Quest Journals
Journal of Architecture and Civil Engineering
Volume 11 ~ Issue 1 (January 2026) pp: 64-71
ISSN(Online): 2321-8193
www.questjournals.org

Research Paper

A Risk Management Analysis Based on ISO 31000 at Tambibendo Dam Rehabilitation Project, Tulungagung – Indonesia

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ABSTRACT : *Risk Management is a systematic process for identifying, analyzing, evaluating, and controlling any project risks. Complexity of the project site, multi-stakeholders involvement, also the age of the structure in Tambibendo Dam Rehabilitation Project increase potentiality of risks which require assessment. This study has a purpose to identify risks, determine dominant risks and analyze risk management strategies.*
This study uses Severity Index (SI) method and interviews. Data were collected by questionnaries passed on 32 competent respondents and analyzed through data compilation, variable processing, assessment, risk evaluation, response determination, also monitoring and review stages.
This study is able to identify 25 risk variables where evaluation phase able to categorized them into 4 high risks, 16 medium risks and 5 low risks found at Tambibendo Rehabilitation Dam project. Highest risks are include difficult access for heavy equipments, hard and rocky ground conditions, and high rainfall on work site. The response strategies to address these high risks included risk reduction, risk transfer, and risk avoidance with their implementation adjusted to the ISO 31000:2018 framework.

KEYWORDS: *Risk management, dam/weir, rehabilitation, ISO 31000:2018, severity index.*

R*eceived 12 Jan., 2026;* ***R****evised 23 Jan., 2026;* ***A****ccepted 25 Jan., 2026 © The author(s) 2026.*
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I. INTRODUCTION

There are 168 irrigation areas under authority of Tulungagung Regency and each of them have different characteristic. Inside these areas many dams and irrigation networks constructed for fulfilling farming water necessity. However, many irrigation dams are found in damage condition at this present time and the damage is caused by several factors such as the age of the structures, geographic location, natural disasters and human error. Therefore, proper maintenance is necessary to make sure these agricultural infrastructure facilities can function well in accordance with the government program as guided by Presindetial Decree No.2 of 2025 stating that acceleration of development, improvement, rehabilitation along with operation and maintenance of irrigation networks are conducted to support Food self-sufficiency program established by Indonesian government. [1]

According to Yuhrizal Muhiddin, research entitled "*Analisis manajemen resiko pada bandungan (Studi kasus pekerjaan plugging proyek pembangunan Bendungan Tapin-Kalsel"* or Risk Management Analisis on Dam (A Case Study of Plugging Work on Tapin Dam Construction Project-South Kalimantan), this study only used limited variables of workers' productivity, difficult access road, weather condition, and lack of administrative documents. Whereas the data collection methods for this study were interviews, questionnaires and observations with experts to obtain a probability and impact matrix. Therefore, a reseach will be conducted for this study with irrigation dam as the object and additional variables of irrigation water users, implementation method and community conflicts which adjusted to research location condition are included, together with an assessment of the mitigation result. [2]

Based on these conditions, this study aims to conduct a risk management analysis on the Tambibendo Dam Rehabilitation project in Tulungagung Regency. This study proposes ISO 31000: 2018 application to develop a structured risk management framework as follows: (1) how to identify impact of risks on Tambibendo Dam Rehabilitation Work? (2) what are the highest potential risks in Tambibendo Dam Rehabilitation Work? (3) how is the mitigation and monitoring plan for the highest risks found in Tambibendo Dam Rehabilitation work?

II. LITERATURE REVIEW

2.1. Irrigation Dam

According to Ministry of Public Works and Public Housing (PUPR) through its Ministerial Regulation No.12 of 2020 concering Irrigation, a weir/dam is a building built in transversal/across a river or canal to lift and regulates river water level to make the water can flow into the irrigation canal. Weir or dam has function as a vital part of water intake system in technical irrigation network system. [3]

2.2. Risk Management

According to Serpell *et.al*, project risk management consisting of risk management planning, identification, analysis, response planning, and risk management within the project. The goal of project risk management is increasing positive outcome of probability and decreasing likelihood of adverse outcomes for the project. Project risk is an uncertain event or condition which positively or negatively affect one or more project objectives such as scope, schedule, cost, and quality. Risk can have one or more causes also one or more effects when present. [4]

