

Retrospective Risk Assessment of Wakal-Taeno Road Functionality Failure Based on SNI IEC/ISO 31010:2016

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ABSTRACT

The Wakal-Taeno road on Ambon Island is a crucial link between Ambon City and the Leihitu sub-district. Although completed in 2023 using Presidential Instruction funds and officially operational in 2024, the road has already experienced multiple functional failures. This study retrospectively analyzes contributing factors and reassesses risks using the *SNI ISO/IEC 31010:2016* standard. Primary data were collected through visual field inspections, supported by secondary data from news reports and academic sources. Root Cause Analysis (RCA) was employed to identify core problems, while the *ISO* framework guided risk identification, probability-impact analysis, and risk evaluation. Key issues identified include the collapse of a temporary Bailey bridge in June 2025, landslides on slopes, and settlement of bridge approaches. RCA revealed root causes such as insufficient geotechnical and hydrological investigations, unsuitable design and materials selection, incomplete risk assessments, and reactive, rather than proactive, maintenance strategies. The risk reassessment categorized bridge collapse, slope failures, and approach instability as high and unacceptable risks (risk scores: 16–20), while drainage system deficiencies were moderate (score: 12), and early pavement degradation was low (score: 9). Recommendations include constructing permanent bridges designed according to local geotechnical conditions, slope stabilization and reinforcement, integrated drainage systems, and proactive maintenance programs. Applying the *SNI ISO/IEC 31010:2016* framework from the planning stage, alongside enhanced inter-agency coordination, is essential for sustainable infrastructure development in hazard-prone regions. Validation was ensured through data triangulation, member checking, and methodological transparency to strengthen the study's credibility.

Keywords: *Wakal-Taeno Road, Functional Failure, Risk Assessment, Root Cause Analysis, SNI ISO/IEC 31010:2016.*

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INTRODUCTION

Road infrastructure plays a critical role in supporting interregional connectivity, facilitating economic growth, and improving the social welfare of local communities (Miller & Chandra, 2021). This is especially true in archipelagic regions like Maluku, where unique geographical challenges demand reliable transportation networks (Suryadi & Alamsyah, 2020). One prominent example is the Wakal-Taeno Road on Ambon Island, which connects the city of Ambon to the Leihitu sub-district in Central Maluku Regency. This road serves as a vital and strategic transportation route for residents in the surrounding area (Puspa & Putra, 2021). The development of such roads not only improves access to basic services but also supports local economic activities such as agriculture and fisheries, which are essential in Maluku's economy (Widodo & Sudrajat, 2019). In addition, the road infrastructure enhances connectivity between islands, reducing transportation costs and boosting inter-island trade (Anggraeni & Asto, 2022). Moreover, the integration of sustainable transport infrastructure in

these regions is essential for long-term social and economic benefits (Nurhadi & Wirawan, 2020). The improvement of roads like the Wakal-Taeno Road also aligns with national policies to promote equitable development across Indonesia's diverse regions (Kusumaningrum et al., 2021).

Although the Wakal-Taeno Road was only completed in 2023 using Presidential Instruction (Inpres) funds and officially opened in 2024, it has already experienced multiple functional failures, despite still being under a maintenance phase (Lestari et al., 2021). One of the most significant incidents occurred on June 21–22, 2025, when a temporary Bailey bridge made of timber collapsed, severing the vehicular link between Ambon and Leihitu and severely impacting daily activities (Rahman et al., 2020). This collapse was triggered by extreme rainfall and underlying ground movement (Kusuma & Hadi, 2019). Previous reports have also highlighted the road's vulnerability to landslides during heavy rain, indicating unstable soil conditions and the potential for frequent access disruptions (Tanuwijaya & Prasetyo, 2022). These structural challenges point to the need for better risk assessment and engineering solutions in infrastructure projects (Yulianto et al., 2018). Additionally, poor construction materials and inadequate drainage systems have been identified as contributing factors to infrastructure failure (Adinugroho & Wijayanto, 2021). The vulnerability of transportation networks in hilly or mountainous regions requires continuous monitoring and maintenance strategies to prevent major disruptions (Sukoco & Wibowo, 2020).

