The Evaluation Of Reservoir Potential Capacity For Irrigation Using The Ripple Method

by Lies Kurniawati Wulandari

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Abstract: This study aims to analyze the weir performance at Samiran Dam in Pamekasan Regency based on the condition and function of the construction. The study took place in Samiran Dam located in Samiran Village, Proppo Subdistrict, Pamekasan Regency, East Java Province. The technique of data collection is done by direct data is processed and processing result the data, the condition and functioning of the Samiran Dam are analyzed. Analysis of data using the AHP method (Analityc Hierarchy Process). The results of data analysis carried out from weir survey data produced dam performance based on the condition of component damage in the form of discharge weight of 18.89%, sedimen weight of 1.25%, light weight of 0.19%, building weight taken by 2.56%, weight of building drain by 4.26%, building weight of rinsing by 1.88%, and weight of sludge bag by 4.15%. As for the result of weir performance analysis based on component function namely in the form of discharge weight 32.92%, sedimen weight of 3%, light weight of 2.39%, weight of building taken by 14.29%, weight of building drain by 21.14%, weight of building rinsing by 9.71%, and weight of sludge bag by 9.86%. The condition of the performance components of Samiran Dam suffered damage to the components at the weir by 33.18% and the weir condition suffered a medium damage. The function performance of component in Samiran Dam was 93.31% and the function of the weir was in good condition.

Index Terms: Weir Performance, Analityc Hierarchy Process, Samiran Dam.

1. INTRODUCTION

Weir is a main building that works to elevate the river water level and divide and provide water so that it can flow into the carrier channel with certain alternatives (Wigati, 2016). A weir is a building made of pairs of river stone, concrete or gabion, with a transverse position on a river that functions as an irrigation channel (Richard et al. 2013). Samiran Dam is one of several weirs in Madura, located in Samiran Village, Proppo District, Pamekasan Regency, East Java Province. This weir is a weir building which was built in 1901 with a service area of 2462 Ha and a planting area of 2600 Ha. To improve the function and extend the life of the weir and the network that has been built, we need an analysis and evaluation of the weir's performance.

As an irrigation infrastructure building, weir buildings are influenced by the volume of river water and flowrate. Unstable discharge conditions and external factors that are not expected to damage the structure of the building on the weir. In such conditions an assessment of the condition of the dam is needed based on the structure of the building, so that appropriate handling can be done to repair and manage the dam before damage occurs (Wahyudi, 2017). Kartino et al. (2015), in his research found that the ability of the Katulampa weir to divert water when it reaches Alert 1 is 7% of the flood discharge through the gates. To be able to optimize the function of the weir and to re-design the weir, the initial step taken is hydrological analysis so that the magnitude of the main discharge, the water debit and the flood discharge are known. Starting from this, this study will discuss the dam component damage based on aspects of the structural function of the building. Damage condition assessment in Samiran weir buildings includes 7 components, namely debit, sediment, lighthouse, retrieval building, rinse building, mud bag and drainage structure. From the 7 components of the weir building, theoretically and visually the assessment of damage of leak type and peeling layer is theoretically and visually to produce a weir criterion. Criteria for assessing dam conditions are made for each component of the weir. Weir criteria will be analyzed using the AHP (Analytic Hierarchy Process) method which is then applied to the Samiran Weir. The results obtained later can show how the performance conditions of the Samiran Dam from the criteria made earlier. Previous research conducted by Wahyudi (2017) in Pekatingan Weir showed that the weir's performance based on component damage conditions in the form of a discharge weight of 9.91%, sediment weight 3.63%, light weight 12.46%, weight of building taking 4.15%, weight of drain building 1.05% . As for the results of the analysis of the performance of the weir based on component functions, namely in the form of a discharge weight of 34.58%, sediment weight of 8.31%, light weight of 19.26%, weight of building retrieval 4.96%, weight of drainage building 3.54%. In addition, component damage to the Pekatingan weir was 33.02% and the weir's condition experienced a "Medium Damage", with a component performance function of 76.55% and functioning under "Enough" conditions. Besides Wahyudi (2017), similar studies using the AHP method include Mahardika and Wahyudi (2017), Prayogi and Wahyudi (2017). This study aims to determine the criteria for the assessment of the function and condition of Samiran dam based on the structure of the building, determine the weight of each component of the dam that can be used as an indicator of dam performance according to the conditions and functioning of the building, and analyze the performance of the dam according to the condition and functioning of the building. The results of this study are expected to be recommendations related to decision making in the matter of evaluating dam performance according to the conditions and functioning of the building, as well as references for further research related to dam performance analysis.

