A Risk Matrix Assessment for the Determination of Future Project Delivery Systems in Road Infrastructure Projects in Indonesia

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ABSTRACT

The Government of Indonesia is undertaking sustainable infrastructure development to meet societal needs and support economic progress. The infrastructure should be designed to fulfil the long-term requirements of the community, and its construction must take into account both technical and non-technical aspects to ensure that budget utilization is accurate and appropriately targeted. The Government should ensure the implementation of a suitable project delivery system for infrastructure development to guarantee minimal risks and prevent the expenditure from exceeding the Government's financial capacity. This study formulates a risk matrix for government road infrastructure development projects in Indonesia to ensure that budget utilization is both efficient and well-targeted. The application of this risk matrix will assist the Government in selecting a project delivery system that enables effective and efficient execution of infrastructure projects. A mixed-method approach was employed, combining quantitative and qualitative

techniques. The quantitative method involved mapping risks based on the factors influencing government road development projects, followed by expert validation to assess the probability and impact of the identified risks. Thirty-two risk matrices were produced and categorized into low, medium, and high-risk levels. These risk matrices serve as the basis for selecting an appropriate project delivery system for government road construction projects, including Design–Bid–Build (DBB), Design and Build (DB), and Integrated Project Delivery (IPD). The recommendations derived from this research contribute to the selection of an appropriate project delivery system and the effective and efficient allocation of budgets in the pursuit of sustainable infrastructure development.

Keywords-risk matrix; risk management; government project; project delivery system; design-bid-build; design and build; integrated project delivery

I. INTRODUCTION

Risk management in construction is the process of identifying potential risks and their impacts in order to take strategic measures to address these risks and their consequences within a construction project. This ensures optimal project performance in terms of cost, quality, time, safety, and environmental aspects [1]. Various risk management frameworks have been developed to identify, analyze, respond to, and mitigate risks that may occur within a project [1-3]. According to ISO 31000:2018, risk is defined as the effect of uncertainty on objectives. This effect may result in either a positive or negative deviation from what is expected; thus, risk is associated with an objective-oriented perspective [4]. ISO 31000:2018 provides guidelines for organizations in managing risks based on established principles, framework, and processes [4-8]. According to risk management principles based on ISO 31000:2018, leadership and commitment constitute the framework, value creation and protection, and the process comprises several stages ranging from risk assessment to risk treatment, as illustrated in Figure 1 [8].

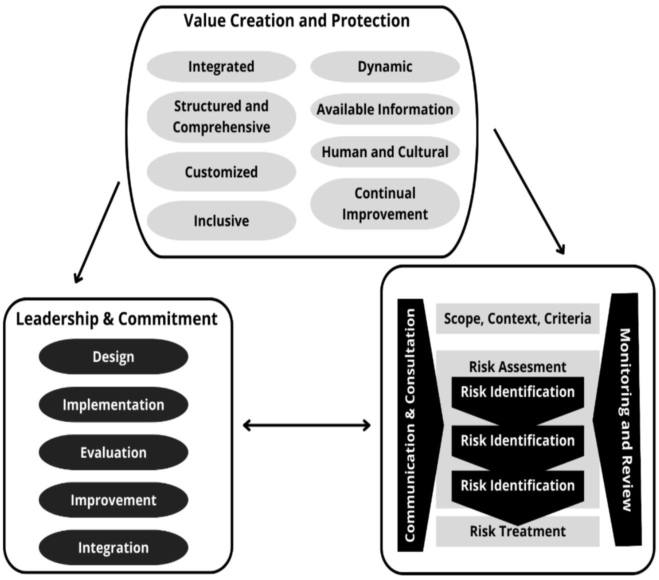

Fig. 1. ISO 31000:2018 principle.

To evaluate risks, a risk evaluation framework is employed through the use of a risk matrix, which maps the relationship between the probability and impact of potential events within a project. The resulting matrix enables the categorization of risks into low, medium, and high. In accordance with the recommendations of the European Commission, a 5×5 risk matrix is commonly used in risk assessment to enhance both visualization and classification. Figure 2 presents an example of a risk matrix that can be utilized to assess risks based on their impact and likelihood of occurrence. In this matrix, risk categorization is defined into 4 levels: low, medium, high, and very high [9, 10].