The functional failure of the Wakal-Taeno Road has had a substantial impact, disrupting daily life and economic connectivity in the area. *Functional failure* refers to a condition in which road infrastructure can no longer serve its intended purpose, resulting in discomfort for users and potential hazards (Koch et al., 2015; Lam et al., 2018). This differs from *structural failure*, which involves damage to components of the road structure, such as unstable subgrades or surface cracking. However, structural issues often lead to functional failures. In this case, structural damage to the bridge and surrounding slopes directly caused the road to lose its functionality.

The rapid deterioration of the Wakal-Taeno Road, despite its recent construction, indicates deeper systemic issues beyond normal wear and tear. These may stem from flaws in the initial design, unsuitable material choices (e.g., the wooden Bailey bridge), poor construction quality, or insufficient geotechnical and hydrological investigations. The fact that the road suffered major failure within one year of opening suggests critical gaps in initial risk assessments or early mitigation strategies. Therefore, a retrospective analysis is essential to identify the root causes and conduct a systematic risk reassessment to prevent recurrence and ensure long-term functionality.

In this context, the application of the *SNI ISO/IEC 31010:2016* standard, which provides guidelines on risk assessment techniques, becomes highly relevant. This framework offers a systematic approach to identifying, analyzing, and managing the risks of functional failure. Its application can enhance preparedness and resilience in infrastructure projects, particularly those situated in disaster-prone areas with complex environmental conditions.

Based on the background outlined, this study aims to answer the following research questions: How can the characteristics and types of functional failure occurring on the Wakal-Taeno Road be identified and classified using visual inspections and public reports? What are the main contributing factors to these functional failures, as identified through a retrospective

analysis of historical events and environmental conditions? How can the *SNI ISO/IEC 31010:2016* framework be effectively applied to reassess the risks of functional failure, including risk identification, probability analysis, and risk impact evaluation? What risk mitigation recommendations should be prioritized to enhance the functionality, safety, and sustainability of the Wakal-Taeno Road?

The objectives of this study are: (1) to identify and characterize the functional failures of the Wakal-Taeno Road using visual inspections and public data; (2) to analyze the root causes through a retrospective approach; (3) to reassess the associated risks using the *SNI ISO/IEC 31010:2016* framework; and (4) to formulate effective and prioritized risk mitigation strategies. The study is expected to provide meaningful contributions: academically, by enriching civil engineering and risk management literature through the contextual application of international standards; practically, by offering evidence-based recommendations for the Maluku Provincial Government and the National Road Authority (*BPJN Maluku*); and socially, by contributing to improved safety, accessibility, and comfort for road users in the region.

METHOD

This study adopted an applied research approach, utilizing a qualitative and descriptive methodology with a retrospective character. The qualitative method was chosen to explore the implementation of risk management and to gain a deeper understanding of the complexity surrounding the functional failure of the road infrastructure. This approach allowed the researchers to draw conclusions from key findings and identify emerging patterns or trends from the collected data.

The descriptive nature of the study provided detailed descriptions of various types of functional failures observed in the road infrastructure, along with their underlying causes. A retrospective approach was employed to analyze past events, particularly those related to the history of construction, maintenance, and damage incidents along the Wakal-Taeno Road. Through this analysis, the researchers aimed to uncover root causes and offer constructive recommendations for future improvements. The study thus focused not only on identifying problems but also on contributing to the development of improved risk management strategies in road infrastructure projects.

This research focused on the Wakal-Taeno Road on Ambon Island, Maluku, examining data from its construction period (2023–2024) until the bridge collapse in June 2025. The study utilized two main data types: primary data gathered through visual inspections to document damage types (deformations, cracks, potholes, landslides), their severity, and exact locations, supported by photographic and video evidence; and secondary data obtained from public sources, including news reports about the June 2025 bridge collapse and landslides, potential government documents from *BPJN Maluku* and provincial authorities, scientific journals on pavement failures and infrastructure risk management, and the *SNI ISO/IEC 31010:2016* standard as the methodological framework.

Two main techniques were employed:

- a) Field Visual Inspection: Conducted directly on-site along the Wakal-Taeno Road, observing road surfaces, slopes, bridge structures, and drainage systems. All types of

damage were classified and geotagged using GPS, with documentation via photos and videos.

