

Risk Identification and Safety Assessment in Kemuning Sky Hills Tourism Area

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Abstrak

Kemuning Sky Hills merupakan salah satu objek wisata alam di Kabupaten Karanganyar yang menyajikan berbagai wahana ekstrem seperti jembatan kaca, ayunan langit, flying chair, dan sepeda terbang. Meskipun menarik minat wisatawan, tingkat risiko keselamatan pada wahana-wahana tersebut belum terkelola secara optimal. Penelitian ini bertujuan untuk menilai risiko keselamatan menggunakan metode Hazard Identification, Risk Assessment, and Determining Control (HIRADC) dan memberikan pemahaman yang lebih mendalam tentang pentingnya analisis risiko keselamatan di destinasi wisata ekstrem. Penilaian risiko dilakukan berdasarkan Australian Standard HB 205-2004. Data dikumpulkan melalui observasi langsung, wawancara dengan petugas dan pengunjung, serta dokumentasi lapangan. Hasil penelitian menunjukkan bahwa terdapat beberapa potensi bahaya yang masuk kategori High Risk hingga Extreme Risk. Terdapat 10 risiko dengan kategori High Risk dan 4 risiko dengan kategori Extreme Risk. Risiko paling ekstrem yang ditemukan antara lain beban berlebih akibat kepadatan pengunjung dan celah pagar pada Jembatan Kaca, tali sandaran putus pada Ayunan Langit, dan ancaman longsor di area wisata. Pengendalian yang diusulkan mencakup pemasangan jaring pengaman, pemandu tali, rambu peringatan, jadwal maintenance terstruktur dan edukasi. Kesimpulan dari penelitian ini adalah manajemen keselamatan di Kemuning Sky Hills perlu diperkuat melalui penerapan sistem manajemen keselamatan yang terintegrasi dan terstruktur, termasuk prosedur operasional yang terstandarisasi, penilaian risiko rutin, mekanisme tanggap darurat yang jelas, dan pelatihan staf yang berkelanjutan, untuk memastikan lingkungan wisata yang aman dan berkelanjutan secara konsisten.

Kata Kunci: HIRADC, Penilaian Risiko, Risiko Keselamatan, Tourism Safety

Abstract

Kemuning Sky Hills is a natural tourist attraction in Karanganyar Regency that offers various extreme rides, including a glass bridge, a sky swing, a flying chair, and a flying bicycle. Although it attracts tourists, the safety risks associated with these rides have not been optimally managed. This study aims to assess safety risks using the Hazard Identification, Risk Assessment, and Determination of Control (HIRADC) and provide a deeper understanding of the importance of safety risk analysis in extreme tourism destinations. The risk assessment is based on the Australian Standard HB 205-2004 reference. Data were collected through direct observation, interviews with officers and visitors, and field documentation. The results showed that several potential hazards fall into the High Risk to Extreme Risk categories. There are 10 risks in the High Risk category and 4 risks in the Extreme Risk category. The most extreme risks identified include overloading due to visitor density, gaps in the fence on the Glass Bridge, broken ropes on the Sky Swing, and the threat of landslides in the tourist area. Proposed controls include installing safety nets, rope guides, and warning signs, establishing a structured maintenance schedule, and providing education. This study concludes that safety management at Kemuning Sky Hills should be strengthened by implementing an integrated, structured safety management system that includes standardized operational procedures, routine risk assessments, clear emergency response mechanisms, and continuous staff training to ensure a consistently safe and sustainable tourist environment.

Keywords: HIRADC, Risk Assessment, Safety, Tourism Safety

1. Introduction

The tourism industry is now growing rapidly and accounts for almost 10.3% of global GDP, with 7% of total world exports in 2019 (Zheng et al., 2023). As tourism destinations continue to expand in scale and intensity, the growing contribution of the tourism sector to economic development is accompanied by rising pressures on destination management systems (Putri et

al., 2022). One prominent segment of this growth is nature tourism, a form of recreational activity that utilises both natural and cultivated resources to create tourist attractions. This activity offers not only scenic beauty but also a variety of adrenaline-pumping activities, including hiking, camping, and extreme sports. However, behind these attractions lie significant safety risks that often receive insufficient attention. Meanwhile, the

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implementation of Occupational Safety and Health (OHS) in the tourism sector is crucial for minimising the risk of accidents to visitors and workers at tourist sites (Mulasari et al., 2020).

