ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul738

Disaster Risk Analysis of Educational Facility Buildings Based on Iso 31000:2018 (Case Study of Educational Facilities in Palu City)

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Publication Date: 2026/07/25

Abstract: Palu City is an area with a very high level of disaster vulnerability due to its location on the Palu Koro Fault line and its potential for tsunamis and liquefaction. The earthquake, tsunami, and liquefaction disaster on September 28, 2018, caused damage to more than 1,100 educational facilities. This study aims to identify and analyze disaster risks in educational facilities in Palu City, assess the level of risk based on the ISO 31000:2018 approach, and formulate disaster risk mitigation strategies. The research employs a mixed-methods approach combining quantitative and qualitative methods with an explanatory sequential design. Data were collected through observation, questionnaires, interviews, and documentation at three elementary schools in Palu City: SDN 1 Talise, SDN Balaroa, and SD Integral Hidayatullah. The analysis was conducted through risk identification, risk analysis using a risk matrix, risk evaluation, and risk treatment stages. The results identified 24 risk indicators with risk values ranging from 7.28 to 11.89. The highest risks were damage to school facilities due to earthquake ground shaking (11.89), school location in disaster-prone zones (11.32), and tsunami threat (11.22). Most risks fell into the moderate and high categories. Recommended mitigation strategies include developing evacuation SOPs, providing evacuation routes and assembly points, installing evacuation signage, conducting regular disaster simulations, and enhancing the capacity of school community members through disaster education.

Keywords: *Disaster Risk Management, ISO 31000:2018 Standard, School Buildings, Non-Structural Mitigation, Earthquake-Prone Areas.*

How to Cite: Etika Inda Hartina Pangale; Andi Asnudin; Adnan Fadjar (2026) Disaster Risk Analysis of Educational Facility Buildings Based on Iso 31000:2018 (Case Study of Educational Facilities in Palu City). *International Journal of Innovative Science and Research Technology*, 11(7), 1120-1124. https://doi.org/10.38124/ijisrt/26jul738

I. INTRODUCTION

Indonesia is one of the countries with the highest disaster risk levels in the world due to its geological and geographical conditions. Its location lies at the convergence of three major active tectonic plates that interact with one another. This condition results in relatively high intensity and frequency of earthquakes in various regions. The subsequent impacts of such tectonic activities include the potential for tsunamis and liquefaction in coastal areas and alluvial plains (Wekke, 2021).

Data from the National Disaster Management Agency (BNPB) indicates that earthquakes constitute one of the largest sources of economic loss in Indonesia. During the period from 2010 to 2023, the contribution of earthquake-related losses ranked second after floods. These losses encompass building damage, disruption of basic services, and long-term recovery costs (BNPB, 2023). Globally, disaster risk reduction has become a cross-national sustainable development agenda emphasizing the protection of strategic public infrastructure, including educational facilities (Danar, 2020).

Palu City is one of the areas with a very high disaster vulnerability level in Indonesia. The presence of the Palu Koro Fault renders this region highly susceptible to large-magnitude shallow earthquakes. The earthquake, tsunami, and liquefaction event on September 28, 2018, serves as tangible evidence of the complexity of disaster risks in Palu City. More than 4,300 fatalities were recorded in this event, and over 1,100 educational facilities suffered damage across various educational levels (BNPB, 2019).

Disaster risk reduction efforts have thus far focused more on structural building resilience. This approach tends to assess physical building damage without considering the supporting safety systems that play a role in the evacuation process. These non-structural aspects relate to the availability and condition of safety support facilities such as evacuation

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul738

routes, evacuation guidance signage, and the designation of safe assembly points within the school environment (Rachmawati et al., 2018).

The international standard ISO 31000:2018 can serve as a comprehensive framework for managing risks in organizations and public facilities. This standard provides guidance on principles, frameworks, and processes that can be adapted to various contexts, including education (ISO, 2018). Previous research has demonstrated that the application of ISO 31000 in educational institutions can improve efficiency, preparedness, and safety of the learning environment (Hutchins, 2018).

Based on the foregoing description, this study aims to: (1) analyze the process of identifying and analyzing disaster risks in educational facilities in Palu City in accordance with the ISO 31000:2018 stages, (2) assess the level of disaster risk at each school based on the results of the risk matrix analysis, and (3) describe the disaster risk mitigation strategies implemented by schools as part of the risk management system.