- b) Literature and Document Review: A systematic search and critical review of relevant secondary sources such as government reports, academic journals, and news articles. Cross-verification of incident timelines (e.g., bridge collapse, landslides) was performed to ensure data validity.

Data analysis followed an integrated, step-by-step process:

- a) Descriptive Qualitative Analysis: Classified damage types, frequency, and geographic distribution, providing an overview of how failures manifested across the road segment.
- b) Retrospective Analysis Using Root Cause Analysis (RCA): Identified direct causes (e.g., heavy rainfall triggering soil shifts), contributing factors (e.g., poor material selection), and root causes (e.g., lack of comprehensive geotechnical surveys). RCA enabled deeper tracing of events, maintenance records, and environmental context.

The observed failures on the Wakal-Taeno Road included the collapse of a wooden Bailey bridge in June 2025, recurring landslides from unstable soil, and subsidence at bridge approaches—primarily caused by extreme rainfall, clay/mud soil instability, and lateral soil movement. Contributing factors involved inadequate materials and design (e.g., timber bridges), ineffective temporary measures (e.g., tarpaulin slope covers), and limited equipment access. Root causes stemmed from insufficient geotechnical surveys, poor design choices, underestimated environmental risks, and reactive maintenance practices. These failures underscored critical planning and risk assessment deficiencies and demonstrated how short-term solutions exacerbated vulnerabilities. The findings emphasize the necessity of applying the *SNI ISO/IEC 31010:2016* framework from the outset, adopting adaptive designs, and establishing long-term monitoring systems for disaster-prone regions to prevent future infrastructure breakdowns.

RESULTS AND DISCUSSION

Overview of Wakal-Taeno Road

The Wakal-Taeno road is one of the very important roads on Ambon Island, which is located in Maluku Province. This road has a crucial role as the main link between Ambon City and Leihitu District, which is located in Central Maluku Regency. The road construction project covers a total length of approximately 3.01 kilometers with a hotmix pavement overlay as well as several supporting buildings, including two temporary bridges with bailey construction designed to improve accessibility. The construction of this road is funded through the 2023 Presidential Instruction Fund, which shows the central government's commitment to improving regional infrastructure, including the province of Maluku.

The Wakal-Taeno Road (IJD) has been completed and opened for public use in 2024. The hope is that the operation of this road can provide significant benefits in various ways, especially cutting travel time and improving connectivity for the local community. This road faces many serious challenges related to its functionality. These challenges need to be overcome to keep Jalan Wakal-Taeno functioning optimally and providing maximum benefits for road users and the surrounding community.

Identification And Characteristics Of Functional Failures

The results of visual inspections and analysis of public reports have identified several significant types of functional failures on the Wakal-Taeno Road that warrant serious attention. The most critical incident was the collapse of one of the two temporary Bailey bridges on June 21–22, 2025, which entirely cut off vehicle access from Ambon to Leihitu due to substantial soil displacement at the bridge's foundation caused by intense rainfall and strong winds. In addition, the road segment is highly prone to landslides on both upper and lower slopes, particularly during prolonged heavy rain. The ongoing instability of the soil has led to repeated landslides that frequently cover the road and drainage channels, making the surface slippery and dangerous, especially for motorcyclists. These conditions have necessitated periodic road closures for debris clearance, disrupting traffic flow.

Another serious issue involves the subsidence of a steel-frame bridge relative to the road surface, creating a height imbalance that poses a high risk of accidents and indicating deeper structural instability at the bridge and its approaches. While the report focuses primarily on bridge and landslide-related problems, the unstable soil and intense rainfall also raise concerns about other surface damage, such as deformations, cracks, or potholes along the 3.01 km stretch of hotmix pavement. Overall, the functional failure of the Wakal-Taeno Road is marked by a significant loss of accessibility and road safety, stemming from structural failures in bridges and slopes. This situation demands urgent attention and immediate corrective action by the authorities to prevent further and potentially fatal incidents.

