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Risk Assessment Based on Sources in The Bali Public School Project and Mitigation Actions Plan

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Abstract— This study aims to identify, analyze, and determine risk mitigation actions for the Bali Public School Project. Ten sources, including literature studies and interviews, determine the risks. Risk sources include environmental, planning, economic, logistical, technical, natural, human, criminal, financial, and safety. The identified risks are then compiled into a questionnaire, and it is first tested for validity and reliability. The method used for data collection was filling out a questionnaire and interviewing respondents. The purposive sampling method is used to determine respondents. Twenty-five respondents filled out the questionnaire from various job positions on the project, such as owners, designing consultants, supervisory consultants, contractors, and the community. The results reveal that ten risk sources led to the identification of 32 (thirty-two) risks. Major risks consist of unacceptable risks of 3 risks (9.38%), undesirable risks of 25 risks (78.13%), and minor risks of acceptable risks of 4 risks (12.5%). Major risks must be mitigated to reduce potential future impacts. A total of thirty-nine mitigation actions can be done, with details of 5 (12.82%) for unacceptable risk levels and 34 (87.2%) for undesirable risk levels. The existence of these mitigation actions is expected to enable related parties to manage all risks that may occur so as not to cause harm in the future.

Keywords— Risk Identification, Assessment, Mitigation, Major Risks, Project Risks.

I. INTRODUCTION

Bali Private Public School is one of the construction projects managed by the private sector or the owner directly. The building located at Jl. Bypass, Prof. Dr. Ida Bagus Mantra No. 72, Banjar Tangtu, Kesiman Kertalangu Village, East Denpasar District, is a school. The manager directly appointed the planning consultant, supervisory consultant, and contractor through a limited tender process. Direct and limited management faces constraints due to higher risks in the private sector compared to government-managed projects [1]. The existing risks, if not handled properly, can have an impact on the project both directly and indirectly [2].

Construction projects are an industry that is intrinsically linked to various risks that can arise from any source. Sources of risk in construction projects can come from internal and external factors. Risks that occur can be unexpected during construction work, and it is a challenge to determine the level and impact on a project [3], [4]. Proper risk management greatly affects project management performance [5]. Construction companies, which must adhere to applicable standards, should carry out risk management through an integrated process [6].

Project managers have an obligation to carry out risk management in both government and private projects. Both government and private have the potential for danger that occurs if risk management is not carried out properly, resulting in losses in terms of costs, quality, or project implementation time [7]. Construction project risks in Indonesia are still classified as dominant or major and still

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have the potential to cause damage and loss [8], [9], [10], [11]. The most common risk in the implementation of construction projects is from the safety aspect [12], [13], [14], where the safety risk is often borne by the contractor [15]. Other risks, such as cost aspects and resource aspects, also have the potential to become risks in construction projects [16], [16]. In addition, other sources of risk also often arise and need attention to be addressed, such as environmental, natural, economic, technical, material and equipment supply or logistics aspects, and criminal factors [17], [18]. The risks that have been identified through various sources can then be analyzed to create a ranking for mitigation actions as an effort to prevent project failure [19], [20].

Based on the description above, this study aims to identify the risks in the Bali Public School construction project, which is reviewed from 10 (ten) sources of risk. The sources of risk include environmental factors, project planning issues, economic conditions, logistical challenges, technical difficulties, natural events, human errors or actions, criminal activities, financial constraints or issues, and safety concerns. Initial risk is determined based on literature studies and then combined with brainstorming results from interviews with parties involved in the project. Respondents (parties) assess the identified risks by filling out a questionnaire. The assessment is a score on the likelihood and consequences, which are analyzed to determine the major and minor risks. Finally, for each main risk or major risk, risk mitigation measures are prepared as an effort to prevent or eliminate it.