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2. METHOD

2.1 Component Of The Weir Performance

The component of weir performance as an indicator of weir condition is divided into seven components, namely Debit, Sediment, Mercu, Retrieval Building, Rinse Building, Mud Bag, and Drain Building. The selection of these components is based on the dominant factors on the performance and condition of the weir, the ease in visual observation in the field and the existence of weir components that are easily found in weirs in Indonesia.

2.2 Criteria Of Functional And Conditional Evaluation

***Table 1**. Criteria of the structural damage*

Criteria	Specification
Collapsed	Structure is not intact and/or partly separated.
Leaked	Structure is intact, but there are damages such as leakage.
Flaked	Structure is intact, but there are cracks or flaked layers.

Source : Paryogi, cited in Wahyudi (2017)

Assessment of damage to the type of leak and peeling layer is done by looking at the percentage of damage from the initial design area of the building. Whereas the type of damage collapses, is the percentage of damaged buildings from the total length of the building. Criteria for damage assessment of dam component structure are taken based on OP-01 (Directorate General of Water Resources Number, 05/SE/D/2016). After the percentage of damage is analyzed, the results of the analysis are then included in the component condition classification. The component condition classification refers to Minister of Public Works Regulation Number 32/PRT/M/2007, and Minister of Public Works Regulation Number 13/PRT/M/2012.

a. Asset Condition

An asset condition assessment is carried out by separating the components of the weir so that the weir can be valued per asset component. Conditions assessment depends a lot on visual observations (color photos). The classification of asset conditions in Indonesia is presented in table 2.

***Table 2**. Classification of the asset condition*

Condition	Score	% Damage	Specification
Good	4	<10%	Asset has minor damages, require routine maintenance or minor repairs.
Mild Damage	3	10%-20%	Asset in severe conditions, require periodic maintenance or minor repairs.
Moderate Damage	2	21%-40%	Asset in severe conditions, services can still be performed, require considerable maintenance work.
Heavy Damaged	1	>40%	The asset is critically damaged, serious structural problems, and operations are not optimal, a major repair or replacement is needed.

Source : Regulation of the Ministry of Public Works No. 32/PRT/M/2007, cited in Wahyudi (2017).

b. Asset Functionality

The expected outcome of maintenance work is the functioning of assets. Asset functioning assessment is intended to show how assets can function according to plan and the effect of asset functioning on irrigation system performance. The classification of the functioning of assets in Indonesia is presented in table 3.

***Table 3**. Classification of asset functionality*

Condition	Score	% Damage	Specification
Good	4	>80%	Assets have a function of more than 80%; throughout the facilitated service area.
Good Enough	3	80%-40%	Assets have a function of between 40% and 80%; difficulty in distributing water, but can still be resolved by turns
Poor	2	20%-40%	Asset has a function of between 20% and 40%, the water distribution turn is not sufficient.
Failed	1	<20%	Assets are not functioning, service areas are not watered.

Source : Regulation of the Ministry of Public Works No. 13/PRT/M/2012, cited in Wahyudi (2017).