Retrospective Analysis of the Factors Causing the Failure

The results of a retrospective analysis of the history of the Wakal-Taeno Road have revealed several key symptoms that reflect a serious functional failure of this infrastructure. One of the most striking symptoms was the collapse of the wooden Bailey-type temporary bridge on June 21-22, 2025, which caused the disconnect of access between Ambon and Leihitu. In addition, the vulnerability of landslides on the upper and lower slopes, especially during the rainy season, has led to repeated road closures. The road surface covered with landslides and clogged drainage channels increases the risk of traffic accidents, especially for two-wheeled users. Another symptom identified is a decrease in elevation at the bridge approach, which creates an imbalance and the potential for accidents due to the significant difference in height between the road and the bridge structure.

The direct causes of these failures are closely related to the extreme weather conditions and soil characteristics at the site. High rainfall accompanied by strong winds triggered significant ground shifts in the bridge foundation, causing the structure's inability to withstand the load and eventually collapse. The type of soil around the area in the form of unstable clay and mud also worsens the situation, as its movement triggers repeated avalanches that cover the road body. Soil movement on the opposite side of the bridge also triggered a decrease in the height of the bridge approach, clarifying the instability that endangers road users.

Several contributing factors exacerbate this condition and show the weak risk mitigation carried out. Among them is the use of the Bailey bridge with wooden floors which is not suitable for locations with extreme geological conditions and high rainfall. Mitigation strategies such as tarpaulin coating on eroded cliffs have proven to be ineffective in preventing landslides. The limitation of heavy equipment to work in harsh terrain conditions and extreme

weather is also a major obstacle in the repair process during the maintenance period. This shows the need for a re-evaluation of technical readiness and resources in dealing with geotechnical risks in the region.

The root cause of this failure lies in weaknesses in the initial planning stage of the project. The absence of comprehensive geotechnical and hydrological surveys causes the project design not to fully consider the dynamics of soil and water at the site. Inappropriate design and material choices, such as the use of wooden Bailey bridges and light steel frames, indicate a lack of adaptation to long-term risks. In addition, the existence of gaps in the risk assessment process and weak implementation of mitigation from the beginning make projects prone to damage. Maintenance efforts are also reactive and not based on a continuous risk monitoring system, so they are not able to effectively prevent further damage.

The analysis conducted shows that the functional failure experienced by the Wakal-Taeno Road cannot be concluded only because of one specific event. Instead, the problem is the result of a complex accumulation involving the interaction of various factors. Among these factors are extreme environmental conditions and potential weaknesses in the planning process as well as the initial design of the project, including the selection of the type of bridge used. In addition, there are significant limitations in the implementation of mitigation and maintenance efforts that should be carried out on an ongoing basis. In other words, this failure is the result of many elements interacting with each other, all of which contribute to the problems that occur in the road infrastructure.

Re-Risk Assessment Based on SNI IEC/ISO 31010:2016

The re-risk assessment process carried out on potential malfunctions on the Wakal-Taeno Road refers to the guidelines set out in SNI ISO/IEC 31010:2016. In order to carry out this assessment, there are several important stages that must be passed, namely risk identification, analysis of the probability and possible impacts, and ending with a comprehensive risk evaluation.

Risk Identification

Through a systematic retrospective analysis approach and the use of data from visual inspections, the process of identifying key risks that could affect the functionality of Jalan Wakal-Taeno is carefully carried out. The techniques used to identify these risks include the use of checklists drawn from the results of field observations and relevant public reports. In addition, failure and impact mode analysis (FMEA) is also applied to better understand the potential for failure and the consequences that may arise from such failures. In this way, it is hoped that a clearer picture can be obtained of the existing risks and the mitigation measures that need to be taken to ensure that the road is maintained.

Table 1. Results of Risk Identification Using Checklist and FMEA Techniques

No.	Risk (Failure Mode)	Failure Description (Effect)	Identification Technique	Data Source
1.	Bridge Collapse (Structural and Functional)	The bridge collapses or experiences significant settlement, causing a complete breakdown of road access, economic losses, and potential casualties.	FMEA, Checklist	Visual Inspection, Public Reports

