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Disaster Mitigation Strategy Based on AS/NZS ISO 31000:2018 in Slum Areas (Case Study: Kampung Lere, Palu City)

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Abstract: The 2018 earthquake, tsunami, and liquefaction resulted in 4.845 people missing or unaccounted for, 4.438 injured, and 212.719 affected and displaced (BPS, Kota Palu dalam Angka). The high number of casualties was certainly not intentional; however, it must be recognized that a lack of disaster preparedness contributed to the increased number of victims. Therefore, the authors researched disaster mitigation variables and formulated strategies based on the AS/NZS ISO 31000:2018 standard. This research was conducted through literature study, field observations, and risk analysis. From field observations, residents of Kampung Lere reported that risk identification scores are still relatively low (1.87), preparedness is moderate (3.32), community participation is low (2.24), and the slum context is moderate (2.79). Meanwhile, according to institutions and community leaders, risk identification is moderate (3.14), risk analysis is moderate (2.79), risk evaluation is moderate (2.79), risk treatment is moderate (3.14), community participation is moderate (3.06), slum context is moderate (2.81), and monitoring and review are moderate (2.94). Based on the risk matrix, several areas require immediate intervention: (a) vital infrastructure, (b) emergency preparedness, and (c) governance weaknesses. Specifically, it was identified that disaster risks in the Kampung Lere area include: (a) earthquakes, (b) liquefaction, (c) tidal flooding, and (d) fires. Thus, the formulated mitigation strategies include implementing strict zoning in accordance with the Disaster-Prone Zone map for new buildings, elevating embankments and improving drainage to handle frequent tidal floods, and enhancing evacuation routes through periodic road maintenance. Based on the AS/SZN ISO 31000:2018 standard, the steps to be taken are: (1) Transformation of the Monitoring and Review System, (2) Strengthening Road and Evacuation Infrastructure, and (3) Integration of Participation and Preparedness.

Keywords: *Disaster Mitigation, Slum Settlements, AS/SZN ISO 31000:2018*

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I. INTRODUCTION

The 7.4 magnitude earthquake caused massive destruction in Palu, Donggala, and Sigi. Buildings collapsed, infrastructure was destroyed, and thousands of lives were buried (Le et al., 2019). Based on data released by the Central Sulawesi Province Central Bureau of Statistics, the number of victims caused by the 2018 earthquake, tsunami, and liquefaction was 4.845 missing and deceased, 4.438 injured, and 212.719 affected and displaced (BPS, Palu City in Figures). The authors recognize that integrated, sustainable strategic steps are necessary to reduce the risk of natural disasters and minimize casualties. In this regard, AS/NZS ISO 31000:2018 serves as a reference for risk management standards, including for earthquake disaster risk management. Implementing AS/NZS ISO 31000:2018 in the context of natural disasters helps organizations and communities identify, assess, and manage disaster-related risks, thereby increasing resilience.

II. LITERATURE REVIEW

➢ *Disaster Mitigation*

According to Law Number 24 of 2007 concerning Disaster Management, Mitigation is a series of efforts to reduce disaster risk, both through physical development and awareness and capacity building to face disaster threats. Mitigation is a crucial step because Indonesia is located between three world plates: Eurasia, Indo-Australia, and the Pacific, posing risks of earthquakes, tsunamis, and volcanic

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eruptions. Specifically, the objectives of disaster mitigation include:

- Minimizing disaster risk
- Serving as a government guide in development planning
- Increasing public awareness about disaster risks
- Increasing public knowledge in facing disaster

➢ *AS/NZS ISO 31000:2018*

AS/NZS ISO 31000:2018 is an international standard that provides principles and guidelines for effective risk management. The 2018 version updates the 2009 edition, with a stronger focus on risk governance, the iterative nature of the risk management process, and the importance of considering external contexts. The main changes in this edition compared to the previous one include:

- A review of the principles of risk management, which serve as the key criteria for its success.
- An emphasis on leadership by top management and the integration of risk management within organizational governance.
- A greater focus on the iterative nature of risk management, acknowledging that new experiences, knowledge, and analyses can lead to revisions of process elements, actions, and controls at each stage.
- Simplification of content with an increased focus on maintaining an open system model to accommodate various needs and contexts.