2.3 Data Analysis

Weir data was collected at Samiran Weir located in Samiran Village, Proppo District, Pamekasan Regency, East Java Province. The steps in this study refer to the weir condition evaluation criteria compiled by Wahyudi (2017). Data analysis was performed using the AHP (Analytic Hierarchy Process) method. AHP is a method used in decision making (decision making) based on qualitative and quantitative parameters. The principle of AHP is the use of pairwise comparison matrices (matrix pairwise comparison) to produce relative weights between two criteria. These criteria are then compared with other criteria in terms of how important or influential the objectives will be achieved. AHP calculations are used on the components that make up weir performance. The weight obtained from the AHP calculation for each component is then multiplied by the weight of the building condition assessment. All weights are written as a percentage (%).

3. RESULT AND DISCUSSION

3.1 Wighting The Conditional And Functional Criteria

The component structure is given a weighting in each sub-component that makes up the overall condition of the component. Weighting is done using the AHP (Analytic Hierarchy Process) method.

a. Pairwise comparison

Determination of the Pairwise Comparison scale in this study the authors worked with the UPT Pamekasan Region and Irrigation Mantri who served in the Samiran Dam to determine the scale of Pairwise comparison between components. The results are explained as follows:

***Table 4**. Pairwise Comparison of weir performance*

No	Pairwise comparison	Scale
1	D vs M	5 toward D (Right)
2	D vs S	7 toward D (Left)
3	D vs BA	7 toward D (Left)
4	D vs BB	1 toward D (Left)
5	D vs KL	9 toward D (Left)
6	D vs BK	9 toward D (Left)
7	S vs M	3 toward M (Left)
8	S vs BA	9 toward BA (Right)
9	S vs BB	7 toward BB (Right)
10	S vs KL	5 toward KL (Right)
11	S vs BK	7 toward BK (Right)
12	M vs BA	9 toward BA (Right)
13	M vs BB	1 toward M (Left)
14	M vs KL	7 toward KL (Right)
15	M vs BK	9 toward BK (Right)
16	BA vs BB	7 toward BA (Left)
17	BA vs KL	7 toward BA (Left)
18	BA vs BK	5 toward BK (Right)
19	BB vs KL	5 toward KL (Right)
20	BB vs BK	5 toward BB (Left)
21	KL vs BK	7 toward BK (Left)

Where :
BA : Water Collection Plant
BB : Flushing plant
BK : Draining plant
D : Discharge
KL : Sludge Container
M : Weir
S : Sediment

Furthermore, the paired comparison data is then entered into the calculation of the total weight relative matrix of the dam's performance.

***Table 5**. Matrix of Relative Weighing Performance*

Criteria	D	S	M	BA	BK	BB	KL
D	1.00	7.00	5.00	7.00	9.00	1.00	9.00
S	0.14	1.00	3.00	0.11	0.14	0.14	0.20
M	0.20	0.33	1.00	0.11	0.11	1.00	0.14
BA	0.14	9.00	9.00	1.00	0.20	7.00	7.00
BK	0.11	7.00	9.00	5.00	1.00	5.00	7.00
BB	1.00	7.00	1.00	0.14	0.20	1.00	0.20
KL	0.11	5.00	7.00	0.14	0.14	5.00	1.00
Σ	2.7	36.33	35.00	13.5	10.79	20.14	24.54

b. Transforming the marrix of relative weighing into normalized

Each value in the matrix needs to be normalized by dividing the relative value (nr_{bk}) by the number of relative values for each column. For example in Table 6, obtained nr13 = 5, then to normalize (n_{bk}) needs to be divided by the sum of column 3 so that:

$$n_{13} = \frac{nr13}{nr13+nr23+nr33+nr43+nr53+nr63+nr73}$$
$$= \frac{5}{35}$$
$$= 0.14$$

Normalization is performed on each relative value so that the results obtained in Table 4.7.

