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ISO 31000:2018 Based Risk Management Integration Towards Secondary Arterial Road Planning

Franky Unmehopa[1]; Andi Asnudin[2]; Adnan Fadjar[3]

[1] Postgraduate Student, Department of Civil Engineering, Tadulako University
[2] Lecturer of Civil Engineering Study Program, Faculty of Engineering, Tadulako University
[3] Lecturer of Civil Engineering Study Program, Faculty of Engineering, Tadulako University

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Abstract: Inter-regional connectivity, population mobilization, and smooth logistics distribution are highly dependent on the existence of secondary arterial roads. However, the process of designing this infrastructure in Palu City faces significant challenges due to environmental uncertainty stemming from the city's vulnerability to natural disasters, including earthquakes, tsunamis, liquefaction, and floods. The lack of optimal integration of risk management in the road project design phase exacerbates this phenomenon. To overcome these problems, this study is designed to map various triggering factors, determine the dominant risk level in the secondary arterial road project in Palu City, identify the sequence of preventive measures, and determine the risk tolerance limit in accordance with ISO 31000:2018. The preparation of this study applies a qualitative descriptive method by raising specific cases in the planning of secondary arterial roads in the Palu City area. The field investigation relied on a combination of instruments, including questionnaires, in-depth interviews, direct observations, and secondary document review. All collected data passed reliability and validity tests before being analyzed using descriptive techniques and risk matrix mapping, which combined probability parameters and impact magnitude in accordance with ISO 31000:2018 guidelines. The inventory session successfully captured 24 types of risk across five major groups: technical dimensions, environmental aspects, social dynamics, economic conditions, and institutional governance. Using matrix calculations, 15 risk variables had high (significant) values, while the other 9 were at medium levels. The priority of mitigation actions is fully directed to the high-risk group, which is divided into 4 parameters (16) and 11 parameters (12). The medium-level risk group comprises 8 parameters with a score of 9 and 1 parameter with a score of 6. The final findings confirm that the internalization of ISO 31000:2018 principles during the secondary arterial road planning period is crucial to sharpen policy accuracy, minimize technical constraints on the ground, and realize the provision of resilient and sustainable infrastructure. As a next step, the research agenda is recommended to formulate a more detailed mitigation scheme and expand the scope of the investigation to include the physical and operational development stages of the road.

Keywords: *Risk Management, ISO 31000:2018, Road Infrastructure Planning, Secondary Arterial Roads, Risk Mitigation.*

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I. INTRODUCTION

The urban transportation system relies heavily on road infrastructure to support population movement, logistics circulation, and regional economic development. When viewed through the lens of sustainable development, road facilities are not merely static physical constructions but a dynamic system that must adapt to natural fluctuations and shifting socio-economic conditions. Optimally integrated road design can strengthen inter-regional connectivity while triggering the birth of a new economic epicenter, a process that requires a structured, comprehensive methodology to reduce speculation that can hinder development achievements [1].

As one of the bureaucratic centers and the driving force of the economy in Central Sulawesi, Palu City faces significant obstacles in providing transportation infrastructure due to its

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topographic characteristics and high natural disaster risk. According to the Road Basic Data (DD1) for Palu City in 2026, the city government's road network comprises 3,050 sections totaling 960.11 km. The quality distribution of the total road length includes 599 km (62.93%) in the good category, 113.87 km (11.86%) in the medium category, 58.40 km (6.04%) in the light-damaged category, and 188.84 km (19.67%) in the severely damaged condition. Within the structure of the urban road network, secondary arterial roads hold a crucial position as the arteries that integrate residential, commercial, educational, and public facilities zones, and the consistency of their services is the main determinant of urban mobility efficiency [2].

Although its contribution is vital, the secondary arterial road planning stage is often overshadowed by a complex spectrum of risks arising from technical, ecological, social, financial, and bureaucratic governance dimensions. The complexity of this threat increases significantly in areas with high vulnerability, such as Palu City, which is often affected by tectonic threats, tidal waves, water overflows, and soil softening. Several studies prove that public facility projects that ignore the urgency of hazard mitigation are prone to schedule delays, budget spikes, and operational failures [3]. To control this volatility, the risk governance instrument guided by ISO 31000:2018 offers a structured blueprint for detecting, dissecting, quantifying, and addressing threats from the initial design phase [4], [5].