No.	Risk (Failure Mode)	Failure Description (Effect)	Identification Technique	Data Source
2.	Slope Landslide (Upper & Lower Slopes)	Landslides from upper or lower slopes cover the road body and/or drainage channels, disrupting or cutting off access, and endangering users.	FMEA, Checklist	Visual Inspection, Public Reports
3.	Premature Pavement Degradation	Road surface damage (such as cracks, potholes, deformation) occurring faster than the design life, reducing user comfort and safety, and requiring more frequent maintenance costs.	FMEA, Checklist	Visual Inspection, Public Reports
4.	Drainage System Failure	Clogging or damage to drainage channels causes water pooling on the road surface, accelerating pavement damage, triggering landslides, and disturbing soil stability.	FMEA, Checklist	Visual Inspection, Public Reports
5.	Bridge Abutment Instability	Movement or settlement in the bridge abutment causing significant unevenness between the bridge and the road body, endangering users, and potentially triggering the bridge's own failure.	FMEA, Checklist	Visual Inspection, Public Reports

Probability and Impact Analysis

Each identified risk was analyzed using a consequence/probability matrix, based on a classification adapted from SNI ISO/IEC 31010:2016 and the Risk Management Guidelines of the Directorate General of Highways.

Table 2. Risk Analysis Results

No.	Risk	Probability (P)	Impact (D)	Risk Level (P x D)	Risk Category
1.	Bridge Collapse	High (4)	Catastrophic (5)	20	High
2.	Slope Landslide	Very High (5)	Major (4)	20	High
3.	Premature Pavement Degradation	Moderate (3)	Moderate (3)	9	Low
4.	Drainage System Failure	High (4)	Moderate (3)	12	Moderate
5.	Bridge Abutment Instability	High (4)	Major (4)	16	High

Note: Risk Category based on the Risk Management Guidelines of the Directorate General of Highways: Low (Acceptable): ≤ 9 ; Medium (Critical): 10 - 15; High - Very High (Unacceptable, Planning Adjustment Needed): 16 - 25.

Risk Evaluation

Based on the results of the analysis, the calculated risk level will be compared with the risk tolerance criteria to determine the priority of treatment. Risks with high or very high levels will be the main focus for mitigation formulation.

Table 3. Risk Evaluation of Risk Analysis Results

No.	Risk	Risk Level (P x D)	Category Risk	Implications/Priorities of Action
1.	Bridge Collapse	20	Tall	Unacceptable, requiring immediate planning adjustments or mitigation measures.
2.	Cliff Slide	20	Tall	Unacceptable, requiring immediate planning adjustments or mitigation measures.
3.	Early Pavement Degradation	9	Low	Acceptable, but still requires monitoring.
4.	Drainage System Failure	12	Keep	Critical, requiring mitigation.

No.	Risk	Risk Level (P x D)	Category Risk	Implications/Priorities of Action
5.	Instability of the Bridge Oprit	16	Tall	Unacceptable, requiring immediate planning adjustments or mitigation measures.

Discussion

A systematic retrospective analysis and risk assessment showed that the failure in the functioning of the Wakal-Taeno Road, which was mainly reflected in the incidents of bridge collapses and the occurrence of repeated avalanches, was the result of a complex interaction between extreme environmental factors and possible weaknesses in the planning and implementation process of the project. A road that has just been completed and is still under maintenance should not suffer such a significant functional failure in a relatively short period of time. This condition indicates that the risk assessment carried out at the planning and design stage may have underestimated the severity of the risks related to geology and hydrology at the site, or it could be due to the choice of solution taken (such as the use of a wooden Bailey bridge) that turned out to be not strong enough to meet the challenges of existing environmental conditions.

The implementation of SNI ISO/IEC 31010:2016 makes it possible to identify and categorize risks in a more structured way. By utilizing a matrix that connects probabilities and impacts, risks that are considered critical, such as bridge collapses, avalanches, and instability in the oprit, can be better prioritized. This standard provides a holistic and systematic framework in risk management, which has proven effective for identifying and managing risks in construction projects, as seen in new shipbuilding case studies. In the context of the Wakal-Taeno Road, this approach provides insight that the ongoing maintenance efforts, such as the stockpiling and repair of gabions, although they have an important role, are not enough to solve the root of the problem of ongoing geological and hydrological instability. This confirms that temporary or reactive solutions will not be able to guarantee the sustainability of road functionality in the long term.