***Table 6**. Matrix of normalized weighing*

Criteria	D	S	M	BA	BK	BB	KL
D	0.37	0.19	0.14	0.52	0.83	0.05	0.37
S	0.05	0.03	0.09	0.01	0.01	0.01	0.01
M	0.07	0.01	0.03	0.01	0.01	0.05	0.01
BA	0.05	0.25	0.26	0.07	0.02	0.35	0.28
BK	0.04	0.19	0.26	0.37	0.09	0.25	0.28
BB	0.37	0.19	0.03	0.01	0.02	0.05	0.01
KL	0.04	0.14	0.2	0.01	0.01	0.25	0.04
Σ	1.00	1.00	1.00	1.00	1.00	1.00	1.00

c. Determining the Eigen and component weighing

Eigen value (X_n) is obtained from the average of each row in the normalized matrix. The eigenvalues obtained are then converted into percentages and multiplied by the weights of the weir's performance to get the weight of each component. For example to find out the weight of the discharge component, it is necessary to find the average normalized weight in the first row and multiplied by the weight of the discharge.

$$(X_D) = \frac{(n11+n12+n13+n14+n15+n16+n17)}{n}$$
$$= \frac{(0{,}37+0{,}19+0{,}14+0{,}52+0{,}83+0{,}05+0{,}37)}{7}$$
$$= 0.3528$$

Discharge weight = X_D x 100 %
= 0.3528 x 100 %
= 35.28 %

The results of the calculation of eigenvalues and component weights can be in Table 7.

***Table 7**. Eigen score and performance component weight*

Criteria	D	S	M	BA	BK	BB	KL	Eigen	Component weight
D	0.37	0.19	0.14	0.52	0.83	0.05	0.37	0.3528	35.28 %

S	0.05	0.03	0.09	0.01	0.01	0.01	0.01	0.0300	3 %
M	0.07	0.01	0.03	0.01	0.01	0.05	0.01	0.0271	2.71 %
BA	0.05	0.25	0.26	0.07	0.02	0.35	0.28	0.1829	18.29 %
BK	0.04	0.19	0.26	0.37	0.09	0.25	0.28	0.2114	21.14 %
BB	0.37	0.19	0.03	0.01	0.02	0.05	0.01	0.0971	9.71 %
KL	0.04	0.14	0.2	0.01	0.01	0.25	0.04	0.0986	9.86 %
Σ	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	100

d. Weighted Sum Factor (WSF)

The WFS value is obtained from the sum of the multiplication results in the row of each component with the component's eigenvalue.

***Table 8**. Weighted sum factor value*

No	Criteria	WSF
1	D	4.87
2	S	0.24
3	M	0.26
4	BA	2.16
5	BK	2.79
6	BB	0.77
7	KL	1.02

The calculation of weighted sum factor is as follows:

$WSF_D = \sum_{m}^{n} = 1\ (\Sigma nr_{bik-bk} \times X_n)$

$=((1x0.3528)+(7x0.0300)+(5x0.0271)+(7x0.1829)+(9x0.2114)+(1x0.0971)+(9x0.0986))$

$= 4.87$

e. Consistency Vector

The vector value is consistently sought by dividing the WSF value of each component by the component's eigenvalue.

***Table 9**. Consistency vector value*

No	Criteria	Consistency Vector
1	D	13.8
2	S	8
3	M	9.59
4	BA	11.81
5	BK	13.20
6	BB	7.93
7	KL	10.34

The calculation of consistency vector is demonstrated as follows:

$CV_D = \frac{WSFD}{EigenD}$

$= \frac{4.87}{0.3528}$

$= 13.8$

f. Lambda (λ)

The $\lambda_{maximum}$ value is obtained by dividing the number of consistent vectors then divided by the number of constituent components of weir performance.

$$\lambda\ maximum = \frac{1}{n} \times \Sigma \frac{\sum_{m=1}^{n}(\sum nrbik - bk \times Xn)}{Xn}$$

$$= \frac{1}{7} \times (13.8+8+9.59+11.81+13.20+7.93+10.34)$$

$$= 10.67$$

g. Consistency Index (CI)