A review of the previous scientific literature reveals that the majority of ISO 31000:2018 implementations are still centered on the physical implementation phase, operational management, or non-transportation industries—per investigations by [6], [7]. Attention was paid to deviations in the construction process, while the study [8], [9] adopts ISO 31000:2018 standards for the medical services sector and for industrial personnel. On the other hand, research [10] focuses more on observations of potential building damage caused by anomalies in soil characteristics. This condition shows that there is still a lack of academic references that provide in-depth reviews of risk management based on ISO 31000:2018 in the phase of secondary arterial road design, especially in urban areas under the threat of massive disasters.

Departing from these theoretical gaps, this study is projected to map and decompose the dominant hazard variables in the planning of secondary arterial roads in Palu City, determine the main preventive measures, and measure the threat tolerance threshold using the ISO 31000:2018 instrument. This scientific exposure makes a theoretical contribution to the body of knowledge on infrastructure risk management by expanding the use of ISO 31000:2018 at the pre-design stage of urban roads, which have been rarely explored to date. In addition, the output of this research serves as a practical reference for regional authorities and related parties in formulating a blueprint for road planning that is more flexible, orderly, and mitigation-based in disaster-prone areas.

II. LITERATURE REVIEW

A. Risk Management

Uncertainty management is carried out in a structured manner through a risk management approach to map, decompose, measure, and control speculation that could distort the achievement of institutional targets. According to ISO 31000:2018, risk is defined as the consequence of uncertainty about the target. In contrast, risk management is an integrated set of actions to command and control institutions in dealing with potential threats. In the pre-design phase of road facilities, this instrument plays a crucial role in anticipating unexpected dynamics that can trigger timeline delays, budget realization spikes, building quality degradation, and movement system dysfunction. The success of implementing this policy does not depend solely on the readiness of technical instruments. However, it is also accelerated by the internalization of work culture, consistency in leadership policies, and the active participation of all stakeholders [11], [12], [13].

B. ISO 31000:2018

The ISO 31000:2018 framework offers universal guidelines applicable to various industries, including the transportation and regional development sectors. The risk management mechanism refers to the ISO 31000:2018 standard, which integrates a series of stages that include communication and consultation, scoping and determination, risk mapping, risk mitigation, periodic supervision and evaluation, and formal documentation and reporting. This methodology emphasizes the urgency of assessing potential hazards from the earliest stages of the project idea so that policymakers can formulate logical tactical steps based on a valid database. Alignment of mitigation within the planning scheme is crucial because it enables early detection of potential obstacles before fieldwork begins [14].

C. Matrix Risk

At the hazard measurement stage, the risk matrix is the most commonly used tool for assessing threat management priorities. This matrix formula combines two fundamental variables: the probability of an event occurring and the severity of its consequences. By cross-correlating the two indicators, the degree of danger can be mapped into low, medium, high, and extreme risk clusters, which, in turn, facilitate the formulation of a sequence of preventive measures.

Table 1 Matrix Risk

Impact / **Possibilities**	**Very Light**	**Lightweight**	**Medium**	**Weight**	**Very Heavy**
Very Rare	Low (1)	Low (2)	Low (3)	Medium (4)	Medium (5)
Rare	Low (2)	Medium (4)	Medium (6)	Medium (8)	Height (10)
Quite Rare	Low (3)	Medium (6)	Medium (9)	Height (12)	Height (15)
Frequent Occurrences	Medium (4)	Medium (8)	Height (12)	Height (16)	Extreme (20)
Very Frequent	Medium (5)	Height (10)	Height (15)	Extreme (20)	Extreme (25)

Source : AS/NZS ISO 31000 in [15], [16]

Table 1 is a visual representation of the hazard level, presented in a two-dimensional table format that brings together two main variables. In the diagram configuration, one vertical or horizontal axis maps the frequency of events (chances/probabilities), while its partner axis measures the scale of the losses incurred (consequences/impacts). Each identified threat indicator is then mapped to a crossover box that reflects the accurate blend of the two indicators.

D. Risk Acceptance Rate

The hazard tolerance threshold is measured through a classification grouping of unacceptable, unexpected, acceptable, and negligible categories, used to determine risk management policies.

Table 2 Risk Acceptance Rate

Risk Acceptance Rate	**Risk Acceptance Scale**		
Unacceptable		X	≥ 15
Undesirable	5 ≤	X	< 15
Acceptable	3 ≤	X	< 5
Negligible		X	< 3

Source : AS/NZS ISO 31000 in [15], [16]

In Table 2, the data distribution mapping shows that the tolerance thresholds for each threat parameter span different numerical intervals. During the testing phase, the variables with the greatest calculation weight were placed at the top of the order of preventive actions, followed by periodic monitoring of indicators of lesser value to prevent the escalation of the hazard to a more critical level.

