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# Occupational safety and health (K3) risk analysis in river tubing activities using the HIRARC method in Sesaot Tourism Village

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*ABSTRACT*

*River tubing is an adventure tourism activity involving direct interaction with a dynamic natural environment and various safety risks. This study aimed to identify potential hazards, assess risk levels, and determine appropriate risk controls for river tubing activities in Sesaot Tourism Village, West Lombok Regency, using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method. A qualitative descriptive approach was employed through two direct observation sessions and interviews with the tourism manager, river tubing guides, and tourists. The results identified eight potential hazards, comprising five high-risk hazards (62.5%) and three medium-risk hazards (37.5%). High-risk hazards included inadequate life jackets, unstable bridge conditions, collisions with river rocks, strong river currents, and increased river discharge during rainfall. Existing controls included safety briefings, helmet and life jacket use, guide supervision, and temporary suspension of activities during unfavorable weather. Recommended improvements include regular PPE inspection and maintenance, infrastructure improvement, safety signage, environmental monitoring, and written safety SOPs. This study contributes a systematic risk profile of river tubing activities in a dynamic natural environment, providing a basis for prioritizing safety controls. The findings provide practical guidance for tourism managers to strengthen safety management and support safer and more sustainable river tubing tourism in Sesaot Tourism Village.*

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## 1. INTRODUCTION

Sesaot Tourism Village is one of the nature-based tourism destinations in West Lombok Regency, offering various outdoor activities, including river tubing. River tubing uses the natural flow of the river as a recreational activity in which tourists and guides travel along the river using inflatable tubes. This activity provides an adventure experience through direct interaction with the natural environment. However, the

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combination of flowing water, uneven river terrain, slippery surfaces, weather conditions, and human interaction with the river environment creates potential safety risks for both tourists and guides. The development of adventure tourism has therefore increased the importance of safety management in ensuring safe and sustainable tourism activities (Wang et al., 2019; Oetoyo and Widiawan, 2022).

River tubing involves several potential hazards, including slipping on slippery river rocks, collisions with rocks or other obstacles, falling while entering or exiting the river, being carried away by strong currents, and exposure to changes in weather conditions and river discharge (Pamungkas, 2024; Pratama, 2022; Hermawan et al., 2025). The severity of these hazards may vary depending on river conditions, terrain characteristics, weather, participant behavior, and the procedures implemented by guides and operators. If potential hazards are not identified and controlled appropriately, they may result in injuries ranging from minor incidents to serious accidents (Wahyuni et al., 2025). Therefore, Occupational Safety and Health (OHS) management is relevant not only to industrial activities but also to tourism activities involving physical interaction with potentially hazardous environments (Isro & Nugraheni, 2024; Muhtia et al., 2020).

Effective safety management requires systematic hazard identification and risk assessment to determine the likelihood and severity of potential incidents and establish appropriate control priorities. Risk assessment enables activity managers to identify hazards at each stage of an activity and prioritize risks according to their potential consequences (Giovanni et al., 2023; Putra et al., 2019). In adventure tourism, this process is particularly important because hazards may arise from the interaction between participants, equipment, operational procedures, and dynamic environmental conditions. Safety education and systematic hazard identification can also improve participants' understanding of potential risks and support safer behavior during activities (Kurnia et al., 2025).

One method widely used for systematic OHS risk management is Hazard Identification, Risk Assessment, and Risk Control (HIRARC). HIRARC provides a structured process for identifying potential hazards, assessing risk levels based on the likelihood and severity of their consequences, and determining appropriate control measures. The method has been applied in various sectors to establish risk priorities and support accident prevention. Pratama (2022) for example, identified 15 potential hazards in garment production, with risks ranging from medium to extreme. (Giovanni et al., 2023) identified extreme risks related to material dust exposure in a corn silo area, while Ulfaturrahmi & Firdaus (2025) identified 16 potential hazards in brick production that could cause respiratory problems, physical injuries, and other serious accidents. These studies demonstrate the usefulness of HIRARC for systematically identifying and prioritizing risks in different activity contexts.

Although HIRARC has been widely applied in industrial and conventional workplace settings, its application to adventure tourism activities, particularly river tubing, remains relatively limited. River tubing presents a different risk profile because it takes place in an open and dynamic natural environment. River flow, water discharge, weather, slippery surfaces, obstacles, terrain conditions, participant behavior, and operational procedures may interact and influence the level of risk during the activity. Consequently, risk assessment in river tubing requires consideration of both operational hazards and environmental conditions that may change during the activity. In the context of Sesaot Tourism Village, a systematic assessment is needed to determine the hazards associated with each stage of river tubing, identify the level of risk, and establish appropriate control priorities.