II. METHODOLOGY

Risk analysis in construction projects must be carried out systematically and measurably to aid the identification and ranking process, focus on major risks, clarify boundaries, minimize potential damage, control uncertainty, and affirm risk management. This study presents the process of identification, analysis, grouping, and mitigation of risks in the Bali Public School project, as seen in Figure 1.

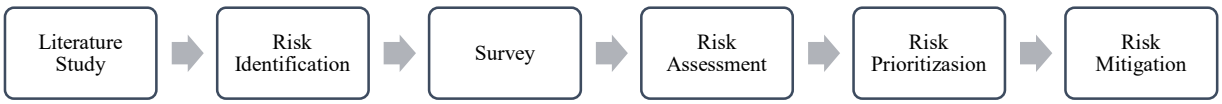

Fig. 1. Research Stages

This study began with a literature study to determine the source of risk based on previous studies. The literature study initially identified the source of risk and then compiled it into a questionnaire. The SPSS program assisted in testing the questionnaire's validity and reliability. Furthermore, a survey was conducted by filling out questionnaires and direct interviews with respondents to provide a risk assessment. The purposive sampling method was used to determine the respondents based on their job position in this project [21]. Table 1 displays the respondent data. The survey results are also used as a reference in correcting the risk identification determined by the literature study so that it is in accordance with actual conditions. The data that has been collected is then analyzed to determine the level of risk acceptance and classify risks into major or minor risks. The level of risk acceptance is obtained based on the multiplication of the likelihood mode and the consequences mode following Equation (1) [17]. The mode represents the most frequently occurring value from each risk's assessment. The main risk necessitates prevention or mitigation actions.

TABLE I. RESPONDENT DATA

Number	Respondent	Amount
1	Project Owners	2
2	Architectural	1
3	Structural	1
4	Designing consultant	1
5	Supervisor	1
6	Mechanical Electrical and Plumbing (MEP)	1
7	Site Manager	1
8	Site Engineer	1
9	Drafter	1

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Number	Respondent	Amount
10	Logistic	1
11	Project Control	1
12	Administration	1
13	Mechanic	1
14	Foreman	3
15	Citizen	8
	Total	**25**

$$X = F \cdot K \quad (1)$$

Where:

X = Risk value

F = Likelihood's mode

K = Consequence's mode

The risk acceptance level is calculated by multiplying the likelihood mode and consequence mode, and then it is categorized into four groups based on their scores: unacceptable ($X > 12$), undesirable ($5 \leq X \leq 12$), acceptable ($2 \leq X < 5$), and negligible (< 2). The major risk category includes the unacceptable and undesirable risk acceptance levels, while the minor risk category includes the acceptable and negligible ones. Risk mitigation is carried out, focusing on major risks that have a significant impact on the project if not handled properly. According to Flanagan & Norman [22], risk mitigation can be done in 4 (four) ways, namely risk retention, where the risk is still within acceptable limits; risk reduction by reducing the risk with consequences that are still acceptable; risk transfer, where the risk is transferred to a party that has the ability to control the risk; and risk avoidance by avoiding activities that have a very high impact and cannot be handled with existing resources.

III. Results and Discussion

A. Risk Identification

Risk identification results from literature studies and interviews on the Bali Public School project amounted to 32 (thirty-two) risks spread across 10 (ten) calculated risk sources. Each risk source contributes a varying amount of risk. Table 2 displays the details of the risks associated with each risk source.

TABLE II. Risk Identification

Number	Source	Identified Risk	Label
1	Environment	The spilled material obstructed the drainage channel.	EV01
2		River water is polluted by project waste.	EV02
3		Project noise is disturbing at night.	EV03
4		Air pollution due to dust	EV04
5	Planning	Changes in the owner's drawing cause project delays.	PL01
6		Use of inappropriate construction methods	PL02
7	Economic	Requires large costs for construction	EC01
8		Escalation or increase in building material prices during the project implementation period	EC02
9		Requires maintenance expenses for construction facilities	EC03
10	Logistic	There is a shortage of storage space for materials.	PM01
11		Delays in the arrival of ordered materials, which hinders work	PM02
12		Difficulty in mobilizing heavy equipment due to conditions in the field	PM03
13		Inconsistency between material order and material arrival at the project site.	PM04
14	Nature	An earthquake can cause damage to buildings.	NA01

