



Infrastructure Condition on Sustainable Tourism in Tsunami-Prone Areas: A Case Study of West Nias, North Sumatera

Edison Reinkarnasi Gulo*, Mahawan Karuniasa, Sri Setiawati Tumuyu

School of Environmental Science, Universitas Indonesia, Jakarta, Indonesia 10430.

Email Correspondence: edison.reinkarnasi@ui.ac.id

Abstract

Coastal tourism destinations in Indonesia offer substantial economic benefits but are highly vulnerable to tsunami hazards. Limited studies have integrated tourism infrastructure assessment, disaster-mitigation infrastructure assessment, and spatial analysis to support sustainable tourism planning in high-risk coastal areas. This study evaluates the condition of tourism and tsunami-mitigation infrastructure at Sirombu Beach, West Nias Regency, North Sumatera, Indonesia. A mixed-method approach was employed, combining field observations, questionnaire surveys, stakeholder interviews, and GIS-based spatial analysis. Data were collected from 66 community respondents, 96 tourists, and six key stakeholders. Infrastructure was assessed using a framework consisting of 12 tourism infrastructure components and three disaster-mitigation infrastructure categories. The results show that tourism infrastructure remains inadequate, with only 6 of 12 assessed components available (50%). Several facilities, including road access, public toilets, gazebos, and the Tourist Information Center (TIC), were damaged or poorly maintained. Disaster-mitigation infrastructure was even more limited, with only one of three infrastructure categories available (33.33%), while evacuation routes, assembly points, and disaster signage were absent. Respondents identified road accessibility and disaster preparedness facilities as the highest development priorities. The findings highlight the need for integrated tourism and disaster-risk-reduction planning through improved road access, sanitation facilities, waste management systems, evacuation infrastructure, and coastal protection measures to enhance the sustainability and resilience of tsunami-prone tourism destinations.

Keywords: Tsunami; Infrastructure; Tourism; Sustainable.

How to Cite: Gulo, E. R., Karuniasa, M., & Tumuyu, S. S. (2026). Infrastructure Condition on Sustainable Tourism in Tsunami-Prone Areas: A Case Study of West Nias, North Sumatera. *Empiricism Journal*, 7(2), 1871-1882. <https://doi.org/10.36312/ej.v7i2.5425>



<https://doi.org/10.36312/ej.v7i2.5425>

Copyright© 2026, Gulo et al.

This is an open-access article under the [CC-BY-SA](#) License.



INTRODUCTION

Tourism has become a strategic sector in global and national economic development. UNWTO (2019) said that tourism sector contributed to about 4% of the world's GDP or about \$3.4 trillion in 2019. Tourism has become an important source of economic continuity and financial sustainability for many countries, including developed countries (Agarwal et al., 2024). In Indonesia, tourism is a priority for national development, Ministry of Tourism and Creative Economy (2025) said that foreign exchange income from the tourism sector in Indonesia in 2024 will reach 202 trillion in rupiah. In addition, the tourism sector makes a significant contribution to creating jobs, as many as 25.8 million workers are absorbed in the tourism sector in Indonesia.

Indonesia is an archipelagic country rich in natural and cultural resources with great tourism potential. Indonesia has the longest coastline in the world after Canada, reaching 58,133 km (Syetiawan et al., 2020). The long coastline has the potential to be a beach tourist destination that can attract tourists around the world. According to the Katadata Insight Center (KIC) (2022), as many as 48.6% of Indonesian tourists are like beach and sea as a destination. The potential of marine tourism, including beach tourism, is one of the main strengths of Indonesia's tourism sector (Yahya et al., 2025). However, the coastal tourism sector in Indonesia is very vulnerable to natural disasters, especially tsunamis and earthquakes (Pahleviannur et al., 2020). Coastal areas that have great potential for natural disasters (Purwanto et al., 2017). Natural disasters are considered as things that can make tourists uncomfortable when visiting an area (Yumantoko, 2019). Indonesia has a high risk of tsunami disasters (Ibrahim et al., 2023). Tsunamis, high waves, and extreme weather pose threats that can increase risks and reduce tourists' intention to visit coastal areas (Rahmafritia et al., 2024).