Therefore, this study contributes to addressing this gap by applying HIRARC to river tubing activities in Sesaot Tourism Village. The study specifically examines potential hazards across the stages of the activity and relates each identified hazard to its risk level and appropriate control measures. This provides a structured basis for identifying priority risks and supporting safety improvements that are relevant to the characteristics of river-based adventure tourism. Accordingly, this study aims to identify potential hazards, assess the level of safety risk, and determine appropriate risk control measures for river tubing activities in Sesaot Tourism Village using the HIRARC method. The findings are expected to provide an evidence-based basis for tourism managers and river tubing operators to improve operational procedures, strengthen safety controls, and reduce the potential for accidents, thereby supporting a safer and more sustainable tourism experience.

## 2. RESEARCH METHODS

This study employed a descriptive qualitative approach with field observation to identify potential hazards, assess risk levels, and determine Occupational Safety and Health (OHS) control measures for river tubing activities in Sesaot Tourism Village using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method. The study was conducted in the river tubing tourism area of Sesaot Tourism Village, West Lombok Regency, West Nusa Tenggara Province, in March 2026. The location was purposively selected because river tubing is a nature-based water tourism activity conducted in a dynamic river environment with potential safety risks.

The study involved 20 participants, comprising one tourism manager, two river tubing guides, and 17 tourists, selected using purposive sampling. The manager and guides served as key informants because of their direct involvement in river tubing operations and their knowledge of safety procedures and risk controls. The tourists were selected because they directly experienced the activity and were exposed to potential hazards. Participants were included based on their direct involvement or experience in river tubing activities, knowledge of relevant safety practices, and willingness to participate. The manager and guides provided information through semi-structured interviews, while tourists provided supporting information regarding safety briefings, PPE use, and perceived hazards.

Data were collected through two direct observation sessions, semi-structured interviews, and documentation. Observations covered participant preparation and safety briefing, PPE preparation and use, access to and entry into the river, river tubing activities, and exiting the river. The observations focused on potential hazards, unsafe conditions and actions, PPE use, safety facilities, river terrain, water flow, and environmental conditions. Interviews with the manager and guides focused on operational procedures, potential hazards, previous accidents or near-miss events, and existing risk controls. Photographs and other relevant documentation were used to support and verify the field findings.

Data were analyzed using the HIRARC method, comprising hazard identification, risk assessment, and risk control (Wahyuni et al, 2025). Potential hazards were identified for each stage of the river tubing activity based primarily on the two observation sessions and supported by interview findings. Each identified hazard was assessed using a 5 × 5 risk matrix based on likelihood and severity. The risk score was calculated using $R = L \times S$, where R represents the risk score, L represents likelihood, and S represents severity. Likelihood and severity scores were assigned by the researcher based on field observations and supporting interview information. The likelihood score represented the estimated frequency or possibility of occurrence under the observed operating conditions, whereas the severity score represented the potential consequence of each hazard. The resulting risk scores were classified as Low, Medium, High, or Extreme according to the risk matrix adapted from Standards Australia and Standards New Zealand (2004).

Table 1. Likelihood scale

| Mark | Category | Information |
|---|---|---|
| 1 | Rare | Very rare |
| 2 | Unlikely | Rarely happening |
| 3 | Possible | It might happen |
| 4 | Likely | Often occur |
| 5 | Almost certain | It happens very often |

Table 2. Severity scale

| Mark | Category | Information |
|---|---|---|
| 1 | Insignificant | Minor injury |
| 2 | Minor | Minor injuries require assistance |
| 3 | Moderate | Moderate injury |
| 4 | Major | Serious injury |
| 5 | Catastrophic | Causes death |

Table 3. Risk matrix

| Likelihood / Severity | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 5 | Medium | High | High | Extreme | Extreme |
| 4 | Medium | Medium | High | High | Extreme |
| 3 | Low | Medium | Medium | High | High |
| 2 | Low | Low | Medium | Medium | High |
| 1 | Low | Low | Low | Medium | Medium |

Risk control measures were determined according to the identified risk levels and included PPE improvement, safety briefings, guide supervision, infrastructure improvement, safety signage, weather and river-discharge monitoring, and the development of safety SOPs. High- and extreme-risk hazards were prioritized for additional control measures.

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## 3. RESULTS AND DISCUSSION

### 3.1 Hazard identification in river tubing activities

Sesaot Tourism Village is a nature-based tourism destination in West Lombok Regency, West Nusa Tenggara Province, where river tubing is one of the developing adventure tourism activities. The activity consists of several stages, including safety briefing, PPE preparation and use, access to the river, bridge crossing, river tubing, and completion of the activity. Each stage involves interaction between tourists, equipment, infrastructure, and the natural river environment.

