

Tourist Safety Risk Management at Piala Waterfall Banggai Regency, Indonesia: A HIRARC-Based Analysis

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Article History	Abstract
Received: 20 April 2026 Accepted: 29 May 2026 Published: 27 June 2026	<p><i>The fast-growing nature-based tourism in Indonesia is not accompanied by academic research. Recent academic research has focused more on destination development and visitor satisfaction, leaving a large gap in research on technical safety assessment and hazard management in natural environments. The current research fills this gap by providing a systematic safety risk analysis at the Piala Waterfall, Banggai Regency. The study was carried out in December 2024 using a qualitative descriptive design. Data were collected through field observation and in-depth interviews with three key informants: destination managers and workers. The novelty of this research lies in the specific application of the Hazard Identification, Risk Assessment and Risk Control (HIRARC) framework, which is typically used in an industrial setting, to the unpredictable and dynamic environment of a waterfall destination. The study found that the most 'Extreme' risks stem from natural factors and visitor behaviour, whereas 'High' risks are attributed to infrastructure deficiencies such as messy steps. The theoretical contribution is the adaptation of the semi-quantitative safety science models to nature-based tourism to fill the gap between hydrological hazards and administrative management. On the practical aspect, the research offers a blueprint for the local authorities on the implementation of engineering and administrative controls such as consistent safety signage and seasonal closures to improve the sustainability and resilience of the destination.</i></p> <p>Keywords: <i>tourist safety, risk management, hirarc, piala waterfall, nature-based tourism</i></p>



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INTRODUCTION

Tourism risk management has received increasing attention in international research due to the vulnerability of tourism destinations to environmental, operational, and anthropogenic hazards. It is widely known that one thing about the tourism industry is that it is very vulnerable to risks, and the risks may lead to injuries, spoilage of reputation, or even unsustainability of the site (Li et al., 2024). In the event of escalation of such risks into a crisis, the effects would go beyond physical damages and fatalities, extending to the deterioration of destination reputation and declining tourism demand. Such consequences have been proven by past occurrences worldwide. For instance, the September 11 attacks in 2001 greatly affected the tourism industry in the United States and contributed to a global decline in travel (Akram et al., 2024). Likewise, the 2003 outbreak of Severe Acute Respiratory Syndrome (SARS) resulted in a decline in foreign tourist numbers, recording one of the few periods of negative growth in decades (Shahzad et al., 2022). More recently, the COVID-19 pandemic has severely disrupted the global tourism system, nearly halting travel activities and leaving a long-lasting

effect on the industry (Lee & Chen, 2020). From all these incidents, it can be seen how vulnerable the tourism industry is, and there is a need for systematic approaches toward risk assessment and management to ensure sustainability.

Tourism activities inherently involve exposure to danger as they can be affected by crises or a disasters, transforming hazards into risks for all stakeholders (Arbulu et al., 2021; Zou & Yu, 2022). Hazards can be objects, events, natural or human-made phenomena, or human activities that inherently have the potential to disrupt conditions that would otherwise proceed normally (Evianny & Sutiyo, 2023). Destination managers should adopt appropriate risk management procedures to protect tourists consequently (Bong, 2019), as tourists consider risk when visiting (Wulandari et al., 2022). Recent research has examined several aspects of tourism risk and it has been argued that they not just associated with natural elements or weather but also lack of proper infrastructure and safety measures or even the tourists themselves. As an example, research on trekking and adventure tourism shows that activities in natural environments inherently involve higher uncertainty, and systematic risk assessment frameworks are needed to ensure safety (Xuemei et al., 2024). According to Ural (2016), the risk management process in the tourism context involves planning and executing the impact of crises and disasters on the industry.

Banggai Regency within the Province of Central Sulawesi holds considerable tourism potential. There are 171 attractions within Banggai that range from nature, heritage, and religion and even man-made attractions (BPS Banggai Regency, 2026). Among these, one of the natural attractions visited by many visitors is Piala Waterfall in Hanga-Hanga Village, South Luwuk District. Nature tourism, especially waterfall tourism, is rapidly gaining popularity since it offers scenic views and outdoor activities. Piala Waterfall is widely known for its beautiful tiered waterfall with a well-maintained nature view. It attracts visitors both locally and regionally (Lestari, 2026). However, the features such as steps and slippery stones along natural pathways pose safety hazards. Visitors engage in activities such as swimming and exploring, increasing the probability of accidents like slipping, drowning, and injuries caused by natural environment (Daniswari, 2024; Sulteng Terkini, 2018).