AS/NZS ISO 31000:2018 establishes the principles of risk management that form the foundation of risk management, such as integration, structure, tailoring, inclusiveness, dynamism, reliance on the best available information, and consideration of human and cultural factors. This standard also provides a comprehensive risk management framework that covers the design, implementation, evaluation, and continuous improvement of the risk management process. In summary, AS/NZS ISO 31000:2018 aims to integrate risk management into strategic and operational management systems.

The goal of risk management is to create and protect value. Its objectives include improving performance, fostering innovation, and supporting the achievement of organizational goals. The principles outlined in Figure 2.4 offer guidance on the characteristics of effective and efficient risk management, highlight its value, and clarify its purpose and objectives. These principles should help organizations manage the impacts of uncertainty on their goals.

The risk management framework is designed to help organizations integrate risk management into significant activities and functions. The effectiveness of risk management depends on its integration into the organization's governance, including decision-making. This requires support from stakeholders, particularly top management. The development of the framework involves integrating, designing, implementing, evaluating, and improving risk management across the organization.

Organizations should assess their risk management practices and processes, identify any gaps, and address these gaps within the framework. The elements of the framework and their interactions should be tailored to meet the organization's specific needs (SNI AS/NZS ISO 31000:2018).

The risk management process involves the systematic application of policies, procedures, and practices to communication and consultation activities, context setting, risk assessment, treatment, monitoring, review, recording, and reporting (SNI AS/NZS ISO 31000:2018). The risk management process involves the systematic application of policies, procedures, and practices for communication and consultation activities, establishing context, and assessing, treating, monitoring, reviewing, recording, and reporting risks.

➢ *Probability Matrix*

A probability matrix is a tool used in risk assessment to determine risk level by weighing the likelihood of an event against the severity of its consequences. It is a simple way to enhance risk visibility and aid in decision-making. This risk analysis helps set priorities and identify the resources needed for mitigation. At this stage, probability and impact matrices are used to map risks based on their likelihood of occurrence and impact (Asnudin, 2018).

Table 1 Probability Matrix

Dampak / Kemungkinan	Sangat Ringan	Ringan	Sedang	Berat	Sangat Berat
Pasti Terjadi	5	10	15	20	25
Hampir Pasti	4	8	12	16	20
Mungkin Terjadi	3	6	9	12	15
Hampir Tidak Mungkin Terjadi	2	4	6	8	10
Sangat Tidak Mungkin	1	2	3	4	5

Source: Asnudin A, et al.

➢ *Risk Acceptance*

We should also understand the theory of Risk Acceptance, as outlined by Godfrey & Espinosa (1996). A risk acceptance strategy is a strategy for accepting risk when there are no other alternatives for avoiding, sharing, or mitigating the risk. After determining the 'risk level,' risks must be categorized to identify those that require immediate attention and those that can be tolerated. In this context, the categorization is as follows:

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Table 2 Risk Acceptance

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

Source: Asnudin A, et al.

An explanation of each category will help clarify the level of disaster risk acceptance involved. The theoretical explanation of risk acceptance by category is as follows:

- *Unacceptable*: extremely severe conditions. The potential for loss of life is very high, and damage is extensive. Immediate preventive measures must be taken.
- *Undesirable*: The risk is fairly high. Serious mitigation planning is needed to prevent it from escalating to an unacceptable level.
- *Acceptable*: The risk is considered within reasonable limits. There are impacts, but the community system is deemed capable of withstanding them.
- *Negligible*: The risk is very small or rare, so it does not require special handling.

III. RESEARCH METHOD

➢ *Research Procedure Details*

- *Preparatory Actions*

Preparations for the analysis of disaster mitigation strategies in slum areas included compiling data on the existing conditions of the research location (from geographic data to population data), the AS/NZS ISO 31000:2018 standard, Palu's urban planning documents, and the disaster preparedness plan.

- *Risk Analysis*

The risk analysis in this study uses the Probability Impact Matrix (PIM) method. PIM is a risk assessment approach that employs two criteria to measure risk, namely:

✓ Probability, which refers to the likelihood that the risk will occur, and

✓ Impact, which refers to the effect on the project if the risk occurs.