II. MATERIALS AND METHODS

➢ *Type and Research Approach*

This study employs a mixed-methods approach (combining quantitative and qualitative data) with an explanatory sequential design (Creswell and Clark, 2014). This approach was chosen to obtain a comprehensive and complementary understanding.

In the first stage, quantitative data were collected through structured questionnaires to measure the level of risk based on respondents' perceptions. In the second stage, qualitative data were collected through in-depth interviews, field observations, and documentation studies to validate and enrich the quantitative findings.

➢ *Location and Time of Research*

The research was conducted at three elementary schools in Palu City: SDN 1 Talise, SDN Balaroa, and SD Integral Hidayatullah. The selection of locations was based on different disaster risk characteristics and the direct impacts experienced during the disaster in Palu City. The research was conducted over a period of 3 months.

➢ *Population and Sample*

The research population consisted of all school community members, including principals, teachers, and administrative staff. Respondents were selected using purposive sampling technique with a total of 30 respondents consisting of 8 males (26.67%) and 22 females (73.33%). Data collection techniques included: (1) questionnaires to measure respondents' perceptions of the likelihood and impact of risks, (2) semi-structured interviews to explore in-depth understanding of disaster risk management, (3) field observations of non-structural mitigation facilities.

➢ *Research Variables and Indicators*

This study employs three main variables to analyze disaster risks in educational facilities in Palu City. The first variable is the type of threat, which includes earthquakes, tsunamis, and liquefaction, where earthquakes are assessed based on the proximity of the school location to the Palu-Koro Fault, tsunamis are assessed based on distance from the coast and site elevation, and liquefaction is identified based on prone zones and the 2018 event history.

The second variable is school location, which includes distance from the coast to determine potential tsunami impact, distance from the active fault to assess potential damage from earthquake shaking, and liquefaction zones to identify whether the school is located in a liquefaction-prone area.

The third variable is non-structural vulnerability, which includes evacuation guidance signage assessed based on its presence, placement, and clarity; assembly points assessed based on area availability, size, accessibility, and location safety; and early warning systems assessed based on equipment condition, operating procedures, and coverage. All indicators in these three variables were measured using a Likert scale of 1-5, where a score of 1 indicates a very low level and a score of 5 indicates a very high level for each parameter assessed.

➢ *Data Collection Techniques*

Data collection was conducted through four techniques. First, questionnaires with a Likert scale of 1-5 were distributed to 30 respondents to measure the likelihood and impact levels of each risk indicator through a series of written questions that respondents were required to answer. Second, semi-structured in-depth interviews were conducted to explore informants' understanding, experiences, and perceptions regarding disaster risk management in the school environment using interview guides flexibly arranged based on the ISO 31000 framework, covering the principal's understanding of earthquake, tsunami, and liquefaction threats around the school location, as well as policies and priorities implemented concerning disaster safety. Third, systematic observations were conducted on the non-structural physical aspects of buildings using observation guides arranged based on ISO 31000 risk management components and the safe school concept, covering evacuation signage (signage presence, clarity of instructions, and physical condition), assembly points (location, area size, accessibility, and safety level), and early warning systems (siren availability, equipment condition, and operating procedures) to obtain actual field data. Fourth, documentation studies were conducted by collecting secondary data from various sources such as BPBD reports related to the 2018 disaster, hazard map data for earthquakes, tsunamis, and liquefaction, and regulatory and policy documents related to disaster preparedness in schools.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul738

- *Instrument Validity and Reliability*

Validity testing was conducted to determine the accuracy level of the research instruments in measuring the variables and indicators used in the study. Validity testing was performed using Pearson Product Moment correlation by comparing the calculated r value against the table r value at a significance level of 5%. With df = 28 (n-2) and $\alpha = 0.05$, the r-table value = 0.361.

The validity test results for the likelihood variable showed that all calculated r values were above the r-table value of 0.361, with calculated r values ranging from 0.537 to 0.917. The validity test results for the impact variable showed that all calculated r values ranged from 0.434 to 0.908. Since all calculated r values were greater than the r-table value, all statement items were declared valid. These results indicate that each statement item is capable of measuring the variables accurately and in accordance with the research objectives.

