



# Operational Risk Management of Palasari Dam in Jembrana Regency, Bali Province

I Nyoman Sedana Triadi<sup>1</sup>, Ketut Wiwin Andayani<sup>2</sup>, Made Mudhina<sup>3</sup>, I Gusti Lanang Made Parwita<sup>4</sup>, and I Nyoman Anom Purwa Winaya<sup>5</sup>

<sup>1,2,3,4,5</sup> Civil Engineering Department, Politeknik Negeri Bali, Bali, Indonesia  
nyomansedanatriadi@pnb.ac.id

**Abstract.** Operation and maintenance of a dam that does not follow established procedures will not only reduce the effectiveness of the dam in question. However, they can also endanger the safety of the dam. The fact that the risk of a dam is mostly caused by inadequate exploitation and maintenance. The Palasari Dam has been in operation for 36 years since 1989. It utilizes the waters of the Tukad Sanghyang Gede River, which has a river basin area of 42.30 km<sup>2</sup> and an average annual rainfall potential of 1,800 mm. The Palasari Dam has a total water volume of 8,000,000 m<sup>3</sup> and is operated to meet the irrigation water needs of a 1,300 ha area. The stages of risk management include risk management planning, risk identification, risk analysis, risk handling, and risk monitoring. Risk identification is the initial step in implementing risk management. The results of the study showed that there were 35 risks identified in the operation and maintenance of reservoirs in Bali Province. There are 10 major risks (28.57%) occurring in the operation and maintenance of the Palasari Dam, and 25 minor risks (71.43%). The shallowing of the Palasari Dam is also due to sediment, resulting in a decrease in the benefits and functions of the Palasari Dam. Sediment control measures in the reservoir include technically inhibiting sediment upstream through the construction of check dams and embankments, dredging sediment based on echosounding measurement volumes, and managing the dam area with a land conservation concept.

**Keywords:** Dam, Reservoir Operation, Risk Management

## 1 Introduction

Dam operation is declared optimal if based on the results of the reservoir operation simulation analysis, it is shown that the reservoir water volume remains above the Minimum Operating Level. A dam is a water structure used to store excess water during the wet season, so that it can be used during low discharge or during the dry season (Nugraha & Anwar, 2016).

Operation and maintenance of a reservoir that does not follow established procedures will not only reduce the effectiveness of the reservoir but also endanger the safety of the reservoir. The fact is that the risk of a reservoir is mostly caused by inadequate exploitation and maintenance, as well as negligence that seems insignificant, but can result in very fatal things (Suyono et al., 1977).

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A. A. N. G. Sapteka et al. (eds.), *Proceedings of the International Conference on Sustainable Green Tourism Applied Science - Engineering Applied Science 2025 (ICOSTAS-EAS 2025)*, Advances in Engineering Research 280,

[https://doi.org/10.2991/978-94-6463-878-3\\_7](https://doi.org/10.2991/978-94-6463-878-3_7)

Dams have quite large benefits for human life, but also have great potential dangers. Dam failure can cause devastating flash floods far downstream, resulting in numerous casualties, extensive property damage, destruction of public facilities, and severe environmental damage in downstream areas. The high potential for disasters has a major impact, requiring strategic planning in the operation and maintenance of dams (Agustian & Frentakoza, 2017).

The implementation of dam operation is a complicated task, making it vulnerable to risks during its execution. Risk is the cumulative effect of the possibility of uncertainty that will have a positive or negative impact on the project target (Wayangkau, 2021).

The function of a reservoir is to provide storage, so its most important physical characteristic is its storage capacity. Reservoir capacity is usually determined based on topographic measurements (Kerzner, 1991).

Risk management has evolved into a formal, systematic process for identifying potential risks and uncertainties. Risk management is a proactive approach that cannot control future events; However, if identified risks become a reality, appropriate decisions and actions can be made.

Dam operations require a risk management system. Risk management not only identifies but also quantifies risks and their impact on dam operations, ultimately determining whether the risks are acceptable or not (Kerzner, 1991).

This research needs to be conducted in order to obtain accurate information on the condition of the Palasari Dam, which has been operated for 36 years, related to operational risks that can be mitigated as an illustration of taking a policy in the operation and maintenance of the Palasari Dam.

