there needs to be assistance from the local government to facilitate this cross-institutional maintenance because the Cacaban dam is the only large reservoir in Tegal. (ST 4)
8) Regarding the good competence of UPB officers, a socialization program was made for residents to maintain the upstream condition of the reservoir from the amount of vegetation that can become dam waste and carry out periodic cleaning for at least two weeks. (ST 5)
9) With a sufficient number of OP officers, OP activities can be made more structured by always cleaning vegetation waste in dams and reservoirs continuously; if it is still not possible, it can be evaluated by adding personnel and increasing cleaning time. (ST 6)
10) It is necessary for users and managers to carry out routine maintenance in the cacaban dam irrigation canal so that water loss in the irrigation canal does not get bigger. (ST 10)

Conclusion

The study concludes that the operation and maintenance performance of Cacaban Dam showed an average value of 3.45, achieving sufficient performance. However, some aspects, such as reservoir, border, and greenbelt conditions, are still lacking. The performance improvement strategy is the Diversity Strategy, focusing on fixing potential threats from outside the dam. Strategy priorities include limiting community activities, implementing maximum OP documents, comprehensive sedimentation monitoring, cooperation with tourism managers, socialization of warning systems, regulation of reservoir inflow utilization, cross-agency cooperation to maintain border locations and green belts, socialization to upstream reservoir communities, dam cleaning activities, and routine maintenance of irrigation canals.

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