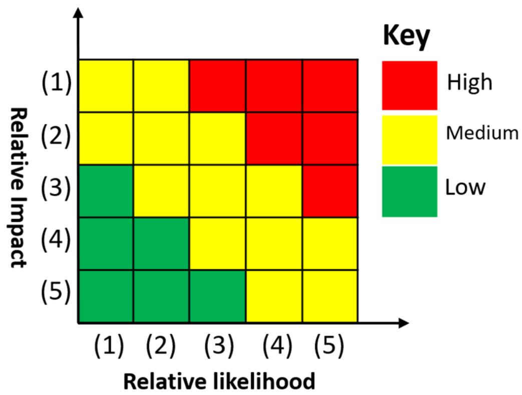

Fig. 2. Example of risk matrix.

In the development of government road projects in Bekasi Regency, West Java, the project owner, represented by the government, selects the project delivery system that presents the lowest level of risk. This decision is driven by the necessity for budget certainty, as government expenditures are limited by annual fiscal allocations. The government must clearly identify which risks can be managed internally and ensure that the project cost is determined at the outset based on the most competitive bid. Table I outlines the rationale underlying the decision-making process in selecting the project delivery system for government projects. One of the main considerations for the project owner in this decision-making process is the evaluation of risks. Therefore, the risk matrix of a project serves as an essential instrument for the project owner in determining the most appropriate project delivery system.

Authors in [11] identified project risks in developing countries, clustering the techniques employed, and analyzing the responses to each identified risk. Authors in [12] stated that unrealistic risk estimation may lead to an increase in project costs of up to 24%. Authors in [13] identified various risks in construction projects and proposed implementing appropriate mitigation measures for each risk, whether arising from natural conditions or organizational activities. Authors in [14] employed partnering as a strategy to mitigate financial risks associated with construction projects. Authors in [15] stated that within project risks under the public–private partnership scheme, a clear risk allocation is significant to achieve optimal project performance.

Authors in [16] classified various risks that occur at each stage of the project life cycle and provided recommendations for every potential risk. However, previous studies on risk management have not yet established a relationship between the urgency of risk management and its impact on the project delivery system selected by the project owner. The present study is therefore significant, as the government, acting as the project owner, is responsible for managing infrastructure projects that must ensure efficient and well-targeted budget utilization. An inappropriate selection of the project delivery system may result in project delays, poor performance, and postponed public access to the constructed infrastructure [17-19]. The recommendations of this study aim to provide guidance to the government in selecting the most appropriate project delivery system for implementing national road infrastructure development.

TABLE I. KEY OWNER CONSIDERATIONS FOR SELECTING A PROJECT DELIVERY METHOD

Budget	Owners must decide how quickly they need to establish final project costs and the risk level of exceeding this cost.
Design	Owners must decide how much control they need to have over the design element of the projects.
Schedule	An owner must decide how important it is to minimize the schedule duration for a project.
Risk assessment	An owner must decide how much project risk they are comfortable assuming.
Owner's level of expertise	An owner must make an assessment of their ability to properly perform under various methods.

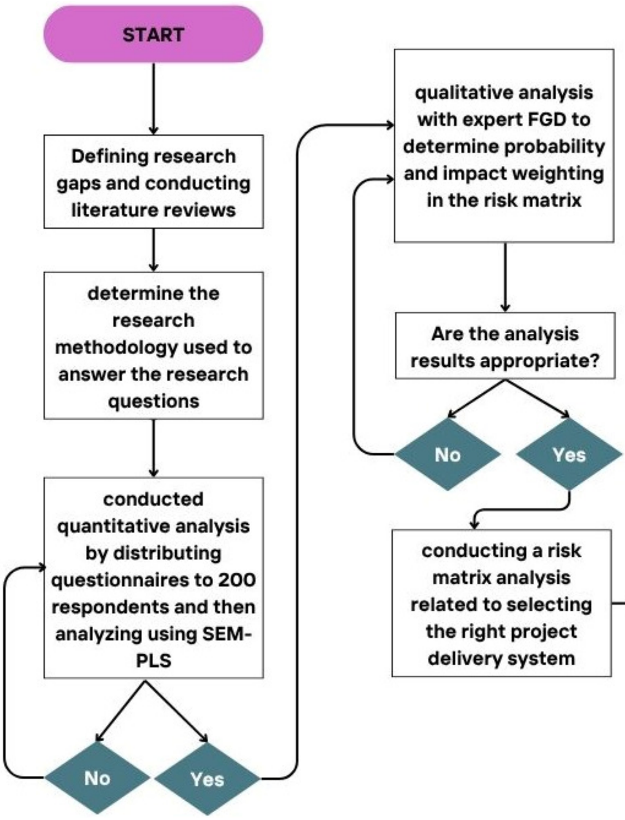

Fig. 3. Research flowchart.