Reliability testing was conducted to determine the consistency level of the research instruments in measuring the research variables. Reliability testing employed the Cronbach Alpha method with the provision that the instrument is declared reliable if the Cronbach Alpha value is greater than 0.60. The test results showed that the likelihood variable had a Cronbach's Alpha value of 0.971, while the impact variable had a Cronbach's Alpha value of 0.971. Both values were greater than the minimum required value of 0.60. Cronbach's Alpha values approaching 1 indicate that the research instruments have a very high level of internal consistency, thus the research instruments are declared reliable.

- *Data Analysis*

Data analysis in this study refers to the ISO 31000:2018 framework, which emphasizes a systematic process in managing risks, from identification to risk treatment, and was conducted qualitatively and descriptively with simple quantitative support through risk scoring in three stages. The first stage is risk identification to recognize events or conditions that can cause negative impacts on the school environment, covering physical building factors, availability of mitigation facilities, environmental factors, school location characteristics, and preparedness aspects of school community members, assessed based on field observations.

The second stage is risk analysis by calculating the average likelihood and impact values of each risk indicator based on questionnaire results from 30 respondents using a Likert scale of 1-5, then the risk value is calculated using the formula Risk = Likelihood × Impact and the results are mapped into a risk matrix with categories of very low (1-5), low (6-10), moderate (11-15), high (16-20), and very high (21-25) to group risks based on the combination of probability and impact levels to facilitate decision-making.

The third stage is data integration (mixed-methods) by deepening the quantitative findings using qualitative data as the basis for formulating mitigation strategies, which includes risk evaluation by comparing the analysis results against established criteria to determine treatment priorities, and risk treatment through the selection of the most appropriate actions after the risk level is determined.

III. RESULTS AND DISCUSSION

- *General Overview of Research Locations*

SDN 1 Talise is located in Talise Village, Mantikulore District, Palu City. This school is situated in the coastal area of Palu Bay with high tsunami risk and high earthquake risk due to its proximity to the Palu Koro Fault. SDN 1 Talise has 6 classrooms, 1 principal's office, 1 teachers' room, 1 library, 1 health unit room, 2 student toilets, 2 teacher toilets, and 1 storage room. Observation results showed that the only available mitigation facility was an assembly point, while evacuation routes, evacuation signage, and early warning systems were not yet available.

SDN Balaroa is located in Balaroa Village, West Palu District, Palu City. The Balaroa area is known as one of the areas that experienced the greatest impact from the 2018 earthquake and liquefaction disaster. SDN Balaroa has 6 classrooms, 1 principal's office, 1 teachers' room, 1 library, 1 health unit room, 1 student toilet, and 1 teacher toilet. Observation results showed that the school already has all the necessary disaster mitigation facilities, namely evacuation routes, assembly points, evacuation signage, and early warning systems.

SD Integral Hidayatullah is located in Tondo Village, Mantikulore District, Palu City. This school is situated in a densely populated settlement near the active fault line. SD Integral Hidayatullah has 12 classrooms, 1 principal's office, 1 teachers' room, 1 library, 1 health unit room, 1 student toilet, and 1 teacher toilet. Observation results showed that of the four mitigation components assessed, only an assembly point was available, while evacuation routes, evacuation signage, and early warning systems were not yet available.

- *Respondent Characteristics*

The respondents in this study numbered 30 people from three schools. Based on gender, male respondents numbered 8 people (26.67%) and female respondents numbered 22 people (73.33%). The number of female respondents was more dominant than male respondents, indicating that the majority of educators and education staff who served as respondents were predominantly female.

Based on age, there were no respondents in the age group under 30 years (0%). Respondents in the 30-39 age group numbered 7 people (23.33%), the 40-49 age group numbered 11 people (36.67%), and the $\geq$ 50 age group numbered 12 people (40.00%). The $\geq$ 50 age group was the largest age group, indicating that most respondents have relatively long work experience in the school environment, thus expected to be able to provide better assessments of disaster risk conditions in educational facilities.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul738

➢ *Risk Identification*

Based on the results of field observations, interviews, and document studies, 24 risk indicators were identified that have the potential to affect the safety of school community members. These risks were grouped into four categories: (1) disaster risks (7 indicators) covering earthquake, tsunami, and liquefaction threats; (2) evacuation signage and routes (6 indicators); (3) assembly points and early warning systems (6 indicators); and (4) evacuation procedures and drills (5 indicators).

Observation results showed that SDN Balaroa already has all disaster mitigation facilities (evacuation routes, assembly points, evacuation signage, and early warning systems), while SDN 1 Talise and SD Integral Hidayatullah only have assembly points and do not yet have other mitigation facilities. This condition indicates a preparedness gap between schools that requires attention.