- Unacceptable: A critical situation characterized by a high potential for failure and the impact of large-scale destruction, thus demanding immediate countermeasures.
- Undesirable: A threat level that is so large that it requires a comprehensive mitigation design to prevent the value escalation from shifting to an intolerable threshold.
- Acceptable: The degree of risk assessed is still within normal limits, assuming that the consequences that arise can still be anticipated and borne by the capacity of the stakeholders.
- Negligible: An indicator of danger that is very minimal or has a very rare frequency of occurrences, so it does not require a specific handling allocation.

E. Road Network System

The process of designing transportation infrastructure cannot be separated from the blueprint of the road network, which is a unified corridor that integrates to facilitate the movement of people and the circulation of logistics. The structure of this network is classified into primary systems and secondary systems, whose formulation is based on the level of movement service functions and their synchronization with the spatial plan of the region [17], [18].

One of the crucial elements in the secondary structure is the secondary arterial passage. This facility serves as a connecting corridor between the primary and secondary zones and integrates various urban activity centers, including commercial areas, educational centers, housing complexes, and community service areas [17]. Secondary arterial roads are characterized by high vehicle capacity, high vehicle speeds, and a strategic role in maintaining the stability of movement in urban areas. On this basis, the design stage is obliged to integrate engineering parameters, land use, mass mobilization demands, and regional expansion trends to realize an effective and sustainable transportation system.

III. RESEARCH METHODOLOGY

A. Types of Research

This study applies a descriptive qualitative methodology, using a case study design, to examine the assimilation of risk management based on ISO 31000:2018 into the secondary arterial road design scheme in Palu City. The qualitative options are designed to comprehensively explore stakeholders' viewpoints, track records, and actual implementation regarding the identification of hazard indicators, the sequence of preventive actions, and the execution of risk management in the pre-design phase of road facilities. This approach pattern facilitates a comprehensive understanding of the object of observation within the scope of disaster-prone areas with a high level of planning complexity [19].

B. Research Location

The research is conducted in Palu City, Central Sulawesi Province, an area with geological characteristics that are vulnerable to tectonic threats, tsunamis, and soil softening. The observation object was focused on the secondary arterial road corridor that crosses five sub-district areas. Based on the results of selecting sample points to calculate the use of the road, the physical reality in the field, and the representation of the region, this research focused on three secondary arterial road corridors, namely Jalan Garuda, Jalan Maleo, and Jalan Veteran. The data collection phase will be carried out throughout 2026, utilizing field review instruments, structured dialogues, and secondary archive reviews.

C. Population and Sample

The research subjects include all stakeholders who have functional attachments, both direct and indirect, to the design of secondary arterial roads in Palu City, including representatives of the regional bureaucracy, planning consultants, university experts, and practitioners in transportation and civil engineering. The selection of resource persons relies on the purposive sampling methodology because it is considered the most effective in capturing substantial data from figures who possess competencies and track records aligned with the topic of study [20], [21]. Through initial identification, 55 respondent candidates were netted who met the participation limit qualifications. The determination of the number of final informants relies on the fulfillment of the data saturation indicator, a condition in which exposure to incoming information becomes uniform and no longer yields significant variation in new findings [22].

D. Data Collection Techniques

The data collection instruments applied include semi-structured interviews, field observation sheets, and document review formats. The dialogue guide was prepared with reference to the division of research variables into engineering, environmental, social, financial dynamics, and institutional governance aspects, in line with the ISO 31000:2018 risk management workflow. In addition to producing qualitative datasets in the form of narrative descriptions and informant testimonials, this research tool includes a questionnaire with probability and level-of-consequence scales to support the calculation of risk. The instrument's feasibility is tested using validity and reliability parameters before being applied in the data dissecting phase.

Data collection is operationalized through three fundamental methodologies: in-depth interviews, field observations, and secondary document review. Face-to-face dialogue was used to explore the track record, opinions, and patterns of risk governance integration in the pre-design phase of secondary arterial roads [23]. Field surveys were conducted in a non-participatory manner to assess the physical condition of the road corridor, potential ecological threats, and spatial indicators correlated with the observation objects [24]. On the other hand, document reviews were conducted on road design files, Regional Spatial Plan documents, technical guidelines, and relevant disaster impact evaluation reports to validate the results of the dialogue and physical review [19].