Kemuning Sky Hills is one of the most popular natural tourist destinations in Karanganyar Regency, Central Java. Based on the latest visitor data, Kemuning Sky Hills averages 30,000 tourists per month, with numbers reaching over 3,000 per day during long holidays like Eid al-Adha. The destination, located at an altitude of 1,540 meters above sea level, combined with the variety of extreme rides, increases the potential risk of accidents (Tempo, 2023)

Interviews with visitors indicate that safety facilities and procedures at the site remain inadequate, as evidenced by insufficient protective equipment, unclear operational instructions, and inconsistent maintenance on certain rides, such as the sky swing. These reflect broader deficiencies in safety-related infrastructure, equipment, emergency preparedness, and rescue personnel commonly found in tourist attractions (Saptadi et al., 2022).

Kemuning Sky Hills represents a high-risk tourism system where extreme, height-based attractions operate within a complex topographical and environmental context. This condition underscores the limitations of the existing safety management system and highlights the urgent need for a more robust and risk-oriented approach, particularly in high-risk tourism destinations. Therefore, an effective risk management system is crucial to ensuring tourist safety and supporting the destination's sustainability (Ruiz-Sancho et al., 2021).

In the context of implementation, tourist safety is not only the responsibility of management but also involves field officers and visitors. Visitors are expected to comply with the provided rules and safety instructions. Many tourists take pride in taking selfies in dangerous locations, ignoring the potential dangers to their own safety. Unfortunately, various obstacles remain, including ineffective communication and inconsistent information in the field, which affect the effectiveness of risk management (Aliperti et al., 2020). A more structured risk management system is needed because the rapid growth of Indonesia's tourism industry poses significant challenges to ensuring tourists' comfort and safety (Wirajuna & Supriadi, 2017).

The existing literature on tourism safety in Indonesia has largely focused on general safety implementation, or conventional recreational facilities, with limited attention to systematic hazard identification and risk control for height-based extreme tourism operating in complex topographical environments. By focusing on a high-risk topographical setting, this study aims to provide a deeper understanding of the importance of safety risk analysis in Kemuning Sky Hills.

In extreme tourism, where risks arise from height-based attractions, complex topography, human

behaviour, and environmental exposure, HIRADC is particularly relevant, as it can identify hazard sources, assess risk levels, and determine appropriate, measurable control strategies (Setyawati et al., 2025). The objectives of this study are to systematically identify potential safety hazards, assess the level of risk associated with extreme, height-based attractions, and determine appropriate risk control measures at Kemuning Sky Hills using the HIRADC framework.

2. Research Methods

This research was conducted at Kemuning Sky Hills. The observation area encompassed the entrance and queue, the glass bridge ride, the sky swing, the flying bike, the flying chair, the suspension bridge, and the public area surrounding the rides. The research activities were conducted for four months, from February to May 2025. This research employs a quantitative descriptive approach, utilising the HIRADC method. HIRADC is a commonly used method in occupational and environmental safety studies and is relevant to safety risk management in extreme tourism destinations.

Data collection was conducted through several stages:

- **Field Observation:** Direct observation of the physical condition of attractions, access routes, and the behaviour of visitors and staff at the tourist site.
- **Structured Interviews:** Conducted with operational staff and visitors to obtain qualitative data regarding risk perception, compliance with safety procedures, and incident experiences.
- **Documentation:** Collecting visual evidence (photos, videos) and other supporting data to strengthen the validity of the observation results.

2.1. Risk Assessment

The risk analysis process involves three main stages:

- **Risk Identification:** Identifying all potential hazards that could occur at each attraction or supporting tourist area, including technical, environmental, and human factors.
- **Risk Analysis:** Determining the risk level based on a comparison of likelihood and consequence.
- **Risk Evaluation and Control:** Grouping risk analysis results into four categories: Extreme, High, Moderate, and Low to determine priority control and mitigation actions.

The risk assessment was conducted using the HIRADC framework, assigning likelihood scores from A (Almost Certain) to E (Rare) and consequence scores from 1 (Insignificant) to 5 (Catastrophic) to each

identified hazard, in accordance with AS/NZS 2054:2004. These scores were combined using a risk assessment matrix to classify risks into Extreme, High, Moderate, or Low, which determined the priority of control measures. The assessment involved operational staff and field officers, visitors, and OHS experts to ensure that the risk ratings and control recommendations reflected both technical standards and actual operational conditions at Kemuning Sky Hills.