The PIM itself is constructed by assigning a risk level to risk variables measured using a combination of probability and impact scales. The PIM calculation formula is as follows:

$$risk\ value = probability\ x\ impact \quad (1)$$

Where:

Risk value = risk severity

Probability = the number of times the event (risk) will occur

Impact = the severity of the consequences (impact) resulting from the risk

➢ *Data Types and Sources*

The data used in this study consists of secondary data obtained from:

- Disaster Event Data in Central Sulawesi;
- PUPR Maps of Central Sulawesi;
- Data on the Geography and Population of Palu City;
- AS/NZS ISO 31000:2018 Document
- Palu City urban planning and disaster preparedness documents
- Road Maintenance Package Documents for the Palu City Area
- Field Observations

Based on Palu Mayor's Decree No. 663/DPKP PERUMAHAN/2022 regarding the Location of Slum Housing and Slum Settlements in Palu City in 2022, the profile of the Slum Area in Lere Village is as follows:

Table 3 Data on Lere

Province	:	Sulawesi Tengah	Decree Area	:	5,69 Ha
City	:	Kota Palu	Verified Area	:	5,69 Ha
District	:	Palu Barat	Number of Buildings	:	180 units
Subdistrict	:	Lere	Population	:	646 people
Area	:	Lere	Number of Households	:	180 people

Source: Palu Mayor's Decree No. 663/DPKP PERUMAHAN/2022

Therefore, with an estimated population of 646 people, a sample is required using the Slovin formula as follows:

$$n = \frac{N}{1 + N\ .\ e^2}$$

$$n = \frac{646}{1 + 646\ .\ 0{,}10^2}$$

$$n = \frac{646}{1 + 646\ .\ 0{,}01}$$

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$$n = \frac{646}{1 + 6{,}46}$$

$$n = \frac{646}{7{,}46}$$

$$n = 86{,}595 \approx 87\ people$$

The sample was then selected randomly according to the following criteria:

- 60% of Kampung Lere residents, equivalent to 52 people
- 25% from the Palu City government, equivalent to 22 people
- 15% NGOs, equivalent to 13 people.

➢ *Research Variables*

Research variables are attributes or characteristics of a group of objects that are the focus of the study and that distinguish one object from another. This study focuses on disaster mitigation planning and road maintenance based on the risk management methods outlined in AS/NZS ISO 31000:2018. The variables in this study are as follows: (1) Risk Identification, (2) Risk Analysis, (3) Risk Evaluation, (4) Risk Treatment (Mitigation), (5) Disaster Preparedness, (6) Community Participation, (7) Slum Context, and (8) Monitoring and Review.

IV. RESULT AND DISCUSSION

➢ *Analysis of Research Information and Data*

Based on the processed data for the two sample groups (residents and institutions/practitioners), the mean values were compared across four key indicators: risk identification, preparedness, community participation, and the context of slum settlements. Descriptively, there was a slight difference in the mean values between the two groups. Group 1 had an advantage in preparedness (3.31) and community participation (2.92). Conversely, Group 2 had slightly higher mean scores for risk identification (2.65) and slum context (2.97).

➢ *Disaster Risk Assessment in Kampung Lere*

The disaster risk assessment was conducted by identifying, classifying, and evaluating risks through several steps, namely:

- *Hazard Assessment*

The hazard index assessment was compiled based on data and historical records of events that have occurred in the city of Palu, specifically in the Kampung Lere area. Hazards can be caused by natural or human factors, such as earthquakes, tsunamis, volcanic eruptions, floods, and landslides. The Kampung Lere area, located within a 2-kilometer radius of Talise Beach, faces the threat of natural disasters such as tsunamis, tidal floods, and potential soil liquefaction. All these hazard threats have been incorporated into the Palu City Disaster-Prone Zone Map issued by the BPBD.