In light of these issues, proper management of tourists' safety is crucial for the sustainable management of tourism destinations. Safety not only affects the health of the visitors but also the destination's reputation, visitor satisfaction, and likelihood of returning. Failure to identify and manage risks can cause reputational damage and loss of revenue. Previous studies on waterfall tourism destinations (Porajow et al., 2025) and other forms of nature attractions (Megantara & Zahran, 2025) reveal that safety standard operating procedures (SOPs), evacuation routes, risk information signs, training of destination managers, and monitoring of tourist activities are vital in managing risks at nature-based destinations. Several studies conducted in Indonesian waterfalls focus on carrying capacity (Laksapriyanti et al., 2020), tourism potentials (Putri et al., 2020), and tourists' perceptions (Pantiyasa et al., 2018), with minimal concern to risk management. On that note, this study intends to fill the research gap while appreciating the fact that with increasing popularity of natural attractions come increased risks without improved safety and risk mitigation systems (Prameswari et al.,

2023). Therefore, a study on tourist safety risk management, especially at Piala Waterfall in Banggai Regency, is important to provide an empirical basis for the development of safer and more professional tourism management policies.

This study aims to identify tourist safety risks in Piala Waterfall through risk management analysis. To be specific, this research is guided by the following research questions: (1) what are the safety hazards associated with tourist activities at Piala Waterfall? (2) how risky are the hazards in terms of probabilities and severity? (3) how have the risks been controlled by the destination management and how successful have the measures been? (4) are there other risk management strategies that could be suggested to ensure safety of tourists? By addressing these questions, the purpose of this study is to provide a thorough understanding of tourist safety risks and offer practical recommendations for effective risk management at Piala Waterfall.

RESEARCH METHOD

This study adopted a qualitative research design using descriptive approach to investigate tourist safety risk management at Piala Waterfall. The research was conducted in December 2024. The qualitative research methodology was selected to provide a deeper understanding of field conditions, hazard characteristics, and destination management's risk control practices. The study focused on Piala Waterfall to explore safety risks in detail within a nature-based tourism context.

This study involved three key informants who were directly involved in the site's management and operations. They were selected through purposive sampling based on these criteria: (1) they actively work at Piala Waterfall, (2) they are involved in daily operations and visitor management, and (3) they have knowledge of safety practices and past incidents at the site. Selecting three informants is considered appropriate in qualitative research, as the study prioritizes depth of information rather than quantity of respondents. In addition, these informants hold essential roles at the destination and provide relevant and experience-based insight. The study focuses on the identification of hazards, the evaluation of risk levels, and the assessment of risk control measures related to the tourist activities at Piala Waterfall. The research variable includes tourist safety risk management, which will be measured by the hazard identification, risk assessment, and risk control.

Techniques of data collection are field observation and in-depth interviews. The structured HIRARC (Hazard Identification, Risk Assessment, and Risk Control) tool is used in observations to systematically identify tourist activities, hazards, potential impacts, and existing controls. On-site observations cover the physical conditions, infrastructure, environmental features, and tourist activities. On the other hand, in-depth interviews with the informants validate the information collected during the observation by interviewing the key informants about hazards, and risk control measures.

The process of analysing data followed several systematic steps. The first step involved organizing the observational data into categories depending on the activities and associated hazards. Secondly, all identified hazards were analysed according to the HIRARC framework

where probability (P) and severity (S) values were assigned depending on the field observations, occurrence frequency, and potential impacts. In the third step, the risk levels were calculated by combining these scores and categorized according to the Australian/New Zealand Standard for Risk Management (AS/NZS 4360:2004). Finally, qualitative data collected through interviews was analysed thematically.

To ensure data validity and credibility, this study used triangulation techniques, including (1) data triangulation by comparing findings from observation and interviews, and (2) source triangulation by cross-checking information among informants. In addition, member checking confirmed key findings and interpretations with informants to ensure data accuracy. The researchers maintained detailed field notes and documentation to ensure transparency and reliability in the analysis.

RESULT AND DISCUSSION

The area of Piala Waterfall has a well-preserved natural environment with minimal human impact, creating a peaceful setting and lush greenery. The main feature is a tiered waterfall that forms a natural cup shape, making it a major draw for visitors. However, while it is visually appealing, the physical and environmental traits also pose serious safety risks. These risks stem from flowing water, elevation changes, and uneven surfaces. Visitors often find themselves near these dangerous spots. This shows that tourist behaviour can expose them to environmental dangers, especially during busy times like weekends.