II. METHODOLOGY

The methodology employed in this study is a mixed-method approach, which integrates both quantitative and qualitative methods [20, 21]. The quantitative method was conducted by distributing questionnaires to identify factors and variables considered as potential risks in road infrastructure development projects. Subsequently, the qualitative method was carried out through a Focus Group Discussion (FGD) involving 11 experts to assess the identified risks based on their probability and impact [22-25]. The results of the risk assessment were subsequently used to develop a risk matrix, classifying the risks into low, medium, and high categories. Based on the established risk matrix, a further analysis was conducted to determine the risk mitigation measures to be implemented by the government according to the identified risk clusters [10, 26, 27]. The analysis results contributed to determining the most suitable project delivery system for road infrastructure projects.

Figure 3 illustrates the step-by-step research process, which was conducted using a mixed-method approach, combining quantitative and qualitative techniques. The quantitative method involved distributing questionnaires to 200 respondents, followed by analysis using Structural Equation Modeling–Partial Least Squares (SEM–PLS) to identify the factors influencing risks in road construction projects in Bekasi Regency, West Java [28-30]. In-depth interviews were conducted to determine the risk matrix for road projects in Bekasi Regency. The resulting risk matrix was then employed to support the selection of the most appropriate project delivery system for road infrastructure projects in Bekasi Regency.

III. RESULTS

A. *Quantitative Analysis Results*

The quantitative analysis was carried out by distributing a questionnaire to 200 respondents, comprising representatives from the government, contractors, and consultants who had previously participated in road construction projects in Bekasi Regency. The questionnaire consisted of 64 questions representing 64 factors that influenced the risks associated with road projects in Bekasi Regency. According to the results obtained from the questionnaire analysis, 3 dimensions were identified as influencing factors in road projects: internal risks (X1), project risks (X2), and external risks (X3). Out of the 64 proposed risks, 32 had loading values greater than 0.5 [28-31] and were categorized, as shown in Figure 4, into internal risks (19 risks), project risks (6 risks), and external risks (7 risks). Subsequently, they were tested using the HTMT and Fornell–Larcker criteria, with the findings meeting the standard thresholds, as presented in Tables II and III.

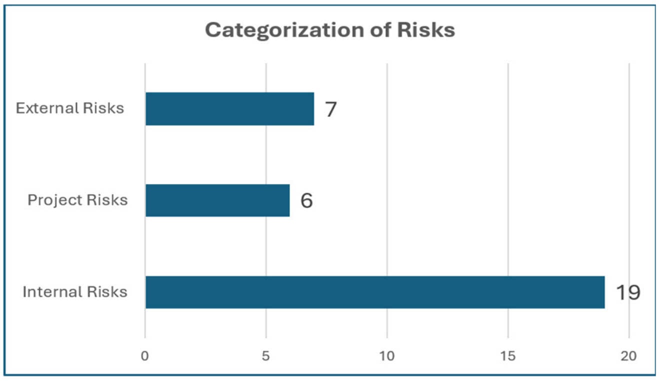

Fig. 4. Risk categorization.

TABLE II. HTMT TEST RESULTS

Criteria	External risks	External risks	External risks
External risks	-	-	-
Internal risks	0.087	-	-
Project risks	0.122	0.890	-

Based on the HTMT test results (Table II), all HTMT values are below 0.9. Therefore, the model meets the discriminant validity criterion, indicating that each construct effectively measures a distinct concept.