HB 205–2004 was selected because its flexible likelihood–consequence risk matrix is well-suited to assessing safety risks in dynamic, high-uncertainty environments, making it particularly relevant for extreme tourism conditions in Indonesia. Tables 1 and 2 show the likelihood, consequence, and risk assessment matrix classifications, respectively.

Table 1: Likelihood, Consequence, and Risk Categories

Likelihood	
A	Almost Certain
B	Likely
C	Moderate
D	Unlikely
E	Rare
Consequence	
1	Insignificant - No injuries and no financial loss
2	Minor - Need first aid, moderate financial loss
3	Moderate - Moderate medical care required, 3rd party help, high financial losses
4	Major - Serious injury, loss of production capacity, major financial loss
5	Catastrophic - Serious injury, loss of production capacity, major financial loss
Risk Categories	
E	Extreme Risk
H	High Risk
M	Moderate Risk
L	Low Risk

Table 2: Risk Assessment Matrix

Likelihood/ Consequence	1	2	3	4	5
A	H	H	E	E	E
B	M	H	H	E	E
C	L	M	H	E	E
D	L	L	M	H	E
E	L	L	M	H	H

To ensure the accuracy of the analysis results, method triangulation was conducted. Triangulation was conducted by systematically comparing data from field observations, structured interviews, and documentation to ensure consistency and reduce subjectivity in hazard identification and risk scoring. Validation of the results was carried out through cross-check discussions with operational staff and OHS experts to confirm the accuracy of likelihood and consequence ratings under actual field conditions. The HIRADC method produced clear outputs, including a comprehensive risk register, risk-level mapping for each attraction, and prioritised, measurable control recommendations aligned with the identified risk categories.

3. Results & Discussion

Based on data processing using the HIRADC method, 4 potential risks were identified as Extreme Risk and 10 as High Risk. The predominance of risks in the extreme and high categories indicates the urgency for management to undertake comprehensive improvements immediately, particularly to the main attractions and supporting infrastructure of the tourist area.

The most extreme risks stem from potential infrastructure and equipment failures that can lead to catastrophic consequences (severe injury or death). Extreme risks were identified at three key points: the Glass Bridge (two potential extreme hazards), the Sky Swing (one potential hazard), and the Tourist Area (one potential hazard related to landslides). Table 3 shows the results of the risk assessment.

Table 3: Risk Assessment Result

Attraction/ Location	Extreme Risk	High Risk	Total
Glass Bridge	2	-	2
Sky Swing	1	2	3
Flying Bicycle	-	2	2
Flying Chair	-	1	1
Suspension Bridge	-	2	2
General Area	1	3	4
Total	4	10	14

Glass Bridge (*Jembatan Kaca*)

- Potential Hazards: Overload due to overcrowding and excessively wide gaps in the fence.
- Impact: Broken glass and falls from heights.
- Risk Category: Extreme Risk.
- Controls: Installation of safety nets, use of full-body harnesses, Smart Weighing Access Gates, regular inspections, and modification of the fence design to meet safety standards.

Sky Swing (*Ayunan Langit*)

- Potential Hazards: Breakage of the backrest rope (Extreme Risk), damage to the seat and support beam (High Risk).
- Impact: Fall from a height or structural collapse.
- Risk Category: Extreme and High.
- Controls: Coated steel rope, Load Cell Monitoring System, stainless steel support, anti-corrosion coating, and regular structural inspections.

Flying Bicycle (*Sepeda Terbang*)

- Potential Hazards: Pulley wear and lack of protective helmets.
- Impact: Fall from a height, head injury.
- Risk Category: High Risk.
- Controls: Pulley maintenance, SNI-certified helmets, and staff training.

Flying Chair (*Kursi Terbang*)

- Potential Hazard: Seat belts are not secure enough.
- Impact: Visitors slip and become injured.
- Risk Category: High Risk.
- Control: Seat belt inspections, use of double-lock seat belts.

Suspension Bridge (*Jembatan Gantung*)

- Potential Hazard: Fragile/broken wooden planks and torn safety nets.
- Impact: Visitor falls.
- Risk Category: High Risk.
- Control: Replacement of wooden planks, daily safety net inspections, and net strength testing by operators.