This study involved three key informants whose input is crucial to the day-to-day operation of the site. They did not just provide information as respondents, but also acted as verification sources. They confirmed the hazard identification and risk assessment from field observations and shared insights into current risk management practices. Their participation enhances the reliability of the findings by ensuring that identified risks reflect real conditions. Below are the profiles of the research informants as provided in Table 1.

Table 1. Informants Profile

No.	Name	Age (year-old)	Position	Length of Service (years)
1.	Mr. S	35	Tour Guide	3
2.	Mr. A	22	Member of Pokdarwis	3
3.	Mr. Y	44	Parking Lot Attendant	3

Source: Researchers, 2026.

A. Risk Identification

The field observation revealed several activities commonly carried out by tourists during their visit to Piala Waterfall. Based on these activities, potential hazards and their possible consequences/risks were identified, particularly in the absence of preventive and risk-control measures, as presented in Table 2.

Table 2. Risk Identification and Its Impacts

Tourist Activity	Potential Hazard / Environmental Aspect	Risk / Consequences
Swimming / playing with water	Strong water current in certain sections	Swept away, drowning
	Slippery underwater rocks	Falling, cuts, bruises
Crossing the wooden bridge	Wet wooden surface due to water splashes	Slipping, falling, bruises
	Low or climbable bridge railing	Falling from a bridge into the water
	Overcrowding on the bridge	Structural strain, collision, fall risk
Walking near the waterfall edge	Steep waterfall drops	Swept away, drowning, severe injury
Using the stairs	Uneven step height	Tripping, ankle sprain
	Moss growth on steps	Tripping, falling
Visiting during the rainy season	Sudden increase in water discharge	Flash flood, severe injury
Taking photographs/selfies	Standing on edge rocks or elevated stone steps	Falling from a height, severe injury
	Leaning on the bridge railing	Loss of balance, fall injury

Source: Researchers, 2026.

Based on data obtained from the destination management, there had previously been a drowning incident at Piala Waterfall that resulted in a fatality in 2018. The victim drowned while bathing at Piala Waterfall on Saturday, 10 March 2018, and was not found for approximately three days. The body of the victim, identified by the initial S and originating from Gorontalo Province, was eventually discovered trapped between rocks on Monday, 12 March 2018. According to the Head of the National Search and Rescue Agency (Basarnas) at the time, the incident began when the victim and his companions were on vacation in Luwuk and visited Piala Waterfall (Sulteng Terkini, 2018). This incident shows that the safety risks at Piala Waterfall are not just possible; they have resulted in real accidents. This reinforces the need for organized risk management measures.

B. Risk Analysis

Risk assessment involves translating field observations of potential hazards into findings. The process used the HIRARC form for each tourism activity at Piala Waterfall and compared the results with the Australian/New Zealand Standard for Risk Management (AS/NZS 4360:2004). To determine the risk level, the researchers combined the probability (P) and severity (S) scores. The results of the risk categorization at Piala Waterfall are shown in Table 3. The common formula is:

$$Risk\ Value = Probability\ (P) \times Severity\ (S)$$

Risk assessment was based on two main components: probability and severity (Standards Australia, 2004). Probability (P) refers to how likely a hazard is to occur during tourism activities at Piala Waterfall. This component was measured by looking at actual field conditions and past incidents in the area. The probability scale ranges from 1 to 5. A score of 1

indicates a rare occurrence, 2 indicates an unlikely occurrence, 3 indicates a possible occurrence, 4 indicates a likely occurrence, and 5 indicates an almost certain occurrence. Hazards commonly found in daily tourism activities, such as slippery underwater rocks or strong water currents during the rainy season, received higher probability scores because of their increased likelihood.

On the other hand, severity (S) is described as to the impact or consequences of an event. This reflects the degree of seriousness that may arise from the harm or danger to visitors and the local environment. Similar to probability, the severity levels also range from 1 to 5. Number 1 signifies an outcome that poses no significant consequence, number 2 refers to a minor outcome, number 3 is considered as a moderate outcome, number 4 is a major consequence, while number 5 reflects severe outcomes like serious injuries, drowning, and death. For instance, hazards in Piala Waterfall involving strong currents, high drops, or risky positions near the fall were assigned higher severity levels since they could lead to fatal accidents. The combination of both the probability and severity scores then determines the overall risk level for each identified hazard.