E. Data Analysis Techniques

The data dissecting process employs an interactive analysis scheme that combines data condensation, data visualization, and the formulation of conclusions or verification [25]. The information resulting from dialogue, observation, and file review is first classified using a coding system to separate the main clusters related to the technical, environmental, social, economic, and institutional dimensions. The next step is to display the data in the formats of a thematic matrix, a risk mapping chart, and a descriptive presentation to unravel the correlation between variables [19]. The hazard level evaluation was conducted using a risk matrix instrument that combined frequency and magnitude indicators to map risk clusters and identify mitigation sequences. The entire analysis is carried out using Microsoft Excel add-ins to process the data, test the validity and reliability of the measuring instruments, and compile a risk matrix. Data accuracy is ensured through source triangulation, technical triangulation, member checking, and an audit trail, thereby strengthening the credibility of scientific findings [23].

IV. RESULTS AND DISCUSSION

A. Identify Risks

The process of identifying hazard indicators is a crucial stage in the risk governance cycle, where the activity begins with determining the scope of risk to be tested and further evaluated.

Table 3 Risk Identification Results

No	Risk	Code
A.	**Technical Factors**	**FT**
1	The topographic conditions of the location and unstable soil can hinder the road planning process	FT1
2	Inaccuracies in field survey data can lead to planning errors as well as geometric design changes	FT2
3	The limitation of pre-existing technical data can affect the quality of road planning results	FT3

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No	Risk	Code
4	Poor drainage planning has the potential to lead to construction failure	FT4
5	Errors in determining the type of road pavement used	FT5
B.	**Environmental Factors**	**FL**
6	The risk of natural disasters such as floods, earthquakes, tsunamis, liquefaction can affect road planning design	FL1
7	Land use changes can lead to road planning revisions	FL2
8	Road construction has the potential to cause environmental damage	FL3
9	Inconsistencies in environmental documents can hinder the project planning process	FL4
10	The environmental impact of road construction can cause licensing obstacles	FL5
C.	**Social Factors**	**FS**
11	Land acquisition conflicts and land disputes can hinder the road planning process	FS1
12	Community rejection of road projects can occur	FS2
13	Lack of community participation can affect the quality of planning	FS3
14	Lack of socialization of projects can disrupt social activities and increase the risk of social conflict	FS4
D.	**Economic Factors**	**FE**
15	Budget constraints can hinder the road planning process	FE1
16	Funding delays can affect project planning schedules	FE2
17	Cost estimation errors can lead to underestimation of project budgeting	FE3
18	Market price changes may affect the project cost budget plan	FE4
E.	**Institutional/Organizational Factors**	**FK**
19	Lack of coordination and ineffective communication between agencies can hinder the planning process	FK1
20	Inadequate expert competence can affect the quality of planning	FK2
21	Poor document control can lead to project administration errors	FK3
22	Changes in government regulations and policies can affect the road planning process	FK4
23	Non-compliance with the RTRW may lead to planning revisions	FK5
24	Non-compliance with technical standards can lead to errors in project planning	FK6

Based on the initial inventory data summarized in Table 3, 5 main risk scopes have been identified. From these five domains, a more in-depth elaboration was carried out, which resulted in the identification of 24 specific risk indicators as the object of assessment and evaluation.

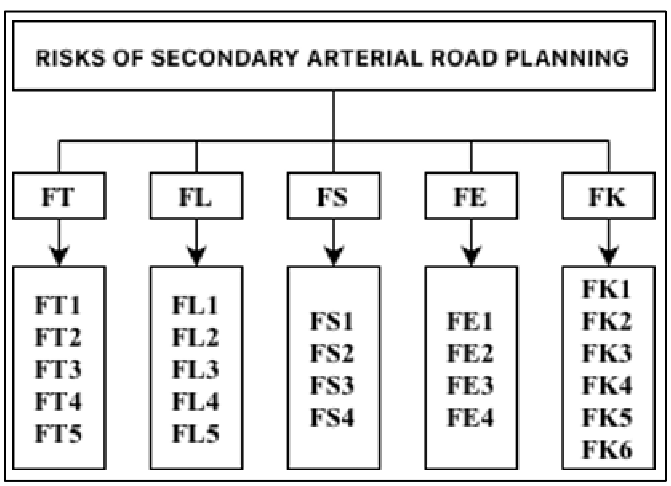

Fig 1 Risk Breakdown Structure

Based on the visual configuration of the data distribution in Figure 1, the risk clustering shows that the technical dimension (FT) includes 5 risk indicators, the environmental aspect (FL) contains 5 risk indicators, social dynamics (FS) involves 4 risk indicators, the economic sector (FE) contains 4 risk indicators, and the institutional or organizational governance (FK) contains 6 risks.