Indonesia has 10 histories of natural disasters such as earthquakes and tsunamis that have caused thousands of casualties. One of the biggest tragedies was the Aceh tsunami in 2004 which caused 227,898 (BMKG, 2019). Various disasters in Indonesia have damaged tourist destinations, physical damage can be seen in buildings such as hotels, restaurants, roads, and public facilities needed by tourists (Berliandaldo et al., 2023; Mustafa et al., 2025). One of the main challenges in the development of beach tourism is the limitation of infrastructure, because without adequate facility support, the beauty of nature is not enough to attract tourists (Yahya et al., 2025), solid infrastructure and a well-organized mitigation system, communities will have better preparedness to deal with disasters and be able to accelerate recovery after disasters occur (Mustafa et al., 2025).

Sirombu Beach in West Nias Regency is one of the tourist destinations that has great natural potential, with beautiful beach panoramas, white sand, underwater richness, and waves that are suitable for surfing activities that attract local and foreign tourists. However, on December 26, 2004 at 7:58 a.m. WIB, a tsunami disaster and an earthquake with a magnitude of 9.3 occurred off the coast of Aceh in the Indian Ocean (Tarigan, 2005). This disaster caused severe damage in Sirombu District, including the destruction of many houses and buildings.

Research on coastal tourism in Indonesia has extensively examined destination attractiveness, tourism competitiveness, and visitor behavior. Meanwhile, studies concerning tsunami mitigation have generally focused on hazard assessment, evacuation planning, and disaster risk reduction. However, the intersection between tourism infrastructure readiness and tsunami-mitigation infrastructure remains insufficiently explored, particularly in small island and peripheral coastal destinations. As a result, there is limited empirical evidence regarding how existing infrastructure conditions influence the sustainability and resilience of tourism destinations exposed to tsunami hazards. Addressing this gap is essential for developing integrated planning strategies that simultaneously support tourism growth and disaster preparedness.

According to the Indonesian Disaster Risk Index (Badan Nasional Penanggulangan Bencana, 2023), West Nias Regency was recorded as having a score of 24.00, which shows the tsunami risk class in the high category. The potential of tsunami disasters in the Sirombu Beach destination shows that efforts to develop sustainable beach tourism destinations are very important. Therefore, this study aims to analyze the condition of Sirombu Beach tourism infrastructure and disaster infrastructure as a basis for planning and strengthening destination readiness in facing tsunami disasters and creating sustainable beach tourism.

METHOD

Study Area

This research was conducted in the Sirombu Beach as a tourism destination, which is administratively located in Sirombu Village, Sirombu District, West Nias Regency, North Sumatra Province, Indonesia (Figure 1). Geographically, Sirombu Beach is located at the coordinates of 1°31' N and 97°27' E, directly adjacent to the Indian Ocean. This beach is known for its natural beauty, sunset views, and waves which are used for surfing tourism activities by local and foreign tourists.

Sirombu Beach was purposively selected as the case study for four main reasons. First, the area possesses significant tourism potential characterized by coastal scenery, surfing attractions, and cultural tourism activities. Second, West Nias Regency is classified as a high tsunami-risk area according to the Indonesian Disaster Risk Index (BNPB, 2023). Third, the area experienced substantial impacts from the 2004 Indian Ocean tsunami, resulting in damage to settlements and public infrastructure. Fourth, despite its tourism potential, preliminary observations indicated limitations in tourism-supporting facilities and disaster-mitigation infrastructure. These characteristics make Sirombu Beach an appropriate case for examining infrastructure readiness for sustainable tourism development in tsunami-prone coastal areas.