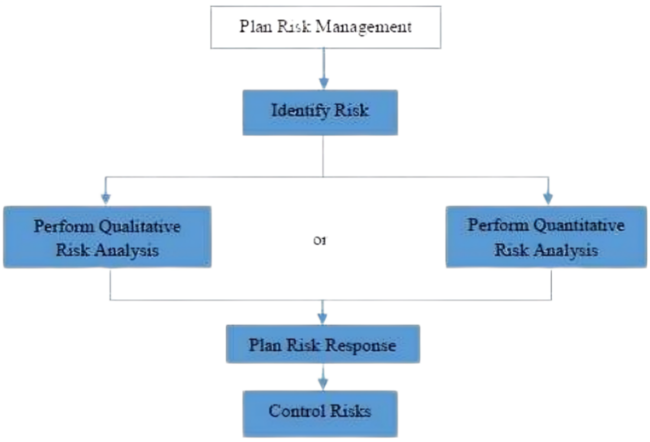

Figure 1. Risk management process according to project management institute

In essential principle, implementing risk management aims to reduce the level of consequences and reduces its probability of occurence. Successful risk management can gradually decrease the risk level. Conversely, a poor risk management can increase the risk level. [5]

2.3. ISO 31000:2018

ISO or International Organization for Standardization is an international organization works in specific direction of standarization field. On November 2009, ISO issued ISO 31000:2009 Risk Management-Principles and Guidelines as a guideline risk management application consisted of three elements of principle, framework and process.

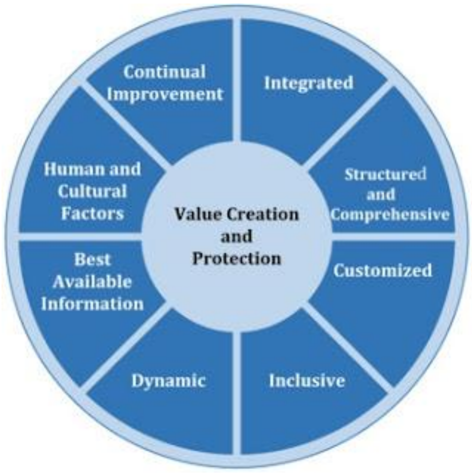

Figure 2. Risk Management Principle ISO 31000:2018. [6]

The risk management process encompasses six activities: (a) defining the scope of context and criteria, (b) communication and consultation, (c) risk assessment, (d) risk treatment/response, (e) monitoring and review, and (f) recording and reporting. Risk assessment consists of three parts: risk identification, risk analysis, and risk evaluation. The risk management process is shown in Figure 3.

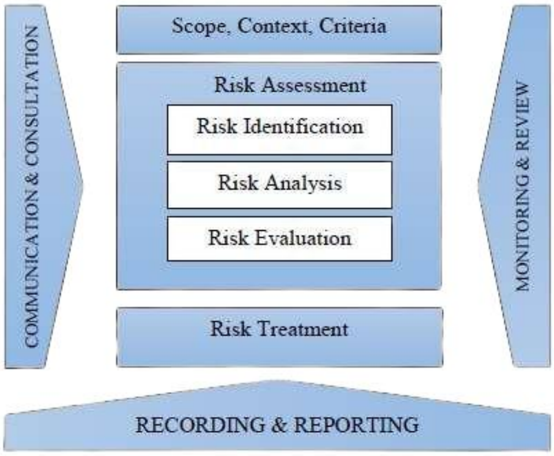

Figure 3. Risk Management Principle ISO 31000:2018. [6]

III. RESEARCH METHOD

3.1. Data Collection

This is qualitative study research where data collection to identify risk was taken through observation, questionnaires, and interviews. The risk management applied in Tambibendo Dam Rehabilitation project in Geger Village, Sendang District of Tulungagung Regency refers to ISO 31000:2018 risk management process that began with risk identification, risk analysis, risk evaluation, and response to these risks. In guarantee for the risks remain monitored and controlled, a monitoring and review process is implemented as well as recording and reporting activities that carried out at each risk management process.

Number of respondents that involved in risk variable questionnaire was 20 individuals, where the respondents profile was experienced individuals in Tambibendo Dam Rehabilitation.

3.2. Population and Sample Study

The research population consisted of individuals and rehabilitation activities involved in Tambibendo Dam in Geger Village, Sendang District from the Public Works and Spatial Planning Agency of Tulungagung Regency, the Water Resources sector which was carried out in 2025.

Whereas the research sample to be used as questionnaire respondents was PPK and PPTK activities, contractors, consultants, technical teams and Occupational Health and Safety (OHS/K3) instructors.

3.3. Risk Assessment

First step in risk identification is identifying typical risks that occur in a project. The potential risk variables are listed and then the respondents were asked to provide information about these risk variables that relevant to their respective fields.