B. Validity & Feasibility Test

In this research, validity testing was carried out by comparing the coefficient of the calculated value with the retable and the critical value at the 1% significance level, which is 0.345 (n=55). An instrument is considered valid if the coefficient exceeds the threshold. On the other hand, the reliability level is measured using Cronbach's Alpha, with a minimum alpha value of 0.70 as an indicator of reliability.

➤ *Validity Test*

- Based on the calculation of the validity test on the probability variable, all calculation parameter gains are above the retable threshold value of 0.345. The distribution of numbers moved from the lower limit of 0.348 to the upper limit of 0.807. Since the quantification of the calculation parameters exceeds the critical value of the table, all statements in this instrument are declared valid.
- The results of the validity test on the impact variable showed similar results, where all question items posted a greater retable value than the retable stipulation of 0.345. The calculation coefficient interval is distributed from 0.348 to 0.810, so that the validity status of all statement items is met.

➤ *Feasibility Test*

- The results of the probability variable reliability test resulted in a Cronbach's Alpha index of 0.917. The acquisition of this number is well above the minimum reliability tolerance limit of 0.70, so the instrument is proven to be reliable.
- The reliability characteristics for the impact variable recorded the magnitude of Cronbach's Alpha value at 0.893. This index has exceeded the reliability standard of 0.70, confirming that this research instrument is feasible and consistent to use.

C. Risk Analysis

The measurement of the degree of danger in this research relies on a risk matrix instrument, applying a multiplication formula between the variable frequency of event occurrence (Probability/P) and the scale of losses incurred (Impact/D). The quantitative value of the risk is determined through the formula (P × D). The output of this mathematical calculation is then grouped into several risk level clusters, ranging from low to critical. The greater weight of the score indicates that the threat indicator holds the highest priority to be addressed immediately in the predesign stage of the secondary arterial pathway.

Table 4. Results of Risk Matrix Determination

		IMPACT				
		1	***2***	***3***	***4***	***5***
POSSIBILITIES	***1***					
	2			***FL3***		
	3			***FT5, FL4, FL5, FS2, FS3, FS4, FK4, FK5***	***FT2, FT3,FT4, FL1,FL2***	
	4			***FE3, FE4, FK1, FK2, FK3, FK6***	***FT1, FS1, FE1, FE2***	
	5					

Based on the distribution of data in Table 4., 15 threat indicators were identified as high risk. This group was dominated by 4 risks (FT1, FS1, FE1, FE2), which recorded the highest cumulative score of 16, as well as 11 other risks (FT2, FT3, FT4, FL1, FL2, FE3, FE4, FK1, FK2, FK3, FK6) at a weight of 12. Meanwhile, 9 threat indicators are categorized as medium risk, consisting of 8 risks (FT5, FL4, FL5, FS2, FS3, FS4, FK4, FK5) with a score of 9, and 1 risk (FL3) with an index value of 6.

D. Risk Mitigation Priorities

The determination of the priority order of hazard management in this research is intended as a tactical step to identify the most crucial and urgent conditioning actions against various threats that could distort the predesign phase of the secondary arterial pathway. Each threat indicator mapped has varying degrees of influence on the achievement of project targets across the technical, environmental, social, economic, and institutional governance dimensions. Based on this phenomenon, a mitigation hierarchy is necessary to ensure the process of handling obstacles runs more efficiently, on target, and in proportion to the scale of the losses caused.

➤ *Mitigation of High Risk Factors*

Variables in the high-risk spectrum are identified as the most important target for countermeasures in the design of preventive schemes because they have a high probability of disrupting the course of secondary arterial road planning.