As presented in Table III, the discriminant validity in this model is evaluated by comparing the square root of the Average Variance Extracted (AVE) (diagonal values) with the correlations between constructs (off-diagonal values). The square root of AVE for each construct is: external risks (0.766), internal risks (0.745), and project risks (0.746). Each diagonal value is greater than the correlations between that construct and the others, indicating adequate discriminant validity. The relatively high correlation between internal risk and project risk (0.879) suggests a strong relationship between these two constructs. Nevertheless, since the square root of AVE remains higher than the inter-construct correlations, the model still satisfies the discriminant validity criterion according to the Fornell–Larcker method [28-31].

TABLE III. FORNELL-LARCKER CRITERION RESULTS

Criteria	External risks	External risks	External risks
External risks	0.766	-	-
Internal risks	-0.058	0.745	-
Project risks	-0.024	0.879	0.746

Table IV summarizes the overall performance of the regression model in explaining project failure. The results show a strong correlation coefficient (*R* = 0.966), indicating a very high degree of association between the independent variables and the dependent variable. The coefficient of determination (R^2 = 0.933) implies that 93.3% of the variance in project failure can be explained jointly by external risks, internal risks, and project risks. Furthermore, the adjusted R^2 value (0.932) is only marginally lower than R^2, suggesting that the model remains stable and is not affected by overfitting. The standard error of the estimate (1.495) indicates a relatively low level of residual dispersion, confirming the model's strong predictive capability.

TABLE IV. STATISTICAL SUMMARY OF THE MODEL

Model	R	R^2	Adjusted R^2	Std. error of the estimate
1	0.966	0.933	0.932	1.495

Predictors: (Constant), external risks, internal risks, and project risks.

Dependent Variable: Project failures.

The results of the regression coefficients are outlined in Table V. Project risks emerge as the most dominant predictor of project failure, as indicated by the highest standardized coefficient (β = 0.756), a large t-value (24.451), and a significance level of well below 0.001. These findings demonstrate that risks directly related to project execution, coordination, and operational control play a crucial role in determining project outcomes. External risks also exhibit a significant positive effect on project failure (β = 0.215, $p < 0.001$), suggesting that factors such as regulatory changes, economic conditions, and environmental uncertainties contribute to project performance. Internal risks, although statistically significant (β = 0.063, p = 0.030), exhibit a comparatively smaller effect size, indicating that internal organizational factors have a weaker but still relevant influence on project failure. Collinearity diagnostics further confirm the robustness of the regression model. All tolerance values exceed the minimum threshold of 0.10, and all Variance Inflation Factor (VIF) values remain below 3.0. These results reveal that multicollinearity among the independent variables is not a serious concern and that each risk dimension contributes explanatory power to the model.

TABLE V. MODEL COEFFICIENT ANALYSIS

Model		Unstandardized coefficients		Standardized coefficients	*t*	p-value	Collinearity statistics	
		B	Std. Error	*β*			Tolerance	VIF
1	Constant	-1.467	0.956	-	-1.535	0.126		
	Internal risks	0.028	0.013	0.063	2.192	0.030	0.415	2.407
	Project risks	0.702	0.029	0.756	24.451	0.000	0.358	2.790
	External risks	0.229	0.028	0.215	8.223	0.000	0.501	1.995

Dependent variable: Project failure

Table VI reports the results of the reliability and convergent validity assessment. Internal risks demonstrate excellent internal consistency, with Cronbach's alpha and composite reliability values exceeding 0.96. External risks also show strong reliability, with Cronbach's alpha and composite reliability values above 0.92. Project risks exhibit acceptable reliability levels, with Cronbach's alpha values around 0.80. However, the AVE values for all constructs fall below the proposed threshold of 0.50, particularly for project risks (AVE = 0.245). This result suggests that while the constructs are measured consistently, the indicators may not fully capture the variance of their respective latent variables. Nonetheless, given the high composite reliability values, the convergent validity can still be considered acceptable in an exploratory or applied research context.

TABLE VI. RELIABILITY TEST RESULTS

Risks	Cronbach's alpha (standardized)	Cronbach's alpha (unstandardized)	Composite reliability (ρ_c)	AVE
Internal risks	0.968	0.967	0.968	0.464
Project risks	0.801	0.800	0.736	0.245
External risks	0.926	0.926	0.927	0.497

The overall goodness-of-fit of the structural model is presented in Table VII. The estimated model demonstrates a substantially better fit than the null model, as indicated by a lower chi-square value (4667.714 compared to 10790.670). The chi-square to degrees of freedom ratio ($\chi^2/df = 2.395$) falls within the commonly accepted threshold of less than 3, indicating an acceptable model fit. Additionally, the RMSEA value of 0.084 suggests a reasonable approximation error, which is significantly lower than that of the null model (0.148). The 90% confidence interval for RMSEA further supports this conclusion, as it remains within an acceptable range. Collectively, these fit indices confirm that the proposed model adequately represents the observed data and is suitable for explaining the relationship between risk factors and project failure.