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Number	Source	Identified Risk	Label
15		Weather changes such as rain during working hours.	NA02
16	Technical	Distribution of materials such as sand and other materials is difficult due to road access and insufficient storage space.	TE01
17		Damage to equipment (heavy equipment) results in delays.	TE02
18		Lack of equipment to support work in the site	TE03
19		Quality problems due to weak supervision.	TE04
20		Design changes due to changes in site conditions	TE05
21	Humans	The presence of dishonest workers or implementers results in the risk of loss due to loss or additional costs.	HU01
22		The labor does not meet the competency requirements.	HU02
23		Lack of competent expert personnel	HU03
24		Lack of teamwork between workers.	HU04
25	Crime	Intentional, planned, and hidden negative actions that have the potential to have an impact or loss on construction	CR01
26		Loss of materials and work tools	CR02
27	Finance	Errors in calculating the RAB	FI01
28		Increase in the market price of materials	FI02
29		Differences in the results of measuring the volume of work in the BQ with conditions in the field	FI03
30	Safety	There are workers who do not use personal protective equipment (PPE) when working.	SA01
31		Lack of control from safety officers causes workers not to use PPE.	SA02
32		Lack of worker understanding of safety	SA03

Table 2 shows 32 (thirty-two) identified risks, with varying details for each source. Technical sources are the most, with 5 (five) risks or 15.6%. Environmental, logistical, and human sources are identified with 4 (four) risks or 12.5%. Furthermore, risks originating from the economy, finance, and safety are each 3 (three) or 9.3%. Finally, planning, nature, and crime account for 2 (two) or 6.3% of all risks. Figure 2 presents the distribution of risk sources.

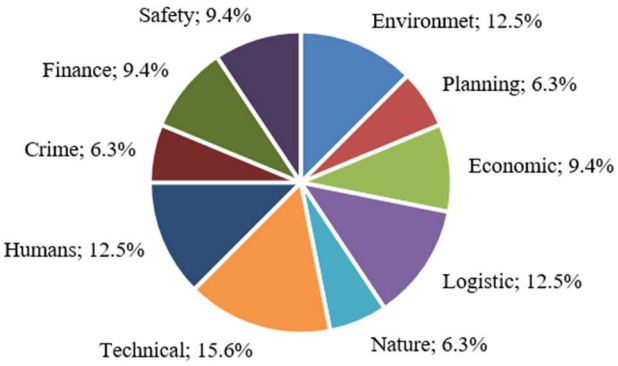

Fig. 2. Risk distribution by source

B. Risk Assesment

The identified risks are then analyzed using Equation (1) to determine the level of risk acceptance. The likelihood mode and consequence mode were determined based on the respondents' assessment of the questionnaire results. The questionnaire has been tested for validity showing that the r count (between 0.415 and 0.878) exceeds the r table value of 0.413. While for the reliability test, the Cronbach's alpha value has been obtained greater than 0.7, namely 0.941 and 0.950 for the likelihood and consequences, respectively. Table 3 presents the analysis of the collected data.