Table 5 High Risk Mitigation

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Code	Assessment Indicators	Risk Assessment	Category Risk	Mitigation Risks
FT1	*The topographic conditions of the location and unstable soil can hinder the road planning process*	*16*	***Height***	*Comprehensive geotechnical investigations must be carried out through soil sampling, topographic and structural mapping, and slope stability calculations before the design blueprint is formulated. In addition, an in-depth review using cutting-edge mapping technology is needed to accurately map the terrain, enabling the geometric design of the road to adapt to soil mechanics and the region's geographical conditions.*
FS1	*Land acquisition conflicts and land disputes can hinder the road planning process*	*16*	***Height***	*The application of participatory methods was carried out through counseling, public polls, and discussions with affected residents from the initial phase of the project idea being rolled out. In addition, the operationalization of land acquisition must be conducted openly and objectively, and rely on the applicable legal corridor, to reduce the potential for social clashes in the field.*
FE1	*Budget constraints can hinder the road planning process*	*16*	***Height***	*A logical formulation of budget calculations must be prepared based on the project's real needs, accompanied by the determination of the sequence of activities in a practical manner. Not only that, but tightening oversight of the absorption of allocated funds and conducting periodic cost reviews are necessary to ensure the design process remains consistent with the set targets.*
FE2	*Funding delays can affect project planning schedules*	*16*	***Height***	*The validation of the availability of funding instruments must be ensured concretely before project activities begin, which is accompanied by strengthening alignment between executing institutions and capital providers. Steps to control the timeline of disbursement of funds must also be strictly controlled so that each stage of pre-design does not experience schedule delays.*
FT2	*Inaccuracies in field survey data can lead to planning errors as well as geometric design changes*	*12*	***Height***	*The use of high-precision survey devices, such as geodetic GPS, mapping drones, and total stations, is necessary to improve the quality of spatial data. In addition, the verification and data validation mechanism must be implemented periodically, accompanied by alignment between the surveyor team and the design team, to reduce information deviation from the initial predesign phase.*
FT3	*Limited technical data can affect the quality of road planning results*	*12*	***Height***	*The collection of technical parameters as a whole must be pursued through strengthening cross-institutional communication, in-depth field observation, and the utilization of valid secondary data. Not only that, regular data updates are crucial to ensure that all calculations applied in the planning scheme continue to reflect the actual field conditions.*
FT4	*Poor drainage planning has the potential to lead to construction failure*	*12*	***Height***	*Dissecting the hydrological aspects and calculating water runoff discharge in detail must be carried out to determine the dimensions and capacity of the drainage system, which are proportional to the area's characteristics. This drainage system must be formulated based on extreme rainfall projections and local topographic conditions, so as to minimize the risk of inundation while preventing future damage to road pavement structures.*
FL1	*The risk of natural disasters such as floods, earthquakes, tsunamis,*	*12*	***Height***	*A comprehensive disaster mitigation document must be prepared by mapping vulnerable zones and adjusting road geometry to the regional vulnerability index. In addition, a*

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Code	Assessment Indicators	Risk Assessment	Category Risk	Mitigation Risks
	liquefaction can affect road planning design			*flexible, adaptive construction concept that accounts for natural shocks needs to be adopted, ensuring the transportation infrastructure built has an optimal level of resilience to disaster risks.*
FL2	*Land use changes can lead to road planning revisions*	*12*	***Height***	*The alignment of the road construction design with the RTRW document and other spatial planning regulations must be established from the earliest stages of the project. Intensive coordination with regional authorities and agrarian institutions must also be strengthened to anticipate fluctuations in land-use change that could disrupt or shift the designation of road routes.*
FE3	*Cost estimation errors can lead to underestimation of project budgeting*	*12*	***Height***	*Detailed cost calculations must be carried out using the latest unit price database and calculating the inflation risk variables for the materials used. In addition, the projected financing estimates must be reviewed periodically so that the budget posture prepared remains relevant to shifting market dynamics.*
FE4	*Market price changes may affect the project cost budget plan*	*12*	***Height***	*Supervision of material price movements and construction costs should be carried out periodically, accompanied by the allocation of a reserve fund to reduce market volatility. This policy is crucial to maintaining the project's fiscal stability while reducing the risk of a future budget surge.*
FK1	*Lack of coordination and ineffective communication between agencies can hinder the planning process*	*12*	***Height***	*Strengthening coordination between institutions must be pursued through periodic meetings, the establishment of a centralized communication system, and a clear division of authority among relevant parties. This tactical step is oriented to minimize miscommunication while accelerating the pace of policy-making in project design.*
FK2	*Inadequate expert competence can affect the quality of planning*	*12*	***Height***	*The implementation of technical training, strengthening human resource capacity, and standardizing the certification of expertise must be tailored to their respective work domains. Not only that, personnel positions must be based on real competencies to improve the quality of planning outputs significantly.*
FK3	*Poor document control can lead to project administration errors*	*12*	***Height***	*The implementation of administrative governance and an integrated digital-based documentation system is necessary to facilitate project database management. This step must be accompanied by tighter oversight of file storage, circulation, and updates to reduce administrative errors.*
FK6	*Non-compliance with technical standards can lead to errors in project planning*	*12*	***Height***	*Escalation of supervision of the implementation of technical standards and pre-design regulations must be carried out through periodic evaluation and document review mechanisms. In addition, the planning team absolutely masters and applies the applicable technical guidelines to ensure consistency in the quality of planning results.*

Referring to the data compilation in Table 5, 15 threat indicators were found to occupy a high-risk classification, with values distributed in the range of 12 to 16. The mitigation formulation for this high-risk group focuses on strengthening the quality of primary data, improving the accuracy of design calculations, and controlling technical deviations. The concrete steps taken include an in-depth geotechnical investigation, a comprehensive field review, periodic verification of the data's originality, and a thorough examination of the hydrological aspects and waterway systems. Threats originating from natural phenomena are anticipated through mapping the vulnerability levels of areas and applying flexible structural blueprints to local geographical characteristics. This series of actions is expected to minimize the occurrence of design shifts during the physical development phase.