The value of the Consistency Index is obtained from the reduction of $\lambda_{maximum}$ with the number of components of the weir performance, after that it is divided by the results of reducing the number of weir performance compilers by 1.

$$CI = \frac{\lambda\ maksimum - n}{n-1}$$

$$= \frac{10{,}67-7}{7-1}$$

$$= 0.061$$

h. Random Index (RI)

Random Index is determined from a table of consistent random indices, the determination of consistent random based on the number of components used in the preparation of weir performance. In the weir performance of the constituent components, 7 components are obtained, based on the number of components, a Random Index (RI) of 1.32 is obtained.

***Table 10**. Random index value*

Matrix sequence	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source : Paryogi, cited in Wahyudi (2017).

i. Cosistency Ratio (CR)

The value of the Consistency Ratio (CR) is obtained from the results of the division of the Consistency Index (CI) value by the Random Index value (RI).

$$CR = \frac{CI}{RI}$$

$$= \frac{0.061}{1{,}32}$$

$$= 0.0462$$

Therefore, CR value is 4.62% (< 10%), which means that the consistency ratio is acceptable.

3.2 Distribution Of Component Weight

Figure 1 shows that the total weight distribution is 100%, which lies in the Weir Performance. The 100% total weight distribution is then divided into Debit, Sediment, Mercu, Retrieval Building, Rinse Building, Mud Bag, Drain Building in accordance with the results of weight calculation using AHP (Analytical Hierarchy Process) method. Debits have a maximum weight of 35.28%, Sediments have a maximum weight of 3%, Mercu has a maximum weight of 2.71%, Retrieval Buildings have a maximum weight of 18.29%, Drain Buildings have a maximum weight of 21.14%, Rinsing Buildings have a maximum weight of 9.71%, Mud Bags have a maximum weight 9.86%.

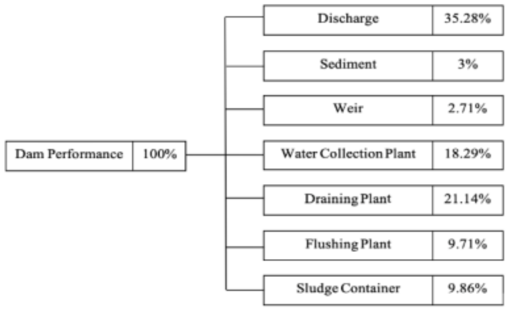

Figure 1. *Distribution of component weight*

3.3 Evaluation Of The Weir Performance

After weighting, weights are calculated based on data from field research results.

1. Evaluation of weir condition

Table 11. *Condition of weir components*

No	Component	% Damage	AHP Weight	Damage Weight
1	Discharge	53.55	35.28 %	18.89 %
2	Sediment	41.67	3 %	1.25 %
3	Weir	6.95	2.71 %	0.19 %
4	Water collection plant	13.98	18.29 %	2.56 %
5	Draining plant	20.16	21.14 %	4.26 %
6	Flushing plant	19.33	9.71 %	1.88 %
7	Sludge container	42.13	9.86 %	4.15 %
	Total		100 %	33.18 %

Pada kolom kerusakan komponen di atas, nilai presentase kerusakan didapat dari hasil perhitungan survei di lapangan. Selanjutnya, nilai bobot kerusakan pada kolom bobot kerusakan dihitung sebagai berikut:

$$\text{Bobot Kerusakan Debit} = \left(\frac{53.55\ X\ 35.28}{100}\right)\% = 0.18\ \%$$

Berdasarkan perhitungan kondisi komponen kinerja Bendung Samiran didapat bahwa kondisi kerusakan Bendung Samiran sebesar 33.18 %. Dari hasil perhitungan, Bendung Samiran saat ini dalam keadaan "Rusak Sedang". Sesuai klasifikasi kondisi komponen, dimana kondisi komponen Bendung Samiran diantara 21%-40%. Dengan uraian kondisi komponen aset parah namun pelayanan masih dapat dilakukan penanganan aset membutuhkan pekerjaan pemeliharaan cukup besar.