TABLE VII. MODEL FIT TEST RESULTS

Tests	Estimated model	Null model
χ^2	4667.714	10790.670
Number of model parameters	131.000	64.000
Number of observations	199.000	NA
Degrees of freedom	1949.000	2016.000
p-value	0.000	0.000
χ^2/df	2.395	5.353
RMSEA	0.084	0.148
RMSEA LOW 90% CI	0.081	0.145
RMSEA HIGH 90% CI	0.087	0.151

B. *Qualitative Analysis Results*

The qualitative analysis was conducted through in-depth interviews with 11 experts representing the government, contractors, and designers. During the interviews, the experts were asked to assess the risk matrix based on the probability and impact of the 32 factors identified as influential in the project. The results of the experts' assessments are displayed in Table VIII [9, 10].

TABLE VIII. RISK MATRIX

Risk Matrix	Impact				
Probability	**1 – Not significant**	**2 - Minor**	**3 - Moderate**	**4 - High**	**5 - Major**
5 – Almost certainly to occur (71% - 99%)	11 (Medium)	16 (Medium)	20 (High)	23 (High)	25 (High)
4 – Likely to occur (51% - 70%)	7 (Medium)	12 (Medium)	17 (Medium)	21 (High)	24 (High)
3 - Possibly to occur (31% - 50%)	4 (Low)	8 (Medium)	13 (Medium)	18 (Medium)	22 (High)
2 - Unlikely to occur (11% - 30%)	2 (Low)	5 (Low)	9 (Medium)	14 (Medium)	19 (Medium)
	1 (Low)	3 (Low)	6 (Low)	10 (Medium)	15 (Medium)

The experts evaluated the probability and impact values of each identified risk, which were then mapped into the matrix to determine the overall risk level. The scales used to assess the impact and probability values are shown in Table IX [9, 10].

IV. ANALYSIS

A. *Government Representative*

From the 32 identified factors, internal risks are those that must be mapped before project initiation, as they are closely related to project preparation. Among the 19 internal risk factors identified, several are considered highly significant and have wide-ranging impacts. As the project owner, the government must ensure that internal factors are properly addressed to minimize potential adverse effects. Project-related risks fall within the domain of contractors and consultants, who are responsible for mitigating them during project execution.

TABLE IX. MEASUREMENT OF RISK IMPACT AND PROBABILITY

Rate	Probability	Description	Percentage (%)	Frequency	Low tolerance
5	Almost certain	Almost certainly to occur	71-99%	>12 times during the project	1 event
4	Likely	Likely to occur	51-70%	10-12 times during the project	1 event
3	Possible	Possibly to occur	31-50%	6-9 times during the project	1 event
2	Unlikely	Unlikely to occur	11-30%	2-5 times during the project	1 event
1	Rare	Rarely to occur	1-10%	<2 times during the project	1 event

Therefore, during the selection of contractors and consultants, the project owner must consider their competence and credibility as service providers. External risks, such as fluctuations in interest rates, inflation, and force majeure events, cannot be predicted by either the government or the contractors. These risks must be accepted as inherent to project implementation, and contractual addenda may be required in case such risks materialize during the construction phase.

B. Contractor Representative

Internal risks are associated with a project when the pre-construction phase is not properly managed. The conformity of the contract with the allocated budget, as well as the accuracy and completeness of contractual documentation, must be ensured to facilitate the identification and resolution of potential disputes. The contractor's design and planning processes must be carefully and accurately managed to prevent design changes during project execution. Human resources (HR) risks must be identified and managed from the outset, as project productivity depends heavily on the personnel responsible for project management. Productivity, commitment, and sense of ownership among workers are essential aspects that should be emphasized during daily morning briefings. Material price escalation is an unpredictable risk; contractors expect that contractual addenda be permitted if economic fluctuations lead to material price increases exceeding 35% of the initial tender estimate. Natural disasters and adverse weather conditions also pose significant risks that may cause project delays. In such cases, contractors expect the government to issue an addendum concerning the project handover timeline.