General Area

- Potential Hazards: No safety railings are present at the edge of the cliff; there is no separation between pedestrians and vehicles; exposed power lines are present; and a potential for landslides exists.
- Impacts: Falls, vehicle collisions, tripping, and landslides.
- Risk Category: 1 Extreme risk, 3 High risk.
- Controls: Guardrails and signs, lane separation, cable protection, and LEWS system.

Table 4 presents several mitigation actions prioritised based on the risk level identified in the previous analysis.

Table 4: Action Plan

Attraction / Area	Main Risk	Category	Priority Actions
Glass Bridge	Overload, wide railing gaps	Extreme	Smart Weighing Access Gate, safety nets, acrylic barriers
Sky Swing	Broken seat rope	Extreme	Load Cell Monitoring, steel ropes, double safety protection
Tourist Area	Landslide-prone	Extreme	Landslide Early Warning System (LEWS)
Other Attractions (High Risk)	Structural damage and PPE issues	High	Routine maintenance, daily inspection, SOP improvement

The recommended priority actions were derived directly from the HIRADC risk classifications and applied in accordance with the hierarchy of risk control, with Extreme Risks prioritised for source-level engineering and real-time monitoring interventions and High Risks managed through a combination of engineering improvements, administrative procedures, and PPE. Action plans were derived through a systematic decision process that combines (1) the risk category results (Extreme or High), (2) the hierarchy of risk

control, and (3) the feasibility of implementation in the field context.

3.1. Risk Analysis on Glass Bridge Ride

The analysis shows that the Glass Bridge is the attraction with the highest risk level, with two potential hazards categorised as Extreme Risk. The first hazard stems from the excessively wide gaps in the railing, which poses a significant risk to children and visitors with limited mobility. This inadequate facility is undoubtedly dangerous and poses a threat to tourist safety. The second hazard relates to the accumulation of excessive loads due to visitor density exceeding the structure's design capacity, which can cause the bridge's glass to break. Inconsistencies in inspection and maintenance schedules, as identified through interviews with staff, suggest a weak internal safety management system. These findings support other research suggesting that community-based tourism managers generally lack an understanding of, and have not effectively implemented, safety and health risk mitigation measures in tourist areas (Rachman, 2023).

To mitigate these risks, strict technical and administrative controls are required. Recommendations include installing safety nets under the structure, using full-body harnesses, and modifying the railing design to meet international standards (with a maximum height of 10 cm). This facility redesign approach aligns with ergonomic principles, which aim to design a work system that enables people to live, work, and operate effectively, safely, healthily, comfortably, and efficiently (Heryanto et al., 2025). Furthermore, adding equipment such as the Smart Weighing Access Gate can be used to monitor the number and total weight of visitors in real time (Riyanti et al., 2025).

3.2. Risk Analysis on Sky Swing

On the Sky Swing ride, one potential hazard is categorised as Extreme Risk (breaking of the backrest rope), while the other two (High Risk) relate to damage to the seat and support pole. This risk pattern reflects structural vulnerability to wear and corrosion, which often occurs on outdoor-based extreme rides. This emphasises that the importance of safety for tourists and workers requires proactive efforts by tourism destination managers in implementing risk management (Noviastuti et al., 2025).

Recommended control strategies include replacing the backrest ropes with vinyl-coated steel cables, replacing wooden seats with rust-resistant metal, and applying anti-corrosion coatings to the support structures. Furthermore, a Load Cell Tension Monitoring System can detect excessive tension in real time, thereby minimising the risk of rope failure (Zhao et al., 2024).

3.3. Risk Analysis on Other Attractions

In addition to the two main attractions, the Flying Bike, Flying Chair, and Suspension Bridge also pose significant hazards and are categorised as High Risk. The Flying Bike poses a risk due to wear on the pulleys and the lack of protective helmets for users. These findings suggest negligence, as the provision of hazard prevention equipment, such as personal protective equipment (PPE), on high-risk attractions should be part of safety standards. The Flying Chair has the potential to cause injury due to loose seatbelts. The Suspension Bridge exhibits structural hazards, including fragile wooden planks and torn safety nets.

These findings are consistent with previous studies, which highlighted a lack of preventive maintenance and inconsistent use of PPE as the primary causes of accidents on extreme rides (Kennedy et al., 2021). Therefore, risk control should focus on regular mechanical maintenance, daily visual inspections, and mandatory use of PPE, such as certified helmets and seat belts.