The dam risk index, using the modified Andersen method, classifies Palasari Dam, Gerokgak Dam, and Benel Dam as satisfactory based on their dam safety values. Using the modified ICOLD method, Palasari Dam and Gerokgak Dam are classified as high risk, while Benel Dam is classified as medium risk. The risk evaluation based on these risk assessments is still considered safe, but repairs, maintenance, and monitoring are required to minimize the potential for future dam failure.

## **2 Methodology**

### **2.1. Risk Identification**

Risks arise from several activities, including political, environmental, planning, marketing, economic, financial, natural, project, technical, human, criminal, and safety. Risk identification of Palasari Dam Operation is done by clearly knowing the source of the risk, the incident or event, and the consequences of the risk. In general, the stages of risk identification involve detailing existing risks to a detailed level and then determining their potential and causes through survey programs and investigations into existing problems. The risks that have been detailed are then classified. To overcome the difficulty in identifying risks, several methods can be used, including compiling a risk list, interviews with experts involved, and brainstorming (Godfrey, 1996).

## 2.2. Research Respondents

The sampling technique used in the Palasari Dam Operational Risk Management study was purposive sampling. To be considered representative of the population, 20 respondents were recruited from various backgrounds, including practitioners, academics, professional organizations, and bureaucratic circles (Ridwan, 2009).

## 2.3. Validity and Reliability Testing

A measurement instrument is said to be reliable if it produces consistent score results for each measurement. Note that a measurement may be reliable but not valid, but a measurement cannot be said to be valid if it is not reliable. This means that reliability is a necessary but not sufficient condition for validity (Uyanto, 2006). correlation between parts of a measuring instrument with the equation:

$$r = \frac{n(\sum_{i=1}^n X_i Y_i) - (\sum_{i=1}^n X_i)(\sum_{i=1}^n Y_i)}{\sqrt{[n \sum_{i=1}^n X_i^2 - (\sum_{i=1}^n X_i)^2][n \sum_{i=1}^n Y_i^2 - (\sum_{i=1}^n Y_i)^2]}} \quad (1)$$

$$t_{count} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \quad (2)$$

## 2.4. Risk Assessment

The scale used to measure the level of respondent assessment is the Likert scale, which is an ordinal scale that shows the respondent's ranking of the identified risks and does not show the distance between one level and another (Djarwanto, 2002). To measure the magnitude of the influence of risk variables on the operation and maintenance of the Palasari Dam, the following scale is used (Godfrey, 1996).

**Table 1.** Frequency Scale

Frequency Level	Scale
Frequent	5
Probable	4
Occasional	3
Remote	2
Improbable	1

**Table 2.** Consequence Scale

Consequence Level	Scale
Catastropic	5
Critical	4
Serious	3
Marinal	2
Negligible	1

**2.5. Risk Acceptability**

Risk acceptance in this study uses the Godfrey (1996) method, which has been developed. The development of the Godfrey (1996) method was undertaken to address risk assessments with very rare frequencies but significant risks, which are now important to mitigate. The assessment of risk acceptance levels is as Table 3.

**Table 3.** Assessment of Risk Acceptability

Consequences	Assessment of Risk Acceptability				
	Catastrophic (5)	Critical (4)	Serious (3)	Marinal (2)	Negligible (1)
Likelihood/ frequency					
Frequent (5)	Unacceptable (25)	Unacceptable (20)	Unacceptable (15)	Undesirable (10)	Undesirable (5)
Probable (4)	Unacceptable (20)	Unacceptable (16)	Undesirable (12)	Undesirable (8)	Acceptable (4)
Occasional (3)	Unacceptable (15)	Undesirable (12)	Undesirable (9)	Undesirable (6)	Acceptable (3)
Remote (2)	Undesirable (10)	Undesirable (8)	Undesirable (6)	Acceptable (4)	Negligible (2)
Improbable (1)	Undesirable (5)	Acceptable (4)	Acceptable (3)	Negligible (2)	Negligible (1)

Considering the risk values obtained from the consequences scale and likelihood scale as above, the following conclusions can be drawn regarding the risk acceptance scale, as shown in Table 4. (Godfrey, 1996).

**Table 4.** Risk Acceptance Scale

Assessment	Acceptance Scale
Unacceptable	$x \geq 15$
Undesirable	$5 \leq x < 15$
Acceptable	$3 \leq x < 5$
Negligible	$x < 3$

**2.6. Risk Mitigation**

If the risk that arises due to an activity has been identified, then the next step is to take action to reduce the risk that arises. This action is called risk management. This risk cannot always be eliminated, but only reduced, so that a residual risk will arise (Flanagan & Norman, 1993).