C. Consultant Representative

Design changes and material specification adjustments are significant aspects within contractual documents. Therefore, a well-prepared contract document should be executed consistently without requiring modifications until the project is completed. Risks related to contractual documentation involve potential alterations in material specifications and the readiness of the project site, both of which must be ensured before commencement. In government projects, consultants are typically integrated with contractors under the DB contract system; consequently, the development of the risk matrix should mainly be the responsibility of the contractor.

D. Academic Representative

Risk mapping in construction projects is crucial, as failing to identify potential risks may negatively affect the contractor's profitability, cause delays in project handover, and postpone the public's access to promised infrastructure. The process of identifying risks should begin before project initiation through systematic risk identification and analysis. According to ISO 31000, risk management must follow structured and measurable stages to facilitate effective corrective action when risks occur. The subsequent stage involves risk treatment, wherein identified risks are mitigated by recognizing their root causes and determining the most appropriate mitigation strategies. Some risks fall within the contractor's domain and must be accepted, while others can be transferred to external parties to minimize potential financial losses.

In the context of infrastructure development failures in Bekasi Regency, contractors typically face 3 risk categories: internal, project-related, and external risks, each occurring at different stages of the project timeline. Internal risks emerge during the project preparation phase, emphasizing the importance of administrative discipline, adequate resource allocation, and effective pre-construction control. Project risks emerge during the execution phase, requiring robust project management to address emerging issues effectively. External risks, on the other hand, are unpredictable and often stem from external factors beyond the project's control. If such external risks are not properly managed, their impact on project performance can be substantial.

V. DISCUSSION

Based on the findings, a risk matrix was subsequently developed using probability and impact as key parameters, where the overall risk value represents the combination of both factors. The risk assessment was conducted through in-depth interviews with 11 experts. Each expert provided their assessment of the probability and impact associated with each identified risk factor. Table X presents the average risk matrix derived from in-depth interviews with experts, categorized into low, medium, and high levels of risk. Within these categories, 1 risk factor falls into the high-risk category, 24 factors are classified as medium risk, and 7 factors are categorized as low risk. The high-risk factor identified is the escalation of material prices within the external risk dimension. This finding aligns with [26], indicating that the risk of material price increase is highly unpredictable, as it is influenced by various factors, including economic, political, and social policies. Authors in [1] stated that financial and economic factors—including inflation, availability of funds, material fluctuation, and financial default—represent categories of risks that are inherently unpredictable. Within the medium-risk category, the most significant risks are associated with project-related factors, including work quality, design risks, land acquisition, theft, surveying errors, discrepancies in contract documents, and work volume deviations. This finding is consistent with [16], which noted that project risk categorization encompasses risks occurring throughout the various phases of the project delivery system, including preliminary design, tendering, detailed design, and construction work.