Based on two direct observation sessions and interviews with the tourism manager, two river tubing guides, and tourists, eight potential hazards were identified. The hazards originated from human factors, equipment, infrastructure, and environmental conditions

Table 4. Hazard identification in River Tubing activities

| | Activity | Potential Danger | Risk Impact |
|---|---|---|---|
| 1 | Safety briefing | Tourists do not understand the instructions | Errors during tubing activities |
| 2 | Use of life jackets | Loose or damaged float | Risk of drowning |
| 3 | Journey to the river | Slippery road | Slip and fall |
| 4 | Crossing the bridge | The bridge is less stable | Fall into the river |
| 5 | River Tubing activities | Hit a river rock | Minor to serious injuries |
| 6 | River Tubing activities | Carried away by the strong current | Sink |
| 7 | Finish area | Slippery stone surface | Slip |
| 8 | Weather conditions | Rain and water discharge increase/flood | Increased risk of accident/being swept away by the current/fatal |

The results show that hazards occur throughout the activity sequence rather than only during the river tubing stage. This finding emphasizes the need to assess the entire operational process, including preparation, access, activity implementation, and environmental conditions.

### 3.2 Risk assessment

The identified hazards were assessed using the HIRARC method. Risk was determined from the combination of likelihood (L) and severity (S) using the following equation:

Table 5. River Tubing activity risk assessment

| No | Potential danger | Likelihood | Severity | Risk Score | Risk level |
|---|---|---|---|---|---|
| 1 | Tourists do not understand the briefing | 3 | 3 | 9 | Medium |
| 2 | Loose/damaged float | 3 | 4 | 12 | High |
| 3 | Slippery road | 4 | 2 | 8 | Medium |
| 4 | The bridge is less stable | 3 | 4 | 12 | High |
| 5 | Hit a river rock | 4 | 3 | 12 | High |
| 6 | Carried away by the strong current | 2 | 5 | 10 | High |
| 7 | Slipped in the finish area | 3 | 2 | 6 | Medium |
| 8 | Water discharge increases when it rains | 2 | 5 | 10 | High |

The HIRARC assessment identified five high-risk hazards and three medium-risk hazards, with no low- or extreme-risk hazards. The highest risk score was 12, identified for loose or damaged life jackets, unstable bridge conditions, and collision with river rocks.

The likelihood scores were determined based on the conditions observed during the two observation sessions, supported by interviews with the tourism manager, guides, and tourists. A higher likelihood score was assigned to hazards that were more likely to occur under the observed operating conditions, such as slippery roads and collisions with river rocks. Lower likelihood scores were assigned to hazards that depended on specific environmental conditions, particularly strong currents and increased river discharge during rainfall.

Severity scores were determined based on the potential consequences of each hazard. A score of 5 was assigned to hazards that could potentially result in drowning or fatality, while a score of 4 represented the potential for serious injury. Lower scores represented less severe potential consequences.

An important finding is that risk priority was determined by the combination of likelihood and severity, rather than likelihood alone. For example, strong currents and increased river discharge during rainfall received a likelihood score of 2 but a severity score of 5, resulting in a high-risk score of 10. Although these hazards may occur only under certain environmental conditions, their potentially severe consequences make them important priorities for control.

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### 3.3 Analysis of high-risk hazards

The five high-risk hazards have different risk characteristics based on their likelihood and severity scores. Loose or damaged life jackets, unstable bridge conditions, and collision with river rocks each obtained a score of 12 but arose from different sources. The risk associated with loose or damaged life jackets was classified as high because inadequate flotation equipment may reduce tourist protection and increase the consequences of a water-related incident. The unstable bridge represents an infrastructure-related hazard that may cause tourists to fall into the river and suffer serious injury. Meanwhile, collision with river rocks obtained a likelihood score of 4, indicating relatively frequent exposure to physical obstacles during river tubing.

The risks associated with strong currents and increased river discharge during rainfall obtained scores of 10 ($2 \times 5$). Their likelihood was relatively lower, but their severity was rated at the highest level because these conditions may cause tourists to be swept away and drown. Thus, these hazards require priority controls even though their probability of occurrence is lower. These findings are consistent with previous research highlighting the importance of safety management in adventure tourism, particularly in activities involving direct interaction with dynamic natural environments (Wang et al., 2019; Morgan, 2021). However, the present study provides a more specific perspective by showing that river tubing risks are influenced by the interaction of tourist behavior, equipment, infrastructure, river terrain, and changing environmental conditions. Unlike conventional industrial environments, river tubing takes place in a dynamic natural setting in which rainfall, river discharge, and current strength can change during operations. Therefore, safety management requires not only PPE and administrative controls but also environmental monitoring and clear criteria for suspending activities.