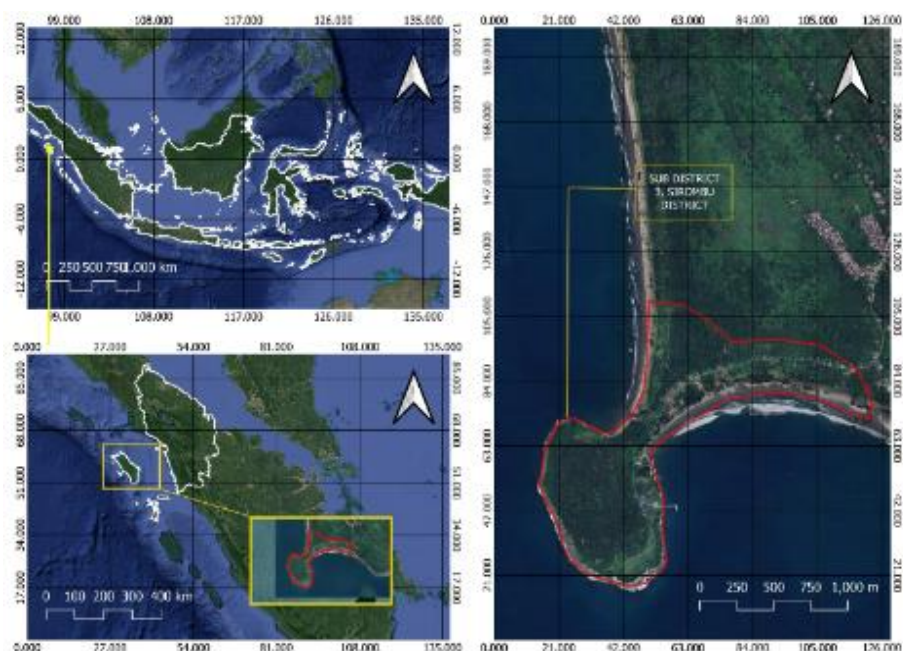


Figure 1. The map of Sirombu Beach, West Nias Regency, North Sumatera Province

Sirombu Village is dominated by plantation land, primarily coconut plantation. In addition, residential areas are located along the roads near the beach. Sirombu Village also has a port and a river estuary. Overall, the Sirombu sub-district is characterized by its extensive land area. The region is categorized as having a high earthquake risk (11,764 ha) and a high tsunami risk (5,484 ha), with tsunami hazards classified as high risk with a risk value of 24.00.

Research Design

This study employed a mixed-method approach integrating field observations, questionnaire surveys, stakeholder interviews, document reviews, and Geographic Information System (GIS)-based spatial analysis. The integration of multiple data sources enabled triangulation of findings and provided a comprehensive assessment of tourism infrastructure and disaster-mitigation infrastructure conditions.

Data Collection

Data collection was carried out through observations, questionnaires, literature reviews, and interviews from October 2024 to March 2025. The data used consisted of primary and secondary data. Secondary data was obtained from documents related to the Sirombu Beach and tourism, journal articles, statistical reports, and relevant scientific research. Meanwhile, primary data was collected directly through field observations and questionnaires completed by the community and tourists to assess their perspectives on the destination's current conditions. Direct observations were conducted to identify and assess the physical condition of tourism infrastructure and disaster-mitigation infrastructure. Observation focused on accessibility, accommodation facilities, sanitation facilities, tourism services, coastal protection structures, evacuation facilities, warning systems, environmental cleanliness, and supporting public facilities. Observation results were documented using field notes, photographs, and georeferenced coordinates collected using handheld GPS devices.

Questionnaire surveys were administered to local community members and tourists visiting Sirombu Beach. Community respondents consisted of residents living within the coastal area of Sirombu Village, particularly those residing in Hamlet III and surrounding settlements directly exposed to tsunami hazards. Inclusion criteria included: (1) minimum age of 18 years; (2) residency in the study area for at least five years; and (3) willingness to participate in the study. A total of 66 community respondents were selected using purposive sampling to ensure representation of residents familiar with local tourism activities and disaster risks. Tourist respondents were selected using incidental sampling, whereby visitors encountered during the survey period were invited to participate voluntarily. Surveys were conducted on both weekdays and weekends to capture differences in visitor characteristics.

A total of 96 tourist respondents participated, consisting of 17 respondents surveyed on weekdays and 79 respondents surveyed on weekends.

The authors acknowledge that incidental sampling may limit the representativeness of tourist perceptions because respondents were selected based on their availability during the survey period. Nevertheless, this approach was considered appropriate given the fluctuating number of visitors and the exploratory nature of the study. The questionnaire utilized a four-point Likert scale consisting of: 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree. The instrument contained three main constructs: 1) Tourism infrastructure condition; 2) Disaster-mitigation infrastructure condition; and 3) Infrastructure development priorities. Indicators of tourism infrastructure included road accessibility, parking facilities, accommodation, sanitation facilities, public amenities, information services, environmental cleanliness, and tourism management. Indicators of disaster-mitigation infrastructure included tsunami warning systems, evacuation routes, evacuation assembly points, disaster signage, coastal protection structures, and emergency preparedness facilities. Prior to data collection, the questionnaire was reviewed by three experts in tourism planning and disaster management to assess content validity. Internal consistency reliability was evaluated using Cronbach's Alpha, with a coefficient 0.81 (>0.70) considered acceptable.