Handling risks involves identifying those that have a significant impact on a job. Risks are acceptable and can be ignored, so they do not require much attention to be handled, namely by mitigating and managing risks. Risks are unacceptable and

unexpected, so they need to be addressed further by either transferring or avoiding them.

### **3 Result and Discussion**

#### **3.1 Operational Activities**

Dam operation activities are efforts to optimally utilize reservoir infrastructure and the arrangement of buildings related to dam operations, including: (1) Data collection work, (2) Calibration work, (3) Counseling on water utilization, (4) Work on making water distribution plans, planting plans, drying plans, etc., (5) Work on opening or closing intake doors related to the arrival of flood discharge, (6) Work on opening or closing drainage doors on mud pockets to drain mud deposits.

#### **3.2 Respondents' Responses to the Frequency and Consequences of Risk**

The number of risks identified in the operation and maintenance of the Palasari Dam is 35. The results of the questionnaire distribution showed that there were no risks with a frequent frequency on a scale of 5, risks with a probable frequency were 2 risks (3.71%), risks with a frequency of Occasional were 1 risk (2.86%), risks with a Remote frequency were 8 risks (22.86%), and risks with an improbable frequency were 24 risks (68.57%).

Risks with very small consequences with a scale of 1 are 2 risks (5.71%), risks with small consequences with a scale of 2 are 1 risk (2.86%), risks with moderate consequences with a scale of 3 are 18 risks (51.43%), risks with large consequences with a scale of 4 are 12 risks (34.29%), risks with very large consequences with a scale of 5 are 2 risks (5.71%).

#### **3.3 Validity and Reliability Test**

Validity test of the frequency and consequences of the risk of operation and maintenance of the Palasari Dam, obtained the following conclusions: for the significance value ( $\alpha$ ) = 0.05 and degrees of freedom (dk) = 18, the calculated (t) value is 1.734. The results of the frequency instrument validity test indicate that 35 measuring instrument items are declared valid. The results of the consequence validity test indicate that 35 measuring instrument items are declared valid. The reliability analysis of each question item obtained a Spearman Brown value of 0.959, which is greater than the (r) r-table value of 0.468, which shows that all frequency item questions are declared reliable.

#### **3.4 Respondents' Assessment of Risk**

Based on the respondents' assessment, the results of the risk assessment of the operation and maintenance of the Palasari Dam can be described, 5.71% of the total risk has an

unacceptable assessment, 22.86% of the total risk has an undesirable assessment, 65.71% of the total risk has an acceptable assessment, 5.714% of the total risk has a Negligible assessment. Risk categories are as follows.

**Unacceptable Risk Category.** High sedimentation in the reservoir due to land erosion, and shallowing of the reservoir due to weeds (water hyacinth) growing in the reservoir pool.

**Undesirable Risk Category.** Damage to the reservoir catchment area due to deforestation in the reservoir catchment area, limited dam maintenance due to small allocation of maintenance funds, dry reservoir due to prolonged dry season, overtopping due to flood discharge exceeding the planned flood discharge, cracks due to wild plants in the dam body, landslides on the cliffs or reservoir embankments caused by earthquakes, disruption of operations due to damage to reservoir operating and monitoring equipment, empty reservoir water due to the loss of water sources in the upstream of the reservoir.

**Acceptable Risk Category.** Community losses due to dam operations, community conflicts due to competing interests in utilizing the dam's water, water waste due to leaks in the distribution system, limited salaries for operational staff due to little government attention to employee welfare, possibility of reservoir collapse due to extraordinary flooding (overtopping), new cracks in the foundation caused by earthquakes, disruption of operations due to damage to reservoir operating and monitoring equipment, delayed information dissemination due to the absence or malfunction of the communication system, operation and maintenance not adhering to dam safety standards, leaks (piping) in the dam due to insufficient compaction and cracks in the dam, possible reservoir failure due to negligence in the operation and maintenance of the reservoir, subsidence of the dam body, disruption of dam stability due to the removal of rock from the dam body, blockage of the intake gate due to waste, limited monitoring data due to the lack of recording of reservoir monitoring data, disruption of reservoir operation due to the loss of instruments/equipment used in reservoir operation, reservoir water receding due to excessive seepage in the reservoir, high water levels in the reservoir due to operators being late in opening the reservoir gates, flooding in the reservoir due to the operator's absence from the reservoir site, lack of professionalism in the workforce due to inadequate training, fatigue due to limited operational personnel, occurrence of work accidents due to lack of attention to operator safety equipment, occurrence of public accidents due to inadequate reservoir safety systems.