In this study, risk level categories were determined by multiplying the probability (P) and severity (S) scores using the HIRARC method, in line with the Australian/New Zealand Standard for Risk Management (AS/NZS 4360:2004). The resulting risk values fell into four categories: low, medium, high, and extreme. The risk value range between 1 to 4 as low risk, suggesting the hazard has a small chance of occurring and minor consequences. Hence, routine monitoring would suffice in handling these hazards. If a risk value is between 5 and 9, it belongs to a medium risk level, implying that there is an average possibility for the risk to occur and the consequences may be significant and therefore require prevention measures. Risk values between 10 and 16 indicate a high risk, with a significant likelihood of occurrence with potentially serious consequences, requiring immediate control measures and focused management. In case a risk value is evaluated in the range of 17 to 25, it indicates extreme risk, and the consequences might result in severe injury or even death, making it necessary to address it quickly and continuously monitor.

Table 3. Risk Analysis

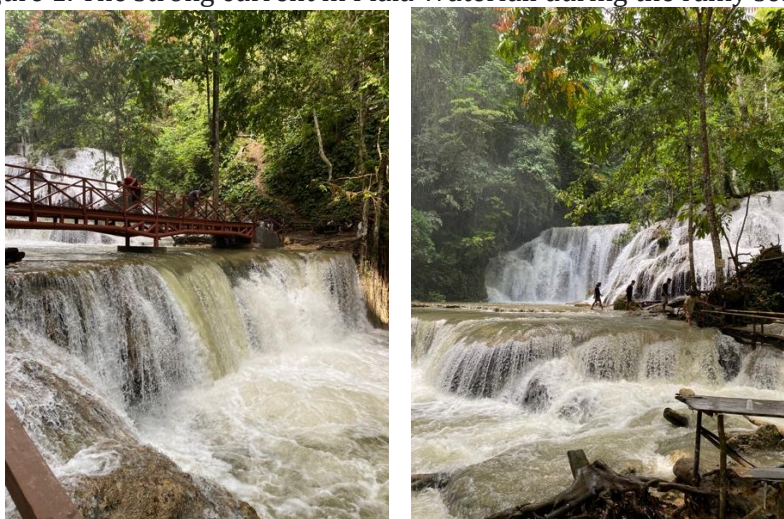
Tourist Activity	Potential Hazard / Environmental Aspect	Risk Analysis			Risk Level
		Probability	Severity	Risk Value	
Swimming / playing with water	Strong water current in certain sections	4	5	20	Extreme
	Slippery underwater rocks	4	4	16	High
Crossing the wooden bridge	Wet wooden surface due to water splashes	3	3	9	Medium
	Low or climbable bridge railing	3	5	15	High
	Overcrowding on the bridge	2	4	8	Medium
Walking near the	Steep waterfall drops	4	5	20	Extreme

waterfall edge					
Using the stairs	Uneven step height	4	3	12	High
	Moss growth on steps	4	4	16	High
Visiting during the rainy season	Sudden increase in water discharge	5	5	25	Extreme
Taking photographs/selfies	Standing on edge rocks or elevated stone steps	4	5	20	Extreme
	Leaning on the bridge railing	3	4	12	High

Source: Researchers, 2026.

The risk assessment revealed that many tourist activities at Pila Waterfall pose extreme risks, such as swimming or playing in strong currents (risk value = 20), visiting during the rainy season (risk value = 25), and taking photos on the edges of rocks or steep stone slopes (risk value = 20). Such activities are classified to the category of extreme risk since there is a great probability of occurrence and their consequences can be severe such as getting drowned, being swept off by the currents, or suffering fatal injuries from falls. It is clear that the presence of high cliffs with steep drops, waterfalls, and rocks covered in slippery algae contributes to these severe risks. This argument is supported by the fact that in 2018, one person drowned due to the described factors.

Figure 1. The strong current in Pila Waterfall during the rainy season



Source: Researchers (2024)

The high-risk category covers activities that can lead to serious injuries but have a slightly lower chance or severity compared to extreme risks. These include slippery underwater rocks during swimming (risk value = 16), low or climbable bridge railings (risk value = 15), uneven stair height (risk value = 12), moss on stairs (risk value = 16), and leaning on a railing while taking photos (risk value = 12). These hazards can lead to falls, cuts, bruises, or, in severe cases, someone falling into the water. The classification of high risk reflects the actual conditions observed at the site, notably the irregular stair construction, wet surfaces, and

the bridge structure that encourages unsafe tourist behaviors, such as climbing or leaning on railings for photos.