A comparison with previous studies shows that although there have been applications of visual inspections and public reports (such as APZARD and INVI-J) to monitor damage to roads, the case of Jalan Wakal-Taeno emphasizes the importance of a deeper integration of such monitoring data with a comprehensive risk management framework, starting from the planning stage. Case studies on other construction failures, such as coastal safety buildings, also highlight the importance of conducting thorough geotechnical and hydrodynamic surveys and designing systems that are adaptive to extreme local conditions. The failures experienced by the Wakal-Taeno Road are a clear example where a lack of a deep understanding of environmental risks or inadequate implementation of solutions can lead to the premature failure of newly built infrastructure.

Table 4. Recommendations for Corrective and Preventive Actions Against Risk

No.	Risk	Corrective Action	Preventive Measures
1.	Bridge Collapse (Structural and Functional)	Rebuild the bridge with a sturdy permanent design and durable materials, considering extreme geological and hydrological conditions. Emergency repairs to restore temporary	In-depth geotechnical and hydrological surveys prior to redesign/development. Bridge design that is adaptive to soil movement and high rainfall. Real-time bridge structural monitoring system. Routine inspection and preventive

No.	Risk	Corrective Action	Preventive Measures
		access (e.g., a stronger Bailey bridge or a safe alternative lane).	maintenance of the bridge structure and its foundation.
2.	Longsor Tebing	Quick and efficient cleaning of avalanche materials. Repair of slopes that are landslides with strong stabilization techniques (e.g., retaining walls, terraces, soil nailing).	Identify and map landslide-prone zones in detail. Application of permanent slope reinforcement techniques (e.g., geotextiles, erosion-resistant vegetation, subsurface drainage). Landslide early warning system. Management of vegetation on slopes to improve soil stability.
3.	Early Pavement Degradation	Repair of surface damage (cracks, holes, deformations) as per road maintenance standards (e.g., patching, sealing cracks, overlay).	Pavement design that is adaptive to moving subsoil conditions and water exposure. The use of high-quality pavement materials and resistance to extreme environmental conditions. Improving the quality of pavement construction implementation. Regular maintenance program and periodic visual inspections for early detection.
4.	Drainage System Failure	Repair of damaged or clogged drainage channels (e.g., replacement of broken segments, sediment cleanup).	The drainage system design is adequate for high rainwater volumes and resistance to soil movement. The construction of an integrated drainage channel with slope reinforcement. Regular drainage cleaning and maintenance programs. Periodic inspections to ensure there is no blockage or damage.
5.	Instability of the Bridge Oprit	Repair of oprit that is experiencing decline or movement with proper restocking and compaction. Reinforcement of oprit structures (e.g., by ground reinforcement or retaining structures).	Oprit design that considers unstable subsoil conditions and potential movement. Construction of equipment with materials and methods that ensure long-term stability. Effective drainage system around the oprit to prevent soil erosion and saturation. Periodic monitoring of oprit deformation.

Validation of Research Results

Validation in the context of qualitative research is a very important process that aims to check and confirm both the accuracy and validity of the data, and the findings produced. This process involves a systematic assessment of both the process, and the results of the research conducted, to ensure that they are trustworthy, credible, and applicable in a broader context. By ensuring that the validity of the research is maintained, the results obtained will be more easily accepted by various parties, ranging from academics, government agencies, to the public.

There are several verification or validation techniques that are commonly used in qualitative research and are particularly relevant to these studies, including:

- Triangulation: this technique involves using a variety of data sources, researchers, or methods to validate existing findings.
- Data triangulation: in this case, researchers use various data sources, such as interviews, field observations (visual inspections), and documents (e.g. public reports and scientific journals), to ensure the accuracy of the findings. In this study, the primary data obtained from visual inspection will be confirmed with secondary data derived from news reports and government reports.
- Researcher triangulation: this technique involves the involvement of multiple researchers in the process of data collection and analysis to reduce the likelihood of individual bias.

Although this research may be conducted by one principal investigator, discussions and consultations with supervisors or other experts can serve as an effective form of researcher triangulation.