- *Vulnerability Assessment*

Vulnerability refers to physical, sociocultural, economic, and environmental conditions that make a community susceptible to disasters. In the case of the settlement in Lere Village, there are 646 residents, as per Palu Mayor's Decree No. 653/DPKP PERUMAHAN/2022 regarding the Location of Slum Housing and Slum Settlements in the City of Palu in 2022. The area spans 5.69 hectares and contains 180 housing units. The majority of female residents work as homemakers, while male residents work as fishermen, civil servants, or entrepreneurs. This occupational distribution was derived from field observations and research data. Classified as a slum area, it is certain that Kampung Lere as a whole falls into the category of communities vulnerable to disasters.

- *Capacity Assessment*

According to the Central Sulawesi disaster *fact sheet* issued by the Regional Disaster Management Agency (BPBD), the capacity score is 0.340, which indicates a moderate level. This result encompasses regional resilience factors (policies and institutions, education and training, and so on). Meanwhile, based on research findings and data, respondents agreed that policies and training related to disasters and their mitigation in the Kampung Lere area remain severely lacking. Consequently, the area's capacity is still classified as moderate to low.

- *Risk Assessment and Ranking*

Disaster risk trends are measured based on changes in capacity components. The parameters used in compiling the 2023 disaster risk index are: a) Results of the BNPB disaster risk assessment, b) Base maps from the National Geospatial Information Agency (BIG), and c) BIG administrative boundaries for 2023.

The results obtained by BNPB in 2023 indicate that Central Sulawesi Province experienced a decrease in its disaster risk index, from 143.33 in 2022 to 140.56 in 2023. The disaster risk assessment was conducted by identifying, classifying, and evaluating risks through several steps, namely:

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➢ *Disaster Risk Assessment in the Kampung Lere Area*

The information and research data collected categorize several variables into risk identification, risk analysis, risk evaluation, and risk management.

The following data were obtained from the questionnaire responses:

Table 4 Perceptions of Lere Village Residents

Variable	Average	Categorization
Risk Identification	1,87	Low
Preparedness	3,32	Moderate
Community Participation	2,24	Low
Slum Context	2,79	Moderate

Risk identification falls into the low category. This indicates that residents may not yet fully recognize or deeply understand the potential disaster risks in their environment. Meanwhile, community participation is also in the low category. This suggests that resident involvement in community activities related to mitigation or planning remains suboptimal. The next indicators—preparedness and slum context— both fall into the moderate category. Residents have a sufficient level of preparedness; however, the settlement's slum conditions are still at an average level and require attention.

Tablel 5 Perceptions of Government Officials / Local Community Leaders

Variable	Average	Categorization
Risk Identification	3,14	Moderate
Risk Analysis	2,79	Moderate
Risk Assessment	2,79	Moderate
Risk Management (Mitigation)	3,14	Moderate
Disaster Preparedness	3,26	Moderate
Community Participation	3,06	Moderate
Context of Slum Settlements	2,81	Moderate
Monitoring and Review	2,94	Moderate

Table 5 shows the assessments provided by parties considered to have greater technical knowledge or authority. In contrast to the results based on community survey data, all variables assessed by government officials or community leaders fell into the "moderate" category, indicating that improvements are still needed in these indicators. In the agency's research data and information, there are additional, more complex variables, such as risk analysis, risk assessment, risk mitigation, and monitoring and review. Regarding the variables of disaster preparedness and risk identification, the findings indicate that, according to staff and community leaders, the existing systems are operational but have not yet reached a high or optimal level.

Table 6 Risk Analysis Research Variables

No.	Factor	Likelihood (1-5)	Severity / Impact (1-5)	Risk Score	Notes
1.	**Risk Identification**				