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TABLE III. ANALYSIS OF THE LEVEL OF RISK ACCEPTANCE

Number	Label	Likelihood (F)	Consequences (K)	Risk Value (X = F · K)	Risk Acceptance
1	EV01	3	3	9	*Undesirable*
2	EV02	3	3	9	*Undesirable*
3	EV03	2	3	6	*Undesirable*
4	EV04	2	2	4	*Acceptable*
5	PL01	4	3	12	*Undesirable*
6	PL02	2	2	4	*Acceptable*
7	EC01	4	4	16	*Unacceptable*
8	EC02	3	3	9	*Undesirable*
9	EC03	4	4	16	*Unacceptable*
10	PM01	3	3	9	*Undesirable*
11	PM02	3	3	9	*Undesirable*
12	PM03	3	3	9	*Undesirable*
13	PM04	2	2	4	*Acceptable*
14	NA01	2	2	4	*Acceptable*
15	NA02	3	3	9	*Undesirable*
16	TE01	3	3	9	*Undesirable*
17	TE02	3	2	6	*Undesirable*
18	TE03	2	3	6	*Undesirable*
19	TE04	3	3	9	*Undesirable*
20	TE05	3	3	9	*Undesirable*
21	HU01	2	3	6	*Undesirable*
22	HU02	2	3	6	*Undesirable*
23	HU03	3	3	9	*Undesirable*
24	HU04	2	3	6	*Undesirable*
25	CR01	3	3	9	*Undesirable*
26	CR02	3	3	9	*Undesirable*
27	FI01	3	2	6	*Undesirable*
28	FI02	3	2	6	*Undesirable*
29	FI03	3	4	12	*Undesirable*
30	SA01	4	5	20	*Unacceptable*
31	SA02	3	3	9	*Undesirable*
32	SA03	4	3	12	*Undesirable*

Based on the analysis of the risk acceptance level presented in Table 3, the risks categorized as unacceptable are three risks (9.38%), of which two come from the economy and one from safety. While for the risks categorized as undesirable, there are twenty-five risks (78.13%) spread across all risk sources. Furthermore, for the acceptable category of risks, only four (12.50%) originated from the environment, planning, logistics, and nature. Figure 3 provides details about the risk acceptance level.

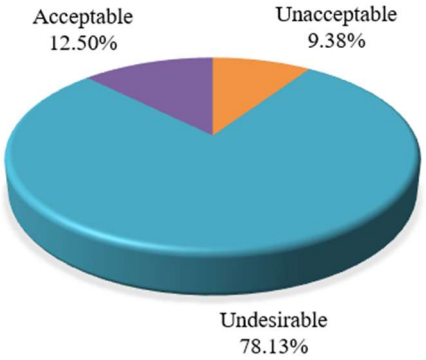

Fig. 3. Risk acceptable level

After the risk acceptance level is determined, it is then classified into major risks and minor risks. Risks that fall into the major category are those with unacceptable and undesirable acceptance levels. Minor risks are those that have acceptable and negligible

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acceptance levels. Thus, the major risks become twenty-eight (87.5%), while the minor risks are only four (12.5%). This is certainly awfully bad and has the potential to cause danger in the future if prevention or mitigation efforts are not carried out. Major risks, often identified during construction or development, typically fall under the contractor's responsibility. If the related parties do not immediately address these risks, they will bear the losses. Figure 4 provides details about the risk category.

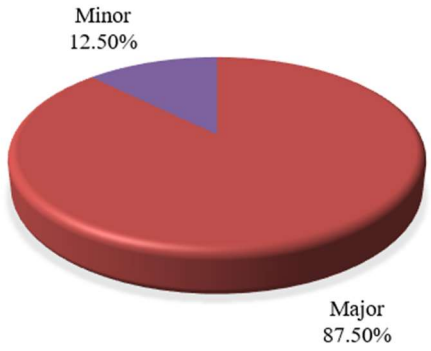

Fig. 4. Risk category

C. *Risk Mitigation*

Major risks are those that have the potential to cause harm to the Bali Public School construction project. Twenty-eight of these risks (unacceptable and undesirable) require preventive or mitigation actions to be reduced and eliminated. The mitigation actions revealed below are a combination of literature studies and opinions from respondents who are parties to this project activity. The risk mitigation methods implemented are as follows: risk retention, risk reduction, risk transfer, and risk avoidance. Table 4 presents the actions taken to mitigate the existing risks.