- d. **Methodological triangulation:** in this technique, various research methods, such as descriptive analysis, RCA, and risk assessment, are used to examine the same phenomenon. This research has integrated descriptive analysis, RCA, and risk assessment based on the SNI ISO/IEC 31010:2016 standard.
- e. **Member Checking / Respondent Validation:** this technique involves verifying research findings with participants or relevant parties to ensure that the results obtained truly reflect their experiences and perspectives. In the context of this research, this process can be carried out by presenting the results of the analysis, such as the identification of failures and causative factors, to related parties, such as representatives from BPJN, local governments, or even representatives of the road user community, to get feedback and confirmation of the existing findings.
- f. **Peer Debriefing:** This technique aims to get feedback from peers or fellow researchers regarding the research process and findings. This process is very helpful in identifying potential biases and assumptions that may exist, as well as improving the clarity and coherence of the research report that is compiled.
- g. **Reflexivity:** this is the process by which the researcher acknowledges and examines the biases, assumptions, and influences that the researcher may have on the research being conducted. One way to do this is to keep a reflective journal that contains documentation of thoughts, feelings, and decisions made during the research process.
- h. **Documentation:** it is important to document each step in the research process, including notes regarding the decisions taken, actions taken, and the reasons behind them. This aims to provide a transparent record of the methodology used and the findings obtained from the research.
- i. **Transparency:** researchers must be open about the methodology used in the research and the limitations that exist. In addition, the researcher must also provide a clear and concise description of the process and findings of the research conducted.

Table 5. Research Validation Techniques and Their Contribution to Admission

No.	Validation Techniques	Description	Contribution to Revenue
1.	Data Triangulation	Using a variety of data sources (visual inspections, public reports, scientific journals) to confirm findings.	Improve the reliability and credibility of findings by demonstrating the consistency of information from various sources.
2.	Researcher Triangulation	Involve multiple researchers or experts in the data analysis process (e.g., discussions with supervisors/experts).	Reduce individual bias and strengthen the objectivity of data interpretation.
3.	Methodological Triangulation	Using a variety of analytical methods (descriptive, RCA, risk assessment) to examine the same problem.	Provide a more comprehensive and in-depth understanding of the phenomenon being studied.
4.	Member Checking	Verifying findings and interpretations with relevant parties (BPJN, local governments, communities).	Ensuring the accuracy of the representation of the experience and the perspective of the relevant parties, increasing validity and trust.

No.	Validation Techniques	Description	Contribution to Revenue
5.	Peer Debriefing	Getting feedback from colleagues or fellow researchers on research processes and findings.	Identify potential biases, refine arguments, and improve report quality.
6.	Reflexivity	Acknowledge and examine the researcher's own biases and assumptions during the research process.	Increase transparency and scientific honesty, build reader trust.
7.	Documentation and Transparency	Document all stages of research and present methodologies and findings clearly and openly.	Enable study replication and audit of research processes, strengthening reliability and trust.

By applying these various validation techniques, this research is expected to increase credibility and trust in the results obtained. This will also ensure that the interpretation carried out by the researcher is accurate, as well as providing an opportunity for relevant parties to clarify or correct existing findings. Ultimately, this approach will support the generalization of the findings to a broader context and make the research more acceptable to a wide range of groups.

CONCLUSION

This study conducted a retrospective analysis and risk reassessment of the functional failures of the Wakal-Taeno Road on Ambon Island, Maluku, using visual inspection data, public reports, and the *SNI ISO/IEC 31010:2016* framework. Key failures included access disconnection due to bridge collapse, landslide vulnerability causing repeated closures, and structural issues with the temporary Bailey bridge and its approaches. These failures were mainly attributed to highly vulnerable geological and hydrological conditions, suboptimal material and design choices, and gaps in initial risk assessments and mitigation during planning and construction. Existing maintenance efforts have been insufficient to address underlying geological instability. The risk reassessment identified bridge collapse, landslides, and approach instability as high and unacceptable risks requiring urgent mitigation, while drainage failures and pavement degradation were categorized as medium and low risks, respectively. This standards-based approach facilitated clearer prioritization of risk management strategies to restore and sustain road functionality. Future research should explore the integration of advanced geotechnical monitoring technologies and community-based early warning systems to enhance adaptive risk management for infrastructure in highly dynamic environments.

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