TABLE X. AVERAGE RISK MATRIX

No	Factors	Average	Risk level
1	Contract documents are inconsistent (internal risks)	8.33	8 (Medium)
2	Discrepancy between contract value and budget ceiling (internal risks)	14.00	14 (Medium)
3	Poor document archiving (internal risks)	9.33	9 (Medium)
4	Fatigue due to overtime (internal risks)	10.33	10 (Medium)
5	Inadequate equipment (internal risks)	5.00	5 (Low)
6	Labor disputes (internal risks)	6.00	6 (Low)
7	Lack of worker awareness (internal risks)	7.00	7 (Medium)
8	Insufficient understanding of contract clauses (internal risks)	9.33	9 (Medium)
9	Shortage of certified personnel (internal risks)	5.00	5 (Low)
10	Incompetent contractors/ subcontractors (internal risks)	14.67	15 (Medium)
11	Loss of materials and equipment (internal risks)	8.00	8 (Medium)
12	Low worker productivity (internal risks)	9.00	9 (Medium)
13	Owner demands abnormal profit (internal risks)	14.67	15 (Medium)
14	Inaccurate planning data (internal risks)	7.00	7 (Medium)
15	Low material quality (internal risks)	5.00	5 (Low)
16	Poor project team collaboration (internal risks)	11.67	12 (Medium)
17	Technical errors (internal risks)	5.00	5 (Low)
18	Occurrence of collusion (internal risks)	7.67	8 (Medium)
19	Unfavorable site conditions (internal risks)	9.33	9 (Medium)
20	Errors in site survey (project risks)	8.00	8 (Medium)
21	Poor equipment maintenance (project risks)	4.33	4 (Low)
22	Inadequate project supervision (project risks)	5.00	5 (Low)
23	Failure to achieve work quality standards (project risks)	8.00	8 (Medium)
24	Design changes (project risks)	11.33	11 (Medium)
25	Inconsistencies in work volume (project risks)	9.00	9 (Medium)
26	Changes in structure/responsibilities (external risks)	7.00	7 (Medium)
27	Damage to facilities (external risks)	13.00	13 (Medium)
28	Increase in interest rates (external risks)	18.67	19 (Medium)
29	Land acquisition obstacles (external risks)	15.33	15 (Medium)
30	Land disputes (external risks)	11.33	11 (Medium)
31	Increase in material prices (external risks)	22.00	22 (High)
32	Public dissatisfaction demonstrations (external risks)	12.67	13 (Medium)

Figure 5 presents the distribution of the identified risk factors according to their risk levels. Medium risks dominate the risk profile, with a total of 24 factors, indicating that most potential risks fall within a moderate impact–probability range and, therefore, require systematic monitoring and mitigation. Low-risk factors account for 7 items, suggesting that a smaller proportion of risks pose minimal threat to project performance and can be managed through routine control measures. In contrast, only 1 factor is classified as a high risk, highlighting that although severe risks are limited in number, they demand immediate attention due to their potential to significantly affect project outcomes. Overall, this distribution suggests that risk management efforts should primarily focus on controlling and reducing medium-level risks, while ensuring that high-risk factors are prioritized for preventive and corrective actions to minimize the likelihood of project failure.

Risk level decision-making evaluates both the severity of each risk and the probability of its occurrence. Experts are asked to assess potential risks by assigning scores for risk impact and occurrence probability. The risk value is then calculated by multiplying the impact score by the probability score, forming the basis of the risk matrix classification. The expert weighting process is implemented through a structured questionnaire, in which each identified risk is rated on a five-point scale (1–5) for both risk level and probability of occurrence. All experts are assigned equal weighting in the assessment. After collecting responses from all experts, the scores are tabulated and averaged. This average value is subsequently used to determine the magnitude of each risk and to classify it within the risk matrix.

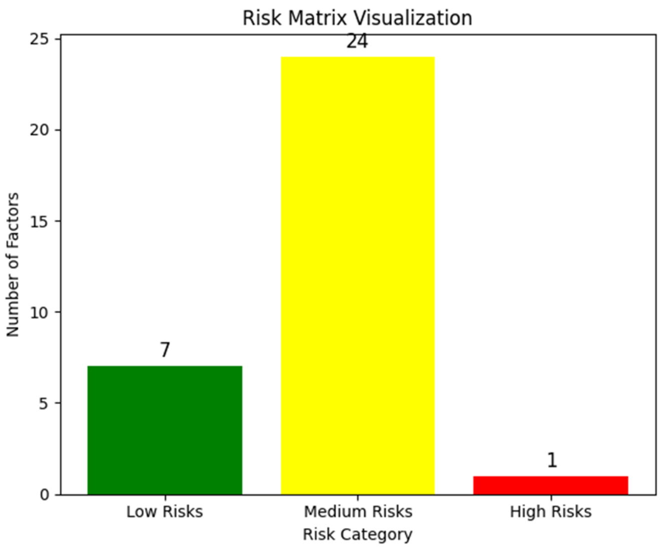

Fig. 5. Risk matrix visualization.

The implementation of risk management that produces a comprehensive risk matrix is crucial for project owners in planning and selecting the most appropriate project delivery system for project execution [32]. When selecting such a system, it is important to consider the types of risks that can be effectively managed by the project owner. Based on the in-depth interviews conducted with 11 experts, it was concluded that project owners assess risks to determine which project delivery system involves the least manageable risk. In the case of road infrastructure projects, which serve as public infrastructure, the government must carefully evaluate which risks can be controlled internally. Government projects are constrained by annual fiscal budgets, making fiscal considerations a critical factor in project risk management.