In addition to fixing technical variables, preventive policies also focus on social, financial, and bureaucratic dynamics. Friction related to land acquisition is reduced through a persuasive approach and community polls. At the same time, budget volatility is controlled through the preparation of a logical spending plan and the certainty of financing commitments. In addition, optimizing cross-sectoral work alignment, adopting a centralized filing system, and increasing the capacity of implementing personnel are implemented to maintain the work rhythm of the pre-design phase. Alignment of plans with RTRW documents and periodic review of economic values are also vital instruments in mitigating potential losses.

- *Mitigation of moderate Risk Factors*

Control of medium-level risk groups remains crucial to maintaining the stability of secondary arterial road projects. Even if it is not at a critical level, leaving it without an adequate protection scheme can trigger the accumulation of impacts that push the hazard indicator to escalate to high risk. If this level shift occurs in the pre-design phase, the immediate consequence is the emergence of massive obstacles that have the potential to undermine the timeline and the target completion of the overall infrastructure planning.

Table 6 Moderate Risk Mitigation

Code	Assessment Indicators	Risk Assessment	Category Risk	Mitigation Risks
FT5	Errors in determining the type of road pavement used	9	Medium	Calculations for daily traffic volume, the carrying capacity of the base soil, and the estimated life of the construction plan must be completed comprehensively before determining the type of pavement to be applied. In addition, the determination of the pavement structure material must account for fluctuations in surrounding environmental conditions and vehicle load tonnage, so that the operational life of the transportation line is extended and long-term maintenance cost efficiency is achieved.
FL4	Inconsistencies in environmental documents can hinder the project planning process	9	Medium	The accuracy of the preparation of all environmental impact documents must be ensured to align with the corridor of applicable legal regulations, and communication with environmental agency authorities must be strengthened from the earliest stages of the project. In addition, the conditioning of the bureaucratic flow and the completeness of administrative files must be monitored periodically to prevent obstacles to the issuance of permits for project implementation.
FL5	The environmental impact of road construction can cause licensing obstacles	9	Medium	Comprehensive mapping of the consequences of ecosystem damage and the formulation of environmental impact preventive documents must be prepared carefully before entering the stage of applying for a license. Optimizing work alignment with relevant sectoral agencies is also needed to shorten permit processing time, ensuring it runs more efficiently and in compliance with applicable regulations.
FS2	Community rejection of road projects can occur	9	Medium	The escalation of public information disclosure must be sought by socializing a clear understanding of the project's strategic function, the consequences of the construction period, and the scheme for implementing activities in the field to residents. Not only that, the absorption of aspirations and input from the undercurrent community must be well accommodated to foster legitimacy and solid social support for the continued implementation of road construction projects.
FS3	Lack of community participation can affect the quality of planning	9	Medium	The active participation of residents in the structured forum and the formulation of pre-design drafts must be opened up to include the real needs and social dynamics of the community in the field. The involvement of the undercurrent community is crucial for sharpening the accuracy of policy design while mitigating potential social friction in the future.

Code	Assessment Indicators	Risk Assessment	Category Risk	Mitigation Risks
FS4	Lack of socialization of projects can disrupt social activities and increase the risk of social conflict	9	Medium	The implementation of regular socialization of development plans must be conducted through face-to-face forums, the use of digital information channels, and mediation with traditional leaders and local community leaders. This strategy is vital to raising the public's understanding of the project's essence and urgency, so that social resistance can be optimally dampened.
FK4	Changes in government regulations and policies can affect the road planning process	9	Medium	Supervision of the dynamics of changes to laws and regulations must be carried out periodically to align the planning file with the latest legal products from the government. In addition, communication with sectoral agencies must be strengthened so that any regulatory shift can be anticipated and responded to instantly.
FK5	Non-compliance with the RTRW may lead to planning revisions	9	Medium	The synchronization of project designs with RTRW documents must be locked in from the initial conceptual phase, accompanied by tighter coordination with regional authorities and local spatial planning offices. This effort is intended to ensure that all road construction corridors do not trigger anomalies or land-use overlaps.
FL3	Road construction has the potential to cause environmental damage	6	Medium	The operationalization of environmental maintenance must ensure compliance with the AMDAL or UKL-UPL document, and must be accompanied by strict supervision of field activities. In addition, nature conservation must be implemented concretely, including soil erosion mitigation, management of construction material waste, and protection of local vegetation along the project corridor.