2. Evaluation of weir functions

Tabel 12. *Keberfungsian Komponen Kinerja Bendung Samiran*

No	Component	Functionality (%)	AHP Weight	Functionality Weight
1	Discharge	93.31	35.28 %	32.92 %
2	Sediment	100	3 %	3 %
3	Weir	88.24	2.71 %	2.39 %
4	Water collection plant	78.12	18.29 %	14.29 %
5	Draining plant	100	21.14 %	21.14 %
6	Flushing plant	100	9.71 %	9.71 %
7	Sludge container	100	9.86 %	9.86 %
	Overall Functionality		100%	93.31 %

Based on the component functioning above, the percentage value of component functioning is obtained from the results of field survey calculations. Next, the functional weight value in the functioning weight column is calculated as follows:

$$\text{Discharge functionality weight} = \left(\frac{93.31\ X\ 35.28}{100}\right)\% = 32.92\ \%$$

Based on the calculation of the functioning condition of the Samiran Weir performance it is found that the functioning of the Samiran Weir is 93.31%. So it is known that the functioning of the Samiran Weir component is in "Good" condition, in accordance with the classification of component functioning in table 4.4 where the Samiran Weir component's functioning is> 80%. With the description of assets having a function of more than 80%, all service areas are facilitated.

Overall, it can be seen that the Samiran Dam is currently experiencing a decline in conditions and performance. For that, there are a number of corrective steps that can be taken, namely:

1. Replacement of old light beams with new ones
Damage of mercury reaching 6.95% resulted in a decrease in mercury performance in raising the water level, causing insufficient discharge to irrigate the entire irrigation area.

2. Repair of leaks in mud bags
Damage to the sludge by 42.13% (leakage) causes the flow of water into the irrigation channel to decrease, so that the samiran irrigation area is not completely irrigated.

3. Routine draining and rinsing to remove sediment
The sedimentation condition of 41.67% in the upstream of the weir and the mud bag caused a reduction in the water reservoir in the weir, causing a decrease in the capacitance of the Samiran dam. Flushing the deposits upstream of the weir and mud bags must be routinely carried out.

4. Perform repair and replacement of weir gate
Damaged weir gate reduce the effectiveness of water uptake for irrigation being disturbed. The condition of the leaking flush gate causing water to enter the irrigation canal is reduced.

4. CONCLUSION

Based on the results, it was concluded that the weighting result of the discharge was 35.28%, the weight of the sediment was 3%, the weight of the lighthouse was 2.71%, the weight of the taking building was 18.29%, the weight of the drainage building was 21.14%, the weight of the rinse building was 9.71 %, and the weight of mud bags is 9.86%. In addition, the weighting criteria for the assessment of the function and structure of the building showed that the weir's performance based on component damage conditions included a discharge weight of 18.89%, sediment weight of 1.25%, light weight weight of 0.19%, weight of building retrieval of 2.56%, weight of drainage building of 4.26% , the weight of the rinsing building was 1.88%, and the weight of the mud bags was 4.15%. As for the results of the analysis of the performance of the weir based on the function of the components in the form of a discharge weight of 32.92%, sediment weight of 3%, light weight of 2.39%, weight of building retrieval of 14.29%, weight of drainage building of 21.14%, weight of rinsing building of 9.71%, and mud bag weights of 9.86%.Based on the criteria for the assessment of the function and structure of the building, it can be stated that the condition of the performance component of the Samiran Dam suffered damage to components in the Dam by 33.18% and the condition of the weir experienced "Moderately Damaged". Furthermore, the component performance function at Samiran Weir is 93.31% and the weir's functioning is in "Good" condition.

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