**Negligible Risk Category.** Lack of private sector interest in managing the reservoir as a tourist attraction due to a lack of tourism promotion, and low revenue due to a lack of contribution to dam management.

### **3.5 Major Risk and Minor Risk**

Risks with the unacceptable category and the unexpected category are included in the dominant risk. The total number of dominant risks that occur in the operation and maintenance of the Palasari Dam consists of 10 risks (28.57%). Risks with the acceptable category and the negligible category minor risk consist of 25 risks (71.43%), including 23 risks with the acceptable category, and 2 risks with the negligible category.

### **3.6 Palasari Dam Sediment Control**

Risks with a high degree of frequency and consequence have a significant impact on the operation and maintenance of the Palasari Dam. The main priority in controlling the operational risks of the Palasari Dam in Jembarana is to carry out sediment control efforts in the reservoir to prevent silting of the reservoir. Sediment control measures in the reservoir include, technically inhibiting sediment upstream by constructing check dams and embankments, dredging sediment based on echosounding measurement volume, land conservation, waste management by constructing trash racks, procuring waste lifting equipment, reforestation in the reservoir catchment area, and selecting productive plants with conservation-based soil cultivation methods. Weed control in the reservoir includes periodic weed clearing, use of organic fertilizers, controlling the use of inorganic fertilizers, utilizing weeds as animal feed and small industrial materials, and regulating fish farming in the reservoir.

## **4 Conclusion**

The number of risks identified in the operation and maintenance of the Palasari Dam is 35. The results of the risk assessment of the operation and maintenance of the Palasari Dam, there are 2 risks (5.71%) that have an unacceptable assessment, 8 risks (22.86%) have an undesirable assessment, 23 risks (65.71%) have an acceptable assessment, and 2 risks (5.714%) have an assessment that can be ignored (Negligible). There are 10 major risks (28.57%) occurring in the operation and maintenance of the Palasari Dam, and 25 minor risks (71.43%). The main priority in controlling risks during the operation of the Palasari Dam in Jembarana is sediment control efforts in the reservoir. Sediment control measures in the reservoir include technically inhibiting sediment upstream through the construction of check dams and embankments, dredging sediment based on echosounding measurement volumes, and managing the dam area with a land conservation concept.

## **Acknowledgment**

This research can be implemented thanks to the support of all parties. Thanks are conveyed to Politeknik Negeri Bali for providing research funds, and thanks are

conveyed to the Bali Penida River Basin Center and the community of Ekasari Village, Jembrana Regency, who have provided information on the current condition of the Palasari Dam.

## References

- Agustian, M., & Frentakoza, D. (2017). Penyusunan strategi disaster management sebagai mitigasi risiko bendungan dalam pengelolaan waduk dan bendungan Cirata. *Jurnal Teknisia*, XXII(2), 383–391.
- Djarwanto, P. (2002). *Mengenal beberapa uji statistik dalam penelitian*. Liberty Yogyakarta.
- Flanagan, R. & Norman, G. (1993). *Risk management and construction*. University Press.
- Godfrey, P. S. (1996). *Control of risk. A guide to the systematic management of risk from construction*. Construction Industry Research and Information Association (CIRIA).
- Kerzner, H. (1991). *Project management. A system approach to planning, scheduling, and controlling*. John Wiley & Sons, Inc.
- Nugraha, A. K., & Anwar, S. (2016). Kajian optimasi pengoperasian waduk Darma. *Jurnal Konstruksi dan Infrastruktur*, 5(3).
- Ridwan. (2009). *Metode & teknik menyusun proposal penelitian*. Alfabeta.
- Suyono, S., & Takeda, K. (1977). *Bendungan type urugan*. PT Pradnya Paramita, Jakarta.
- Uyanto, S. S. (2009). *Pedoman analisis data dengan SPSS*. Yogyakarta: Graha Ilmu.
- Wayangkau, H. G. (2021). Analisis manajemen risiko pada proyek pembangunan bendungan. (Studi kasus: Bendungan Titab di Bali, Bendungan Jatibarang di Kabupaten Semarang dan Bendungan Diponegoro di Semarang). *Jurnal Proyek Teknik Sipil*, 4(1), 18-23.

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