Stakeholder Interviews

Semi-structured interviews were conducted to obtain in-depth information regarding infrastructure development, tourism management, and disaster preparedness policies. A total of six key informants were interviewed, consisting of representatives from West Nias Tourism Office, West Nias Regional Disaster Management Agency (BPBD), Public Works and Housing Office, Village Government of Sirombu, Community leaders, and Tourism business operators. Interview questions focused on existing infrastructure conditions, development priorities, institutional constraints, disaster preparedness programs, and future planning strategies. All interviews were recorded with participant consent and subsequently transcribed. Data were analyzed using thematic content analysis involving coding, categorization, and theme development. Interview findings were triangulated with observation results, survey responses, and spatial analysis outputs to improve data validity and reliability.

Infrastructure Analysis

The analysis of infrastructure conditions in the Sirombu Beach Tourism destination was carried out based on a direct review of observations, questionnaires, literature studies, and interviews and then supported by spatial analysis using land use analysis maps at the research location and descriptive statistical analysis of the results of the questionnaire obtained. The presentation and interpretation of the results will be carried out using ArcGIS software to show infrastructure locations that support sustainable tourism sustainability in tsunami-prone locations, such as evacuation zones, evacuation zones, and other tourism infrastructure facilities. The analysis will be conducted by considering the existing conditions at the Sirombu Beach tourism destination to evaluate its suitability for developing the conceptual framework of environmental aspects and current land use. GIS software will be utilized not only for infrastructure location analysis but also for mapping the existing conditions and geographical characteristics of the study area, including the mapping of potential hazards at Sirombu Beach. The questionnaire data will be analyzed using descriptive analysis.

Spatial analysis was performed using ArcGIS software. Spatial datasets included administrative boundary maps, land-use maps, coastal zone maps, transportation networks, disaster-risk maps obtained from BNPB, satellite imagery, and GPS coordinates collected during field surveys. All spatial datasets were projected using the Universal Transverse Mercator (UTM) coordinate system, Zone 47N, WGS 1984 datum. The GIS analysis consisted of four stages: 1) Compilation and georeferencing of spatial datasets; 2) Mapping of tourism infrastructure and disaster-mitigation infrastructure locations; 3) Overlay analysis between tourism infrastructure distribution, land-use patterns, and tsunami hazard zones; 4) Identification of infrastructure gaps and potential areas for evacuation routes, assembly points, conservation zones, and tourism development. The resulting maps were used to visualize the spatial relationship between tourism facilities, hazard exposure, and disaster preparedness infrastructure.

RESULTS AND DISCUSSION

Tourism Infrastructure

The Sirombu Beach tourism destination, located in Sirombu Village, Sirombu District, West Nias Regency, is supported by various infrastructures that facilitate both community activities and tourist needs. Access to the beach is primarily available by land from Binaka Airport, an airport that serves only domestic flight routes. International tourists who wish to visit this destination must transit through Medan. In addition, the Port of Gunungsitoli also serves domestic routes connecting nearby islands, Medan, and Sibolga.

A variety of facilities are provided to support tourist activities at Sirombu Beach, including gazebos for relaxation, a stage commonly used for art and cultural performances, a Tourist Information Center (TIC), and public restrooms. For visitors who wish to stay longer, several accommodation options are available, such as Homestay RPJ, Homestay ToZeroBeach, and Homestay MarcoBeach. In addition, there are restaurants and the Avalokitesvara Temple.

The Sirombu Beach Port also plays an important role in supporting sea transportation and contributing to the economic activities of the surrounding community. The tourism infrastructure points at Sirombu Beach are illustrated in Figure 2.