➢ *Disaster Risk Analysis*

The risk analysis results showed risk values ranging from 7.28 to 11.89. All risk values fell into the moderate to high categories, with details presented in Table 1.

Table 1. Risk Analysis Results

Risk Code	**Risk**	**Risk Score**	**Category**
P2	Damage to school facilities due to earthquake shaking	11,89	Tinggi
P5	School location in disaster-prone zone	11,32	High
P3	School affected by tsunami	11,22	High
P1	Location with earthquake potential due to Palu Koro Fault	10,98	High
P7	Location in liquefaction zone	10,89	High
P6	Damage to facilities due to tsunami	10,23	High
P14	No safe assembly point available	9,7	Moderate
P8	No adequate evacuation signage available	7,28	Moderate

The highest risk was damage to school facilities due to earthquake shaking (P2) with a value of 11.89. This indicates that the earthquake threat remains the top priority.

➢ *Risk Matrix and Risk Evaluation*

Based on the mapping in the risk matrix, all risk indicators were in the moderate and high categories. There were no risk indicators in the low or extreme categories. High-category risks (P2, P3, P5, P6, P7) were all related to natural disaster threats due to geographical conditions, while moderate-category risks were mostly related to non-structural preparedness aspects. The high-risk category indicates that if adequate control measures are not taken, the consequences can have a major impact on school operations and the safety of students, educators, and education staff. Within the ISO 31000:2018 framework, risks with high levels require immediate risk treatment through the implementation of mitigation measures appropriate to the characteristics of the identified risk sources.

		Impact				
		1 Very Low	2 Minor	3 Moderate	4 Severe	5 Very Severe
Likelihood	1 Very Rare					
	2 Rare		P8	P11, P12		
	3 Possible		P9, P19	P1, P4, P10 P13, P15, P16 P17, P20, P21, P22	P2, P3, P5 P6, P7	
	4 Frequent			P14, P18, P23, P24		
	5 Frequent					

Fig 1. ISO 31000:2018 Risk Matrix

The evaluation results indicate that the factor of school location concerning earthquake, tsunami, and liquefaction threats remains the primary source of risk. Non-structural preparedness aspects such as evacuation routes, assembly points, early warning systems, disaster SOPs, and disaster drills also require serious attention.

➢ *Risk Mitigation Strategies*

Risk mitigation strategies were developed based on risk priority levels. For high-category risks, recommended strategies include: (1) regular inspection and maintenance of school facilities and securing non-structural components, (2) development of school risk maps and updating emergency response plans, (3) provision of evacuation routes to safe areas and installation of evacuation maps, (4) enhancement of

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26jul738

school community preparedness through disaster education and routine drills, and (5) development of specific evacuation procedures for liquefaction hazards.

For moderate-category risks, mitigation strategies include determining and marking safe assembly points, installing easily visible evacuation signage, regular inspection and maintenance of early warning systems, developing disaster evacuation SOPs, conducting regular SOP training and socialization, and conducting disaster drills at least twice a year.

IV. CONCLUSION

Based on the research results, the following conclusions are drawn:

- There are 24 risk indicators that have the potential to affect the safety of school community members during a disaster, including earthquake, tsunami, and liquefaction threats, availability of evacuation facilities, assembly points, early warning systems, and disaster preparedness and evacuation procedures.
- Risk values range from 7.28 to 11.89. The highest risks are damage to school facilities due to earthquake shaking (11.89), school location in disaster-prone zones (11.32), and tsunami threat (11.22). Most risks fall into the moderate and high categories.
- Recommended mitigation strategies include enhancing school community preparedness through disaster education, developing and implementing disaster evacuation SOPs, providing safe evacuation routes and assembly points, maintaining early warning systems, conducting regular disaster drills, and strengthening coordination between schools, BPBD, and relevant agencies.

ACKNOWLEDGMENT

The authors express their gratitude to Dr. Andi Asnudin, ST., MT as the primary supervisor and Dr. Ir. Adnan Fadjar, ST., M.Eng.,Sc as the co-supervisor for their guidance and direction throughout the research. Appreciation is also extended to the Principals of SDN 1 Talise, SDN Balaroa, and SD Integral Hidayatullah, along with all teachers and staff who provided permission and participation in this research. Thank you to all respondents who were willing to take the time to complete questionnaires and provide valuable information for this research.

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