3.4. Risk Analysis in General Areas

In addition to the rides, the public tourist area at Kemuning Sky Hills also poses a high risk, particularly in relation to environmental conditions. The danger of landslides in sloped areas is categorised as Extreme Risk because it can cause loss of life if not addressed. This risk is a frequent threat in highland tourist areas, where the potential for landslides during the rainy season can result in significant losses and compromise the safety of residents and visitors alike. Additional risks, such as the absence of safety fences along the edge of the cliff, unseparated pedestrian and vehicle paths, and scattered electrical cables, are categorised as High Risk.

These findings suggest that the fulfilment of general security requirements at the location is inadequate, which ideally includes the provision of clear, easily understood warning signs, CCTV monitoring, and security officers on regular patrol (Maharani, 2022). In addition, safety education for visitors and enforcement of regulations in the field by officers are essential components in building an effective and sustainable safety system (Sari et al., 2024).

Effective mitigation strategies include installing guardrails, moving cables underground, separating pedestrian and vehicle paths, and using the Landslide Early Warning System (LEWS). This system has proven effective in increasing regional resilience to geotechnical risks, as demonstrated in a study on rainfall thresholds for more accurate landslide predictions in Indonesia (Yuniawan et al., 2022).

3.5. Managerial Implications

The results of this discussion indicate that safety risks at extreme tourism destinations, such as Kemuning Sky Hills, are not only related to the main attractions but

also to the supporting environment and operational management systems. Similar risk patterns have been observed at other extreme tourism locations, particularly those that rely on open natural features.

Risks classified as Extreme are now addressed primarily through engineering controls and real-time monitoring systems to eliminate or substantially reduce the hazard. In contrast, High risks are managed through a combination of preventive maintenance, administrative controls, and mandatory personal protective equipment.

The main contributions of this research are: (1) Providing a comprehensive safety risk map in extreme tourism areas. (2) Providing a technology-based risk control plan (e.g., Smart Weighing Access Gate, Load Cell Monitoring, LEWS) to prevent structural failures and fatal incidents. (3) Emphasising the importance of a multi-level approach to risk mitigation: engineering, operational procedures, and visitor education.

Tourism safety is crucial, as accidents not only cause losses to the victims but can also damage the company's image and have long-term impacts on the sustainability of the tourist attraction. By implementing appropriate control strategies, managers can significantly reduce risk levels, increase visitor confidence and satisfaction, and support the sustainability of extreme tourism destinations (Berthanila et al., 2025; Sukmana & Prasetya, 2025).

This study advances previous tourism safety research by extending the application of the HIRADC framework beyond conventional assessments and demonstrating how risk mitigation technologies, such as smart load monitoring, real-time structural sensing, and a landslide early warning system, can be systematically integrated into safety management for nature-based, height-dependent extreme tourism.

4. Conclusion

Based on the research conducted, four risks were categorised as Extreme Risk and ten as High Risk across various attractions, including the Glass Bridge, Sky Swing, Flying Bike, Flying Chair, Suspension Bridge, and public tourist areas. The most critical risks include gaps in the railing, excessive weight on the Glass Bridge, broken ropes on the Sky Swing, and the threat of landslides in tourist areas lacking adequate soil-retention systems. These findings highlight the urgent need for an integrated safety management approach at Kemuning Sky Hills.

From a practical perspective, the results emphasise the need for an integrated, risk-based safety management system that prioritises engineering controls such as safety nets, acrylic barriers, and slope stabilisation supported by routine inspections, preventive maintenance, and the enforcement of PPE and SOPs. Theoretically, this study extends the application of the HIRADC framework into the domain of extreme, nature-based tourism, demonstrating its effectiveness in linking quantified risk

levels with targeted engineering, administrative, and technological control strategies.

This study is limited by its site-specific focus and cross-sectional data collection, which may not capture seasonal variations, long-term environmental changes, or the evolving effectiveness of implemented control measures. In addition, the risk assessment relies partly on qualitative judgement in assigning likelihood and consequence scores, which may introduce subjectivity despite triangulation and expert validation. Future studies should focus on the longitudinal evaluation of the effectiveness of implemented control measures and safety technologies, including real-time monitoring systems and early warning mechanisms.

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