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a.	A disaster risk map is available	3	5	15	**Very Severe**
b.	Type of risks identified	3	5	15	**Very Severe**
c.	Frequency of previous disasters	3	5	15	**Very Severe**
2.	**Risk Analysis**				
a.	There is a formal assessment of the likelihood and impact of risks	3	5	15	**Very Severe**
b.	Historical disaster risk data is available	3	5	15	**Very Severe**
3.	**Risk Assessment**				
a.	There is a risk assessment matrix	5	5	25	**Very Severe**
b.	Risk Categorized (high, moderate, low)	5	5	25	**Very Severe**
4.	**Risk Management**				
a.	Roads are repaired periodically	5	5	25	**Very Severe**
b.	The roads made of weather-resistant material	5	5	25	**Very Severe**
c.	Road maintenance budget is available	5	5	25	**Very Severe**
5.	**Disaster Preparedness**				
a.	Evacuation routes are accessible to emergency vehicles	5	5	25	**Very Severe**
b.	Evacuation signs are available	3	5	15	**Very Severe**
c.	Roads prone to flooding or landslides	3	4	12	**Very Severe**
6.	**Community Participation**				
a.	The community participates in mutual aid	2	3	6	**Light**
b.	Mitigation awareness campaigns are conducted periodically	4	4	16	**Severe**
c.	The level of public awareness regarding risks is considered good	4	5	20	**Very Severe**
7.	**Context of Slum Settlements**				
a.	Ideal building density	2	4	8	**Light**
b.	Wide, paved road	2	4	8	**Light**
c.	There is a drainage channel	2	4	8	**Light**
d.	Resident’s income level is considered good	2	4	8	**Light**
8.	**Monitoring and review**				
a.	No regular monitoring schedule	5	5	25	**Very Severe**
b.	No documentation of maintenance activities	5	5	25	**Very Severe**
c.	Changes in risk are not routinely evaluated	5	5	25	**Very Severe**

Table 7 Risk Categorization

Risk Level	Score	Primary Variable
Critical	25	Monitoring, Evaluation, Budget, Evacuation routes
Very high	15 - 20	Public awareness, risk maps, historical data
Moderate/Low	6 - 8	Community cooperation, drainage conditions, community income

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The weakest points were identified in road evaluation and improvement. Indicators such as the availability of an evaluation matrix and a road maintenance budget achieved a maximum score of 25. Meanwhile, the lack of a regular monitoring schedule and the absence of routine evaluations of risk changes significantly contributed to a "very high" risk score (25). Additionally, initial identification processes such as risk maps, disaster frequency, and formal assessments have a risk value of 15 (very high). This indicates that, while baseline data may exist, the urgency and impact remain critical. There is also a positive contrast in community participation (gotong royong), which is still classified as low, with values ranging from 6 to 8.

The current state of disaster mitigation in Lere Village is dominated by high-level risks in the managerial (monitoring) and physical infrastructure (roads) aspects. Although the residential environment and community participation aspects show relatively safe (Low) scores, these are not strong enough to compensate for weaknesses in the early warning system and maintenance of evacuation facilities. Overall,

The majority of indicators fall into the Very Severe category, with the highest risk score reaching 25. This indicates systemic vulnerabilities in the area's infrastructure and risk management.

➢ *Disaster Mitigation Strategy in the Kampung Lere Area*

Based on AS/NZS ISO 31000:2018, the first step is to define the scope, context, and criteria. The objective is to tailor the risk management process, enable effective risk assessment, and ensure appropriate risk treatment. In this case, the local government or administrators must consider both the internal and external contexts. The internal context consists of the maintenance budget, equipment availability, and human resources. Meanwhile, the external context includes the region's geological conditions, rainfall levels, and traffic volumes.

Table 8 Risk Analysis of Disaster Types in Lere

Disaster Type	Probability (Frequency)	Impact (Severity)	Risk Level	Notes
Earthquake	Almost Certain	Very High	**Extremely Severe**	Located near the Palu-Koro Fault; very high risk of structural damage
Liquefaction	Possible	Very High	**High**	The soil in Lere has high water saturation (coastal), making it prone to subsidence
Tidal Flooding	Certain to Occur	Moderate	**Severe**	Occurs periodically during high tides, exacerbated by post-2018 land subsidence
Wildfires	Possible	Moderate	**Moderate**	Related to densely populated settlements and poorly organized electrical installations

V. CONCLUTION

Based on the framework of AS/NZS ISO 31000:2018, it can be concluded that the appropriate mitigation strategies are as follows:

➢ Transformation of the Monitoring and Review System,
➢ Strengthening Road Infrastructure and Evacuation, and
➢ Integration of Participation and Preparedness

To achieve maximum, sustainable results, cooperation from various parties is required, including relevant agencies, community leaders, and residents.

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