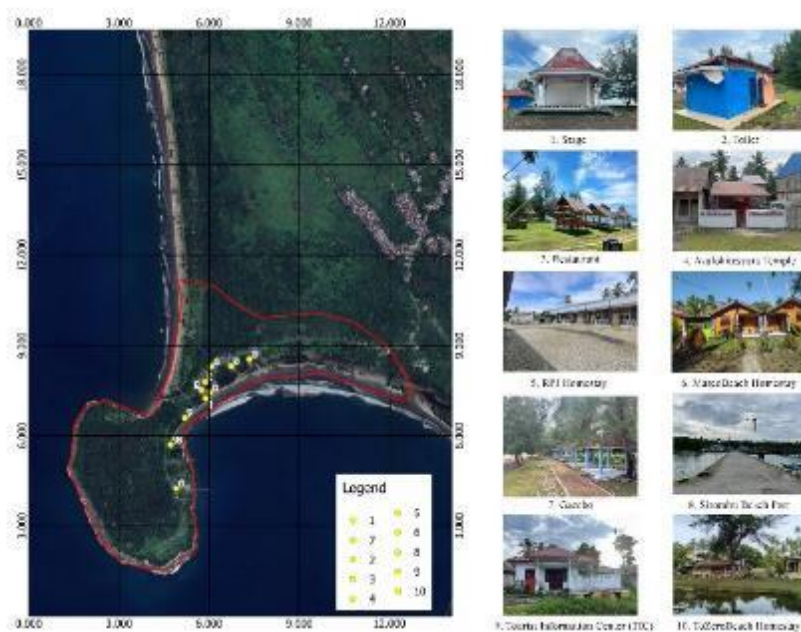


Figure 2. Existing tourism infrastructure

Sirombu Beach has 41 gazebos intended for visitors; however, 17 of them are damaged and abandoned, rendering them unusable. In addition, there is a stage that is frequently used for various cultural events in West Nias Regency, such as the Aekhula Festival, Aekhula Manari, and other local art and cultural performances.

Besides the gazebos and stage, the site also has a Tourist Information Center (TIC). However, this facility is poorly maintained due to the absence of a designated manager. Structurally, the building remains usable; nevertheless, the lack of maintenance has caused the paint to fade and moss to grow on the walls. Overgrown grass reaching the windows further reflects the neglected condition of the facility.

Sirombu Beach is also equipped with a parking area to support visitor convenience. There is a pedestrian pathway made of interconnected concrete paving blocks. However, several sections are damaged and overgrown with weeds due to inadequate maintenance, thereby reducing the comfort and aesthetic quality of the tourist area. The toilets are in a severely damaged condition and are no longer functional, including a deteriorated roof that makes them unsafe and difficult to use. This situation poses challenges for visitors, particularly after swimming, as there are no adequate facilities for rinsing and changing clothes. Consequently, many tourists are compelled to use toilets in nearby restaurants by paying a fee of IDR 2,000 (approximately USD 0.12).

Observations also indicate that the road leading to Sirombu Beach is damaged at several points. The damage varies from cracks and peeling asphalt to large potholes, which

hinder accessibility for both local residents and tourists. In addition to physical infrastructure issues, the cleanliness of Sirombu Beach remains a serious concern. Observational findings reveal a significant accumulation of waste that pollutes the environment and diminishes the aesthetic value of the destination. Furthermore, cattle allowed to roam freely by local resident scatter animal feces throughout the area, causing unpleasant odors. Although a village regulation prohibits the release of livestock in coastal areas, its implementation has not been effective due to weak enforcement. The absence of regularly assigned cleaning personnel further contributes to the increasing accumulation of waste. Moreover, the lack of waste management facilities, such as trash bins and an adequate transportation system, encourages littering by visitors. In addition to hard infrastructure, Sirombu Beach also possesses elements of soft infrastructure, including cultural initiatives such as the Aekhula Charm Festival (FPA), which aims to promote regional culture, support community empowerment, and enhance tourist attractions, but also very limited.

Overall, Sirombu Beach has limited tourism facilities and infrastructure; stage, parking area, gazebos, pedestrian pathways, roads (in damaged condition), homestays, a church, restaurants, toilets (damaged), and a Tourist Information Center (TIC), most of which are inadequately maintained due to the absence of management. These findings are supported by an interview with the West Nias Public Works and Public Housing Office, which stated that *“Yes, currently the infrastructure at Sirombu Beach is still very limited, the road to tourist locations from the airport and port is very damaged, and the connectivity road between districts/cities is also damaged. I went there yesterday to see the toilets is damaged, there is no management there”*

Infrastructure for Disaster Mitigation

Sirombu Beach Tourism Destination has a high level of tsunami disaster risk, equipped with disaster infrastructure sharing to reduce the potential impact of disasters. There are breakwaters built to the west of the destination as protection against high waves and breakwaters to reduce abrasion and protect vegetation and residential areas. In addition, there is a tsunami alarm that functions to provide information on potential tsunami disasters to the public and tourists. The existence of disaster infrastructure at Sirombu Beach can be shown in Figure 3.