The findings also support Arji et al., (2024), who emphasized that risks with higher levels require priority control. In the present context, however, risk control must also account for environmental conditions that may change rapidly and cannot be completely controlled by the tourism operator.

### 3.4 Risk control and recommended improvements

The tourism operator has implemented several safety controls, including safety briefings, the use of life jackets and helmets, guide supervision, tourist assistance, and temporary suspension of activities during heavy rain. However, field observations identified several weaknesses, including deteriorating life jackets, limited hazard warning signs, and the absence of comprehensive written safety SOPs. To clearly distinguish between measures that are already implemented and improvements that are recommended based on the findings, the control measures are presented in Table 6.

Table 6. Existing Risk Controls and Recommended Improvements

| No. | Potential Risk | Existing Control | Recommended Improvement |
|---|---|---|---|
| 1 | Tourists do not understand instructions | Safety briefing before the activity | Strengthen safety briefing and provide clearer safety instructions |
| 2 | Risk of drowning due to inadequate flotation | Life jackets and helmets | Conduct routine PPE inspection and replace damaged life jackets |
| 3 | Slipping on access road | Tourist assistance | Improve access conditions and install warning signs |
| 4 | Injury from rock impact | Safety helmets | Strengthen route assessment and guide supervision |
| 5 | Being carried away by strong currents | Guides accompany tourists and remain on standby | Strengthen environmental monitoring and emergency preparedness |
| 6 | Increased river discharge during heavy rain | Activity is temporarily suspended | Establish clear weather and river-discharge criteria for suspending activities |
| 7 | Slippery or unsafe areas | Tourist assistance | Conduct regular infrastructure inspections and install warning signs |
| 8 | Lack of standardized safety procedures | No comprehensive written SOP identified | Develop and implement written river tubing safety SOPs |

The existing controls demonstrate that basic safety management has already been implemented. Safety briefings, PPE, guide supervision, and temporary suspension during heavy rain provide initial protection against several identified hazards. However, the observed weaknesses indicate that these controls have not yet been fully standardized. The recommended improvements therefore focus on strengthening existing controls rather than replacing them. Routine PPE inspection is particularly important for high-risk drowning hazards, while infrastructure inspection and warning signs can reduce exposure to physical hazards. Environmental monitoring and clear activity-suspension criteria are also necessary because river conditions can change rapidly during

rainfall. In addition, written safety SOPs are needed to standardize procedures for guides and tourists and to improve emergency preparedness.

### 3.5 Overall discussion

Overall, the HIRARC assessment identified eight potential hazards, consisting of five high-risk and three medium-risk hazards. The hazards originated from human factors, equipment, infrastructure, and environmental conditions and were distributed across different stages of the river tubing activity. The results demonstrate that risk management in river tubing should not focus only on the main tubing activity. Preparation, access routes, infrastructure, PPE, weather, and river conditions also contribute to the overall risk profile. In particular, environmental hazards require special attention because their likelihood and severity can change according to rainfall and river discharge.

Compared with previous HIRARC studies that have largely focused on industrial environments, this study highlights the specific characteristics of adventure tourism in a dynamic natural environment. The findings indicate that conventional OHS controls such as PPE and safety briefings need to be complemented by infrastructure inspection, environmental monitoring, guide preparedness, emergency procedures, and clear criteria for stopping activities.

The existing safety measures at Sesaot Tourism Village provide a foundation for risk management, but the identified weaknesses indicate the need for further improvement. Strengthening PPE maintenance, infrastructure safety, warning signs, environmental monitoring, emergency preparedness, and written SOPs can reduce exposure to high-risk hazards and support a safer and more sustainable river tubing tourism experience.

## 4. CONCLUSION

Based on the HIRARC analysis, eight potential hazards were identified in river tubing activities in Sesaot Tourism Village, consisting of five high-risk and three medium-risk hazards. The high-risk hazards were associated with inadequate life jackets, unstable bridge conditions, collisions with river rocks, strong river currents, and increased river discharge during rainfall. Existing controls include safety briefings, the use of helmets and life jackets, guide supervision, and temporary suspension of activities during unfavorable weather conditions. Further improvements are recommended through regular PPE inspection, infrastructure maintenance, installation of safety signage, environmental monitoring, and the development of written safety SOPs. The HIRARC method provided a systematic basis for identifying hazards and prioritizing risk controls, supporting efforts to strengthen safety management and promote safer and more sustainable river tubing tourism in Sesaot Tourism Village.

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