TABLE IV. MITIGATION ACTIONS AGAINST MAJOR RISKS

Label	Risk Acceptance	Identified Risk	Mitigation Action
EC01	*Unacceptable*	Requires large costs for construction	Looking for third parties or investors and bank loans to help finance the construction
EC03	*Unacceptable*	Requires maintenance expenses for construction facilities	Ensure that there are costs for the maintenance of construction facilities at the planning stage.
SA01	*Unacceptable*	There are workers who do not use personal protective equipment (PPE) when working	Provide personal protective equipment (PPE) according to the number of workers.
			Require employees to continue to use personal protective equipment (PPE) while working.
			Make regulations regarding PPE and impose sanctions on workers who do not use personal protective equipment (PPE).
EV01	*Undesirable*	The spilled material obstructed the drainage channel.	Divert or build drainage channels in another direction so that there is no blockage.
EV02	*Undesirable*	River water is polluted by project waste.	All workers are advised not to throw project waste into the river.
			Provide a waste disposal site for workers in the project environment.
EV03	*Undesirable*	Project noise is disturbing at night	Mapping and doing work that does not cause noise at night
PL01	*Undesirable*	Changes in the owner's drawing cause project delays.	Ensure that changes to the drawing are in accordance with the owner's wishes before the work is carried out so that it does not significantly affect the project schedule.
EC02	*Undesirable*	Escalation or increase in building material prices during the project implementation period	Make contracts with building material providers during the project.
			Order materials that are definitely used well in advance to avoid price increases.
PM01	*Undesirable*	There is a shortage of storage space for materials.	Rent a warehouse around the project to store materials.
PM02	*Undesirable*	Delays in the arrival of ordered materials, which hinders work	The logistics division always carries out control and ensures the availability of ordered materials.
			Working on work for which the materials are available
PM03	*Undesirable*	Difficulty in mobilizing heavy equipment due to conditions in the field	Ensuring that field conditions are ready for the mobilization of heavy equipment

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Label	Risk Acceptance	Identified Risk	Mitigation Action
NA02	*Undesirable*	Weather changes such as rain during working hours.	Making work plans according to weather forecasts
TE01	*Undesirable*	Distribution of materials such as sand and other materials is difficult due to road access and insufficient storage space.	Providing smaller tools to facilitate the distribution of materials
TE02	*Undesirable*	Damage to equipment (heavy equipment) results in delays.	Choosing quality heavy equipment and competent resources
TE03	*Undesirable*	Lack of equipment to support work in the site	Ensuring that the tools used are completely available
TE04	*Undesirable*	Quality problems due to weak supervision.	Ensuring that site supervisors always supervise the work and check the work results according to the specified specifications
TE05	*Undesirable*	Design changes due to changes in site conditions	Re-measuring field conditions and ensuring field conditions before making working drawings
HU01	*Undesirable*	The presence of dishonest workers or implementers results in the risk of loss due to loss or additional costs.	Choosing honest workers and project implementers
HU02	*Undesirable*	The labor does not meet the competency requirements. Lack of competent expert personnel	Bringing in workers according to the required competencies Procuring workshops or training so that workers can hone their skills
HU03	*Undesirable*	Lack of teamwork between workers.	Bringing in competent experts in the required number
HU04	*Undesirable*	The presence of dishonest workers or implementers results in the risk of loss due to loss or additional costs.	Ask the foreman to direct workers so that they can work together well.
CR01	*Undesirable*	Intentional, planned, and hidden negative actions that have the potential to have an impact or loss on construction	Be more selective in choosing workers. Monitoring and building a conducive atmosphere
CR02	*Undesirable*	Loss of materials and work tools	Storing materials and tools in a safe place Increasing the security of the project area with special officers
FI01	*Undesirable*	Errors in calculating the RAB	Recheck the calculations.
FI02	*Undesirable*	Increase in the market price of materials	Submitting changes to the contract if they exceed the agreed-upon price increase limit
FI03	*Undesirable*	Differences in the results of measuring the volume of work in the BQ with conditions in the field	Rechecking the volume calculation on the working drawings and field Submitting an addendum to the volume of work if there is additional work due to changes in the drawings
SA02	*Undesirable*	Lack of control from safety officers causes workers not to use PPE.	Safety officers are actively encouraging workers to use personal protective equipment (PPE) in accordance with the Minister of Manpower's regulation number PER.08/MEN/VII/2010. The competence of safety officers is given more attention so that they always conduct briefings and controls during the work.
SA03	*Undesirable*	Lack of control from safety officers causes workers not to use PPE.	Increase socialization about the implementation of K3 Construction at every morning briefing. Conducting inspections to ensure that workers use personal protective equipment (PPE)