Figure 2. The climbable bridge railings and uneven stair height



Source: Researchers, 2024.

The medium-level risks include dangers associated with walking on the wooden bridge over the river. These risks include the danger of slipping on a wet surface caused by water splashes (risk value = 9) and overcrowding (risk value = 8). These risks are considered moderate because slipping on a wet floor or colliding with other visitors happen often enough; however, the consequences are typically not fatal and may only cause minor injuries. Nonetheless, without appropriate management, medium risks have potential to transform into high risks especially during busy periods such as weekends and holidays.

In conclusion, it becomes evident that risks at Pila Waterfall are predominantly high or extreme. Thus, tourist safety management should become a priority in destination management planning. The prevalence of these risk levels underscores the urgent need for preventive measures, such as better infrastructure, warning signs, access restrictions in risky areas, and continuous visitor supervision to minimize accidents and ensure a safer tourism experience.

As previously mentioned, the HIRARC method was adopted to conduct risk assessment where each hazard is given a probability score and a severity rating. This approach is popular due to its practicality, simplicity, and suitability for field assessments where information is limited. By using the HIRARC model at Pila Waterfall, it helps facilitating risk assessment according to observable conditions and expert insight shared by the informants. Nevertheless, this method has limitations that need to be taken into account. The scoring of probability and severity may lead to a subjectivity issue, where researchers and informants' perceptions influence scores rather than objective statistics. As a result, the calculated risk levels might be affected by perception bias and may not fully reflect changes over time, such as seasonal variations in water flow or visitor numbers.

Compared to other risk assessment approaches, HIRARC offers a more qualitative and semi-quantitative view. For example, methods like Failure Mode and Effects Analysis (FMEA)

prioritize risks by considering detection factors, while Quantitative Risk Assessment (QRA) provides numeric estimates of accident probabilities based on historical data and modelling. Additionally, other risk assessment methods such as Bow-Tie Analysis can help establish the cause-and-effect relationships and control measures that exist between hazards and their outcomes. However, these methods usually require more data, technical expertise, and time, which may not be practical for small or developing tourism sites like Piala Waterfall. Consequently, using HIRARC within this research is appropriate in creating an initial and context-specific risk profile. Future studies should consider integrating HIRARC with other approaches in risk assessment that involve numerical calculations or integration processes.

C. Risk Control

The following section presents the results of the risk control analysis and the recommendations proposed by the researchers to Piala Waterfall’s management.

Table 4. Risk Control

Tourist Activity	Potential Hazard	Risk / Consequences	Risk Control
Swimming / playing with water	Strong water current in certain sections	Swept away, drowning	Install warning signs in high-current zones; restrict swimming in dangerous sections; provide lifebuoys and rescue ropes; assign staff supervision during peak hours
	Slippery underwater rocks	Falling, cuts, bruises	Install warning signage; provide non-slip stepping areas where possible; advise visitors to use proper footwear; routine cleaning of moss/algae
Crossing the wooden bridge	Wet wooden surface due to water splashes	Slipping, falling, bruises	Apply anti-slip surface coating; conduct regular maintenance and drying; install “Caution: Slippery Surface” signs
	Low or climbable bridge railing	Falling from a bridge into the water	Increase railing height; reinforce rail structure; prohibit climbing through signage and supervision
	Overcrowding on the bridge	Structural strain, collision, fall risk	Set visitor capacity limit; control visitor flow; place staff to monitor crowd density
Walking near the waterfall edge	Steep waterfall drops	Swept away, drowning, severe injury	Install safety barriers / guardrails; place warning signs; restrict visitor access to dangerous edge zones

Using the stairs	Uneven step height	Tripping, ankle sprain	Repair and standardize stair dimensions; add anti-slip stair strips; provide handrails
	Moss growth on steps	Tripping, falling	Routine cleaning and maintenance; apply anti-slip coating; install caution signs
Visiting during the rainy season	Sudden increase in water discharge	Flash flood, severe injury	Temporary closure during heavy rain; install a weather-based warning system; emergency evacuation procedures
Swimming / play with water	Strong water current in certain sections	Swept away, drowning	Restrict access during high water flow; increase staff monitoring; install floating barriers
	Slippery underwater rocks	Falling, cuts, bruises	Visitor warning signs; restrict barefoot walking; periodic area inspection
Taking photographs/selfies	Standing on edge rocks or elevated stone steps	Falling from a height, severe injury	Designate safe photo spots; restrict access to dangerous edges; install barriers and warning signs
	Leaning on the bridge railing	Loss of balance, fall injury	Strengthen railing; install signage prohibiting leaning; staff supervision

Source: Researchers, 2026.