Then, the risk assessment table is completed through a questionnaire administered to relevant parties, such as project managers, implementation teams, field supervisors or other stakeholders who understand about the field conditions and potential risks. Each respondent is asked to rate each type of risk based on two main parameters (impact level and probability or likelihood occurrence). The risk assessment is conducted on a scale of 1 to 5 with 1 indicating the lowest level and 5 indicating the highest level.

3.4. Risk Evaluation

Result of risk evaluation will determine which risks that require specific treatment and in which priority level that risks must be handled. The risk evaluation results are then be validated against the risk level mapping established by stakeholders based on research interviews.

IV. RESULT AND DISCUSSION

4.1. Risk Identification

Risk identification method for Tambibendo Dam Rehabilitation project began with a literature review to identify the potential risks in study site. Then, it was followed by expert judgment and a preliminary survey to enhance validity of risk variables based on project condition. This process resulted in 25 risk variables derived from literature and 11 expert suggestions where 10 suggestions taken from professional consultants and 1 from the contractor).

As identification result of the study, there are indications of several risks have a high level of urgency particularly those risks related to environmental factors and geographic conditions of the project site such as risks of high rainfall, potential flooding, steep terrain and possibility of extreme weather. These risks are uncontrollable and directly impact productivity, work safety, equipment operation, and project schedule. High intensity of rainfall able to delay mobilization of work equipments and work labor, inundate the work area, increases the landslide potential and cause delays and cost overruns.

While steep terrain conditions giving higher operational and safety risks, in particular for project work during extreme weather. Steepy slope complicate heavy equipment access so it increases potential of accidents and make this risk becomes critical risk, impacting on time, cost and safety of the overall project.

These risks become more crucial given a short project time duration of four months, and contractor of the project has full responsibility for comprehensive risk management through mitigation planning, adaptive scheduling, work area security, provision of temporary drainage, and equipment readiness to minimize the risks impact on the project workperformance.

4.2. Risk Analysis

Initial step from risk analysis process is assessing probability and impact/consequences of each risk variable. The values of probability and impact/consequences are obtained from the first questionnaire that distributed to study respondents which applied with a 1-5 Likert scale and put into analysis by calculating obtained values for each variable from each respondent using Severity Index (SI) calculation.

The following explanation is an example of Severity Index (SI) calculation. Questionnaires were distributed to 32 respondents, and respondents' assessment of probability (P) of the risk variable 'changes in design and technical work' said the probability (P) occurrence of very low was stated by 1 respondent, a low occurrence stated by 9 respondents, moderate occurrence stated by 17 respondents, while high occurrence stated by 5 respondents. Meanwhile, the impact/consequence value (I) was stated by 10 respondents as explained to be moderate consequences, high consequence values was stated by 11 respondents, low consequences by 8 respondents, and very low consequences by 1 respondent.

Table 1. *Severity Index* (SI) Scale [7]

Description	Code	Scale	Severity Index (SI %)
Very Low	SK	1	≤ 20
Low	K	2	> 20 – 40
Moderate	S	3	> 40 – 60
High	B	4	> 60 – 80
Very High	SB	5	> 80 – 100

According to Table 1, the Severity Index (SI) value for probability (P) and consequence (I) of risk variable "Changes in design and technical work" is found in the range of > 40 – 60, so the conversion value for probability (P) and consequences/impact (I) is 3 which indicates the risk is found in moderate category.

R (Risk Level) = Probability x Impact

R (Risk Level) = 3 x3

R (Risk Level) = 9

Based on calculation of risk variable "Changes in design and technical work", it has risk level value of 9 whereas the rest of risk variables calculations are performed in same way as the above pattern. The result calculation from all risk variables are listed in the following table (Table 2).