The findings of this study indicate that several risks are closely related to fiscal constraints in government projects, including material price escalation, interest rate increases, contract modifications, and design changes. Considering these risks, it is proposed that the government, as the project owner, select a project delivery system capable of addressing such challenges without requiring contract modifications or violating fiscal regulations. The DB project delivery system, according to representatives from the contractor and design sectors, is appropriate for managing risks in road infrastructure projects, as it adopts a lump-sum approach and integrates both design and construction responsibilities under a single main contractor [33-37]. The DB approach contributes to minimizing design changes, as contractors and designers collaboratively determine the most suitable construction methods from the project's inception. The DB system can also mitigate the impact of fluctuating material prices, as contractors have already estimated and planned the required materials during the design phase [38]. Consequently, the developed risk matrix provides valuable insights for contractors and project owners in selecting the most suitable project delivery system.

To further support the selection of an appropriate project delivery system, a comparative analysis was conducted between DB, DBB, and IPD using several standard criteria, including budget certainty, design maturity, schedule completeness, and risk assessment capability. This comparison aims to evaluate how each delivery system responds to the identified risk characteristics in government-funded road infrastructure projects, particularly those related to fiscal control and risk allocation. The results of this comparison are presented in Table XI.

TABLE XI. COMPARISON OF PROJECT DELIVERY SYSTEMS

Standard criteria	DB	DBB	IPD
Total budget is known	100%	50%	100%
Maturity design	100%	80%	20%
Complete schedule	100%	100%	100%
Risk assessment	100%	20%	100%

Based on the comparison in Table XI, the DB system demonstrates greater maturity than the DBB approach, particularly in risk management and design completeness. In the DB system, risks are identified and addressed from the early project stages, resulting in a more mature design and minimizing design changes that could lead to change orders during construction. In contrast, the DBB system shows weaker risk assessment performance due to the separation between designers and contractors, which often results in incomplete risk identification during the design phase and increases the likelihood of variations and cost overruns. IPD system performs well in terms of budget certainty and shared risk management through early collaboration between the owner and contractor; however, its relatively low initial design maturity reflects the concurrent development of design and construction, which may not fully align with the fiscal and regulatory constraints of government-funded projects.

Overall, the selection of a project delivery system depends on the level of risk the project owner is willing to accept. By systematically mapping acceptable risk factors in road infrastructure development, project owners can define clearer risk treatment strategies and select delivery systems that align with their risk tolerance, regulatory framework, and budget limitations. Within this context, the DB approach emerges as a practical and effective option for managing risks in government road infrastructure projects.

VI. CONCLUSION

Risk mapping through the stages of risk identification, analysis, and mitigation provides a clearer basis for the owner (in this case, the government) in selecting the most appropriate project delivery system. This conclusion is supported by the following reasons:

- Budget limitations and contract flexibility: The government, as the owner, must consider which risks can still be managed directly, since project contracts are limited by a predetermined fiscal year budget, leaving very little room for budget revisions. Therefore, choosing the Design and Build (DB) project delivery system is an effective solution, as it enables the government to make decisions based on the level of risk that can still be controlled.
- Anticipation of medium to high-level risks: Risks categorized as medium to high should be anticipated from the planning stage through the selection of a suitable project delivery system. The chosen system must be capable of minimizing the impacts of these risks, particularly those beyond the owner’s control. Hence, the DB system is considered capable of providing an adaptive response to dynamic and unpredictable risks in government infrastructure projects.
- Fluctuations in material price: According to experts, material price increases cannot be predicted in Indonesia because they still depend on imported goods’ suppliers. Thus, if this risk occurs, it may have a significant impact on project performance.

This research focuses solely on road projects and associated risks within road infrastructure. Further analysis for buildings, bridges, dams, airports, or other infrastructure has not been conducted. In formulating policies, the government must emphasize the protection of controlled material prices, as they significantly influence project costs. Imported materials are those commonly subjected to price increases, with the import supplier dependent on increases in bank interest rates and international currencies. For future studies, the factors influencing the risks of road infrastructure development can be expanded to include buildings, dams, bridges, and airports to more effectively predict the risks involved in these projects.

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