The results from field observations and in-depth interviews indicate that the management of Piala Waterfall has taken several steps to lower potential hazards and improve tourist safety. One of the main control measures observed is the installation of warning signs in several high-risk areas, especially around slippery pathways, waterfall edges, and areas with strong water currents. These warning signs serve as an administrative control by informing visitors about potential dangers and encouraging safer behavior during their activities.

This result corresponds with practices observed at Guyangan Waterfall (Suprastayasa et al., 2025) and Coban Lanang Waterfall (Akbar & Adnyana, 2024), where the use of similar signs warns visitors about cliff and tide hazards. Besides that, the limited use of warning signs for mossy walkways and railings at Curug Seribu waterfalls (Agustin & Chisco, 2025) also indicates the practice adopted by Piala Waterfall. This emphasizes that while signage is standard, it requires better placement. This consistency is seen in Upang River conservation areas (Pusparini & Lestari, 2024) and Bali tourism policies (Dewi et al., 2025), where destination managers pair signs with monitoring or barriers. This validates Piala Waterfall's efforts and highlights the need for additional improvements.

In addition to warning signs, this study also found that the management has introduced a temporary closure policy as an important strategy to reduce risk, especially during bad weather. Piala Waterfall often closes during heavy rainfall or when water discharge increases

significantly. Under these conditions, the water usually becomes cloudy, indicating stronger currents and reduced visibility, which increases the risk of accidents such as slipping, drowning, or being swept away.

This finding is in agreement with previous studies on tourism risk management and destination resilience. Previous research indicates that temporarily closure of tourism sites during heavy rainfall or flooding is an effective preventive strategy to reduce tourists' exposure to hazards and is part of administrative and risk elimination controls (Lohmann et al., 2026). Similarly, research on tourism crisis and disaster management has demonstrated that destination closures during environmental disruptions are essential components of preparedness, response, and recovery strategies in risk management frameworks (Liu et al., 2024). It is clear that studies on tourism safety policy and sustainable public management reveal that infrastructure improvements, including safe pathways, stronger bridges, and improved visitor amenities, significantly reduce accident risks and strengthen tourists' sense of safety (Dewi et al., 2025; Lohmann et al., 2026). Hence, the research findings clearly validate the existence of evidence that proactive closure strategy is a key element in the safety risk management process within nature-based tourism destinations.

Figure 3. warning signs in several high-risk areas



Source: Researchers (2024)

Based on the researchers' literature review, the closure policy has been applied on several occasions. For example, Piala Waterfall was temporarily closed from Monday, 13 May 2024, until Sunday, 19 May 2024 due to unfavorable environmental conditions. Moreover, between 5 and 15 December 2024, the destination underwent temporary closure in connection with the development of a new trekking path and bridge, representing a vital engineering control aimed at enhancing the access and safety infrastructure. In addition, on 19 June 2025, the destination experienced temporary closure in order to repair the waterway and dam infrastructure in relation to engineering and infrastructure risk control strategy employed by the destination's management. Access to the waterfall was also temporarily closed again on

Monday, 30 March 2026, due to the increased water discharge (Alisan, 2026; Jajad, 2026). These periodic closures effectively reduce risk and maintain control by preventing tourists from encountering dangerous conditions during high-risk periods. The implementation of this measure indicates that the management understands the importance of addressing risks to keep visitors safe and ensure the destination remains sustainable.

However, many tourism activities at Piala Waterfall are still classified as high to extreme risk, indicating that more control measures are needed. For example, engineering controls, such as higher bridge railings, anti-slip stair surfaces, stronger handrails, designated safe photo zones, and physical barriers near steep edges have not been adequately implemented according to field observations. Additionally, operational measures such as ongoing staff supervision, visitor capacity management, emergency rescue equipment, and formal standard operating procedures (SOPs) need improvement. Thus, while the existing practices of risk management are rather good and effective, they should be complemented with more infrastructure-based measures aimed at increasing the tourists' safety.