Table 2. Risk analysis on Tambibendo Dam Rehabilitation Project

No	Risk Variables	Severity Index Conversion				Risk Level I
		Probability		Impact		
		SI (%)	Skala	SI (%)	Skala	
1	Changes in design and technical work	56%	3	58%	3	9
2	Access difficulty to project site for heavy equipment	67,5%	4	68%	4	16
3	Hard and rocky soil condition	60%	4	64,38%	4	16
4	Incompatible selection of construction method	46,88%	3	56,88%	3	9
5	Low productivity from workers	41,25%	3	51,25%	3	9
6	Lack of worker awareness regarding PPE use	59,38%	3	59,4%	3	9
7	Work team replacement or project personnel	36,88%	2	40,6%	3	6
8	Lack of worklabor availability	39,38%	2	48,75%	3	6
9	Delayed payments by the project owner (*termin)*	31,88%	2	37,5%	2	4
10	Delayed payments for materials and workers	36,25%	2	38,75%	2	4
11	Increased material price	49%	3	48%	3	9
12	Damage/delays/loss of equipment	40,6%	3	43%	3	9
13	Poor material quality	40,6%	3	51,2%	3	9
14	Frequent rain resulting rising river water level	68%	4	69%	4	16
15	Flooding at work site	52,5%	3	63,75%	4	12
16	Landslide at the work site	39%	2	51,8%	3	6
17	Water pollution due to project activities	35,6%	2	36%	2	4
18	Noise pollution due to project activities	33%	2	38,75%	2	4
19	Ambiquity in contract provisions	30,6%	2	42,5%	3	6
20	Work delayed due to irrigation opening and closing schedule	42,5%	3	33%	2	6
21	Project implementation socialization	65%	4	48,75%	3	12
22	Conflict with local residents due to project access roads	42,5%	3	58%	3	9
23	Incomplete traffic/security/environmental permit	36,9%	2	45%	3	6
24	Illegal security money (extortion) around the work site	33,75%	2	36,25%	2	4
25	Customary or cultural activities from the surrounding community (ceremonies, festivals, and others)	43%	3	39,6%	2	6

The result of risk analysis is presented in Table 2 where it showed probability (P) value of a risk occurrence as well as the high or low consequences or impact occurrence from the risk. These findings will be used to determine priority in risk management. Based on Table 2, several risk variables were found to have a fairly high-risk level value when compared to other risk variables. The highest risk level appeared in the risk variables of: (a) Access difficulty to project site for heavy equipment, (b) hard and rocky soil condition, (c) flooding at work site, and (d) Frequent rain resulting rising river water level. These findings are in line with identification of problems at the beginning of exploration on Tambibendo Dam rehabilitation project. High level risks in these variables showed that they have more significant impact compared to other risk variables to the final target work completion of the Tambibendo Dam rehabilitation project. The higher the risk level value, then the bigger the impact will be for the project.

4.3. The Application of Risk Management Process Based on ISO 31000:2018 to Tambibendo Dam Rehabilitation Project

ISO 31000:2018 is an international standard that provides general guidelines on how organizations across government, private, and construction sectors able to manage risk in a systematical, structured and effective way. This standard has no resctrictive intention or technical in nature, but it provides a flexible framework and principles that can be tailored to the organization's needs. In general, ISO 31000 emphasizes the risk management must be included as part of organization's culture and integrated into every decision-making process, from initial planning to work performance evaluation. Main content of this standard are three components of principle, framework and process. Principles in this standard emphasize on the importance of added value, integration, a systematic structure and continuous evaluation. The ISO 31000 frameworks help the organization to build a base of risk management through leaders' commitments, integration into the organization structure, and continuous improvement. Meanwhile, the risk management process is consisted of several stages from risk identification, risk analysis, evaluation, handling, communication and consultation, monitoring and review to enable full control of risk through proactive and continuous risk management. Therefore, ISO 31000:2018 able to provide a comprehensive approach for improving decision reliability, optimizing opportunities and minimizing negative impacts that could disrupt the organization objectives.

Table 3. The Application of risk management process based on ISO 31000:2018 to Tambibendo Dam Rehabilitation Project

No	Risk Management Process based on ISO 31000:2018	Risk Management Process according to result interview
1	Risk identification	The project implementer conducts thoroughly risk identification for all work aspects including technical, environmental, social, financial, labor and permitting riks based on field condition and the previous project experience.
2	Risk analysis	The implementer evaluates any probability and impact risk level to determine its urgency and its potential impact on cost, time, quality and safety of the project.
3	Risk evaluation	The implementer evaluates risks by assessing management priorities with relevant stakeholders and conducting internal evaluations to determine the most appropriate management strategy for the project implementer.
4	Risk treatment	The implementer arranges and discusses risk treatment steps, both from internal and also with stakeholders, including steps of risk avoidance, risk reduction, risk transfer, and responsibility transfer according to field conditions. These steps are then implemented throughout the project work.
5	Monitoring and review	The implementer conducts routine monitoring and review risks through daily or weekly reports convering aspects of quality, methods, materials, equipment, costs, time, safety and changes at the field condition.
6	Recording and reporting	The implementer documents the entire risk control process and makes internal decisions at the low-impact risks, whereas for the high-impact risks, the reporting and decision-making process are conducted in collaborative act with all stakeholders.