Based on Table 4 above, there are thirty-nine mitigation actions that can be taken. There are five mitigation actions for unacceptable risks and thirty-four actions for undesirable risks. Mitigation actions for unacceptable risks originating from economic aspects (EC01 and EC03) are actions by the owner and design consultant that should be taken before construction. Meanwhile, unacceptable risks originating from safety aspects (SA01) are efforts by the supervisory consultant and contractor carried out from the beginning of construction until the work is completed [15]. Mitigation actions for risks in the undesirable category are mostly owned by the contractor, and only a few are owned by the owner, design consultant, and supervisory consultant. Contractors need to take appropriate mitigation actions from the beginning of construction to the end of the work so that risks can be reduced and eliminated in order to achieve project success.

The owner or private party directly manages the Bali Public School project, which carries a high level of major risk. The high percentage of major risks (87.5%) among the identified risks indicates weaknesses in its risk management. This condition is likely due to financial constraints, planning time, and lack of professional personnel involved. Major risks were mostly identified from the contractor's side, where the contractor has not yet maximized risk management. This can also arise from a limited tender process, starting with the readiness of tender documents that are still incomplete, especially the risk impact analysis. The selection of the

winning contractor should not only consider the lowest cost or the fastest time, but also consider the suitability of quality and the completeness of supporting management. On the planning side, there are also several advantages, such as differences in size in the drawings and field conditions, which result in adjustments to size and volume during the work. Also, the drawings should be updated during planning and finalized when the contractor is appointed. However, efforts that have been made by various parties and proposed mitigation actions based on risk analysis are expected to reduce and eliminate the identified risks. This is to ensure the project's success and prevent unanticipated losses for all involved parties.

IV. CONCLUTION

The construction project of Bali Public School, located on Jl. Bypass Prof. Dr. Ida Bagus Mantra No. 72, Banjar Tangtu, Kesiman Kertalangu Village, East Denpasar District, has risks that cannot be ignored. Risk identification was carried out using a literature study and observation by interview. The results of the study indicated that there were thirty-two risks identified from ten risk sources. Five (15.6%) of the identified risks were technical, and they were the most numerous compared to other risks. Risks originating from the environment, logistics, and humans each numbered four (12.4%). Risks originating from the economy, finance, and work safety each numbered three (9.3%). Risks originating from planning, nature, and crime each numbered two (6.3%). Risk analysis from respondent assessment data on identified risks showed that the risks classified as major were 87.5%, with a total of twenty-eight risks, while the minor risks were 12.5%. Major risks consisted of three unacceptable risks and twenty-five undesirable risks. Only four acceptable risks fall into the minor risk category and do not include negligible risks. The contractor primarily bears major risks, with the owner, design consultant, and supervisor bearing only a few. After categorizing the risks, thirty-nine mitigation actions were designed. These mitigation actions consist of five for the unacceptable risk acceptance level and thirty-four for the undesirable risk acceptance level. The mitigation actions obtained based on the results of discussions during interviews and literature studies are expected to be a solution to the risks that may arise in the Bali Public School construction project.

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