The safety risks assessment at Piala Waterfall uncovered several extreme hazards, particularly during the rainy season (risk value = 25) and when tourists engage in risky behaviours like taking selfies on elevated stone steps or standing on edge rocks (risk value = 20). These results are corresponded by international data, including the North Carolina's 13-year study stated that "unsafe acts," such as dangerous photo shoots near waterfalls resulted in many deaths. (Attarian, 2015). While this study highlighted such dangers as slippery rocks and uneven stair height levels, similar findings from the Peneda-Geres National Park found out that slipping and falling accidents were the most common accident due to challenging weather conditions and hilly landscape (Silva, 2025). At the same time, the absence of proper safety regulations and resorting to informal management of tourism, which is typical for such other places in Indonesia as the Bogor's Ciahisan Tourist Village, proves the necessity of implementing a more formalized HIRARC analysis model, as applied in this research (Agustin & Chisco, 2025). Another evidence supporting the idea of the need for better physical facilities is related to findings made in Gianyar Regency that ponted to insufficiently tall bridge railing and lack of proper safety signage (Dharmayanti et al., 2023). Finally, these studies emphasize that any nature-based destinations is required to have not only engineering controls but also appropriate risk management in response to inherent risks associated with the waterfall (Sarkodie et al., 2023).

The main contribution of this study is its context-specific use of the HIRARC framework in a natural tourism destination, particularly in a local area where studies on tourist safety risk are limited. Unlike previous studies that focused on tourism potential or visitor satisfaction, this study offers a thorough analysis of hazard identification, risk classification, and control measures in the context of waterfall tourism. In addition, this research contributes to the broader discourse on sustainable tourism by demonstrating that tourist safety is a key component of destination sustainability, shaping visitor protection, the destination's image, trust, and long-term viability.

CONCLUSION

This study concludes that Piala Waterfall poses several potential hazards that could threaten tourist safety, especially during activities, such as swimming, crossing the wooden bridge, walking near the edge of the waterfall, using the stairs, visiting during the rainy season, and taking photos in elevated or risky areas. Using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method, the study found that most hazards fall into the high and extreme risk categories, particularly those related to strong water currents, steep waterfall drops, slippery surfaces, and sudden increases in water flow during rainy periods. The findings also indicate that the destination management has undertaken different actions to control the risks; for instance, warning signs, temporary closures of the destination due to hazards, and shutdowns of the destination to improve infrastructural aspects.

The practical implications of this research serve as a useful reference for destination managers and local government authorities to improve safety standards for tourists. The study offers practical suggestions, such as enhancing physical infrastructure, improving bridge and stair safety, adding more warning signs, creating safe photography zones, restricting access in high-risk areas, and establishing standard operating procedures (SOPs) for emergency response and temporary closures during bad weather. Thus, the proposed recommendations are aimed at improving management practices and making them more efficient in terms of providing safety tourists. In addition to these practical findings, the study provides a significant theoretical contribution. Firstly, it shows how principles of industrial safety frameworks could be applied to tourism. While traditional tourism research in Indonesia has often focused on marketing and visitor satisfaction, this study offers an interesting approach to understanding tourism through safety science.

The academic importance of this work lies in its establishment as an empirical baseline for tourism risk management in Eastern Indonesia, a region that is often overlooked in safety research. By linking hydrological hazards to visitor behaviour, this study offers a structured approach that other small, nature-based destinations can use to improve their safety management practices. Eventually, it emphasizes the need to blend administrative and engineering controls to uphold destination resilience against inherent environmental risks.

While this study provides a detailed risk profile for Piala Waterfall, it does have several limitations. First, the methodological limitations of the HIRARC framework warrant mention. As a semi-quantitative tool, assigning risk values depends on subjective interpretations of likelihood and severity. This could introduce observers' bias since the data collection came from the researchers' direct observations of site conditions and tourist behaviours during certain times. These observations may not reflect all the hazards present during rare or extreme weather events.

Furthermore, it is important to mention that the present study does not include longitudinal analysis, so the risk assessment represents a "snapshot" of the current conditions. Future studies should take into account perspectives from multiple stakeholders, including quantitative hydrological modelling and surveys from a wider range of tourists, to confirm these findings and reduce researchers' bias. Expanding the scope to include other waterfalls in

the Banggai Regency would also provide a better comparative understanding of regional safety standards.

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