Implementation of risk management conduct for Tambibendo Dam rehabilitation project refers to ISO 31000:2018 framework which emphasizes a systematic, integrated, and sustainable approach while identifying, analyzing, evaluating and managing project risks. The process began with *establishing context* by determining the internal-external context of the project, objectives of the project, stakeholders' involvement, surrounding environmental condition, and technical limitation of the work, to create scope of relevant risks that can be determined. Next, the *risk identification* stage collected many risks through field observation, interview, and document studies, including type of natural risks (floods, heavy rain, hard ground condition and else), technical risks (design changes, heavy equipment difficult access), financial risk (delayed payments), and social risks (community conflicts, project socialization). The stage continues with *a risk analysis* activity to assess the probability and impact level, resulting in risk categorization into low, moderate and high category. The analysis results then processed in the *risk evaluation* stage to determine management priorities based on the level of urgency and the organization's ability to handle the risks.

After all risks evaluated then a risk treatment strategy is selected based on four categories stated in ISO 31000: risk avoidance, risk reduction, risk transfer, and risk retention. For Tambibendo Dam Project, the risk treatment strategy for major risks such as rising/increasing water discharge, extreme soil condition and difficult access for heavy equipments tend to be addressed with a risk avoidance strategy (avoiding risky activities through rescheduling or selecting alternative methods). For manageable risks such as personnel turnover, delayed payments, and environmental pollutions are addressed with risk reduction strategy through technical and administrative mitigation. Meanwhile, risks involving responsibility of third parties such as material quality, equipment damage, community conflicts and project socialization are handled through risk transfter strategy through contract mechanism, coordination with local government, and project insurance. Then for several minor risks with low impacts are addressed through risk retention strategy by accepting the risk and preparing simple response actions.

The next stage is monitoring and review activity to ensure the applied risk management strategy can work effectively throughout the project. Project team established a regular monitoring mechanism such was weekly reports, coordination meetings and field inspections to assess risk dynamics which able to change according to weather, soil condition or project progress. The final stage is communication and consultation where the project team continues to communicate with consultants, village or local government, labor providers, and local community to ensure each risk is managed according to actual development in the work field. Through consistent risk management process implementation referred to ISO 31000:2018 standard, Tambibendo Dam project was able to control potential major problems related to time, cost, quality and work safety, and resulting in a more focused and measurable project implementation.

V. CONCLUTION

According to result analysis and discussion of this study, there are several conclusions can be drawn from risk management research on Tambibendo Dam project as follow:

1. As the result identifications, there are 25 risk variables found and able to affect the project implementation, consisting of 4 risks in the high-risk category, 16 risks in the moderate risk category, and 5 risks in the low-risk category. Based on the probability and impact level, the implemented risk treatment strategies are risk avoidance, risk reduction and risk transfer. Implementation of risk management in Tambibendo Dam project refers to ISO 31000:2018 standard and has covered all main stages (risk identification, risk analysis, risk evaluation and risk treatment, so the implementation level reaches 95 – 100 %). All significant risks whether in category of high risk or moderate risk level have been addressed. However, there is still room for improvement at the aspects of analysis depth, documentation consistency and monitoring also review implementation to make the risk management implementation able to run more optimal and fully aligned with ISO 31000:2018 standard.
2. The highest potential risk for Tambibendo Dam Rehabilitation project as seen from result of risk analysis and risk evaluation of this study falls into high-risk category. These risks include access difficulty for heavy equipment to the project site, hard and rocky soil condition, frequent rain that rises the river water discharge, and flooding at the work site. These risks convey high probability and impact level since they are heavily influenced by geography and environmental condition of the project, which located in a resindential area, among rice fields and near a river. These high-risk situations have significant potential to cause work delays, increased costs or cost overrun, disrupt equipment operation, also able to threaten workers' safety, making these risks become a top priority of the project risk management.
3. Mitigation and monitoring plan to the highest risks found in Tambibendo Dam Rehabilitation work is prepared based on ISO 31000:2018 risk response strategy (risk avoidance, risk reduction and risk transfer). Meanwhile, to overcome risk of difficult access for heavy equipment and extreme ground conditions are handled through risk avoidance by determining alternative road routes, providing temporary access, and using method and equipment that appropriate to the work field condition. Risks of extreme weather and flooding are mitigated by adjusting work schedules, avoiding risky work during high rainfall condition, constructing cofferdams and diversion channels, whereas for financial risk is mitigated by transferring financial risk through project insurance. Risk monitoring is carried out through continuous daily and weekly reports, field inspections and coordination meetings with consultants and stakeholders. With implementation of technical and administrative mitigation supported by routine monitoring allows the highes risks to be controlled so their impact on project time, cost, quality and safety can be minimized.

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