Based on the data compilation in Table 6, 9 threat indicators were also identified as occupying the medium risk classification, with values distributed in the range of 6 to 9. The mitigation formulation for the medium-risk group focuses on meeting ecological standards and improving predesign quality. The concrete steps taken include dissecting the volume of vehicle movements and soil-carrying characteristics to determine pavement type, preparing environmental feasibility files in accordance with the legal corridor, and implementing a comprehensive environmental impact evaluation. In addition, AMDAL or UKL-UPL instruments and ecosystem supervision are implemented to ensure that physical design and development activities remain compliant with applicable regulatory provisions.

In the community dimension and in bureaucratic governance, preventive policies are implemented through strengthening citizen involvement, periodic project planning and counseling, and harmonizing work with relevant stakeholders. This strategic effort is projected to reduce the potential for resistance and social friction while fostering community legitimacy for the project's sustainability. At the same time, supervision of the dynamics of changes to laws and regulations, and synchronization with RTRW documents, is carried out on an ongoing basis to maintain the consistency of the planning draft with applicable government and spatial policies.

E. *Risk Acceptance Rate*

Measuring the limit of hazard tolerance is a crucial phase in a series of evaluations to determine the extent to which a threat can be tolerated, conditioned, or requires immediate preventive action.

- *Unacceptable Risk*

The unacceptable classification ranks highest in the tolerance threshold with a risk score weight of ≥ 15. Based on the test results, 4 threat indicators (FT1, FS1, FE1, FE2) were detected, bringing the total to 16. The dimensions of field reality, community friction, and the volatility of budget allocation are the most critical variables in the pre-design stage of the secondary arterial route. This series of problems has a high probability of triggering project timeline delays, geometric design shifts, surging operational costs, and threatening development continuity if optimal governance is ignored. The level of danger in this group confirms that the frequency of occurrence and the scale of the resulting impact are so massive that they can paralyze the course of project planning.

- *Undesirable Risks*

The undesirable classification is for values in the interval $5 \leq X < 15$. From the evaluation calculation, 20 threat indicators were netted (FT2, FT3, FT4, FL1, FL2, FE3, FE4, FK1, FK2, FK3, FK6, FT5, FL4, FL5, FS2, FS3, FS4, FK4, FK5, FL3) with a score weight distribution in a range of up to 12. These field findings prove that all observation dimensions, both technical, ecological, social, financial, and institutional governance, are summarized in this cluster. This condition confirms that the majority of potential obstacles in the design of secondary arterial roads remain at a level requiring continuous control and supervision. Danger indicators include deviations from field survey data, insufficient supply of technical information, fluctuations in land-use change, and weak alignment of work across agencies, which can trigger revisions to draft designs, bureaucratic bottlenecks, and mismatches between technical blueprints and terrain realities. If proper governance is neglected, this pre-design phase is prone to distorting the productivity of physical development execution in later stages. This risk group is still within the control limits. However, it requires close attention because it could trigger major dysfunction in the project planning process if the mitigation scheme fails.

V. CONCLUSION

- The inventory session successfully mapped 24 specific types of risks distributed into five main pillars, covering technical dimensions, environmental aspects, social dynamics, economic conditions, and institutional or organizational governance. Through data dissection, using a risk matrix instrument that combines the probability parameters and impact magnitude for a total of 24 identified variables, 15 high-category or significant risk indicators with fluctuating value distributions were identified, as well as 9 risk indicators included in the medium-level classification with varying score weights.

- The determination of the priority order of hazard management is based on the calculation of the frequency of occurrences and the scale of consequences through the risk matrix methodology. Based on the analysis and evaluation, a mitigation hierarchy was established, with the high-risk group required to receive treatment at the earliest, represented by 4 risk variables with a score of 16, followed by 11 risk variables with a score of 12. The next step is directed to the risk group with a medium category, which includes 8 risk variables with a score of 9 and 1 residual risk variable at 6. Although not included in the classification of significant threats, this medium-level risk group still requires special attention during the infrastructure planning process.

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