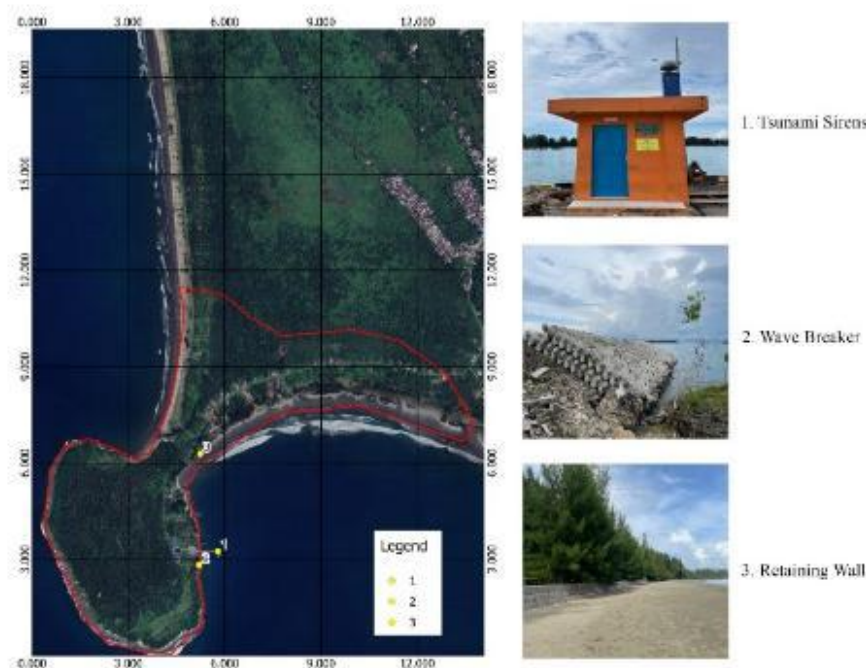


Figure 3. Infrastructure for tsunami mitigation

The construction of a breakwater in West Nias Regency began in 2023 and was completed in December 2024, with a total length of 98 meters. Furthermore, in 2025, an additional 182 meters of construction is planned to further strengthen coastal protection against disaster risks, especially tsunami.

An abrasion-prevention seawall has been constructed along the coastline of Sirombu Beach, with a height of approximately 60 cm above the ground surface. Portions of the seawall are designed in the form of steps, allowing them to function as seating or resting areas for visitors. The tsunami early warning siren located at Sirombu Beach belongs to the Sirombu Class III Port Operator Unit Office and is not part of the official tourist destination facilities. However, the siren has a sound range of up to 5 km from the port, enabling it to be heard by both tourists and local residents in the surrounding area.

Despite these developments, several essential disaster-related infrastructures are still absent at Sirombu Beach. These include the lack of designated evacuation routes, evacuation assembly points, disaster signage, and the absence of coast guards or safety personnel to monitor tourism activities and provide guidance. This condition indicates the need for additional disaster mitigation infrastructure to ensure the safety and comfort of both the local community and tourists engaging in activities at Sirombu Beach.

These findings are supported by an interview with the West Nias Regency Tourism Office, which stated that disaster preparedness remains minimal. Specifically, evacuation routes have not yet been established. The office has communicated this issue to the Regional Disaster Management Agency; however, no follow-up action has been taken, despite the importance of such infrastructure. The inadequacy of disaster-related infrastructure is further evidenced by an interview with the West Nias Regional Disaster Management Agency, which indicated that no physical infrastructure programs are currently being implemented. The agency faces significant budget constraints, with an annual allocation of less than IDR 1 billion. Consequently, planned initiatives, including the installation of disaster signage at Sirombu Beach, have not yet been realized due to limited and fluctuating funding.

In general, the existing infrastructure in the Sirombu Beach Tourism Destination is still very lacking and needs to be restructured. All the observations and interviews results is supported by the results of a questionnaire on the surrounding community and visiting tourists shown in Figure 4.

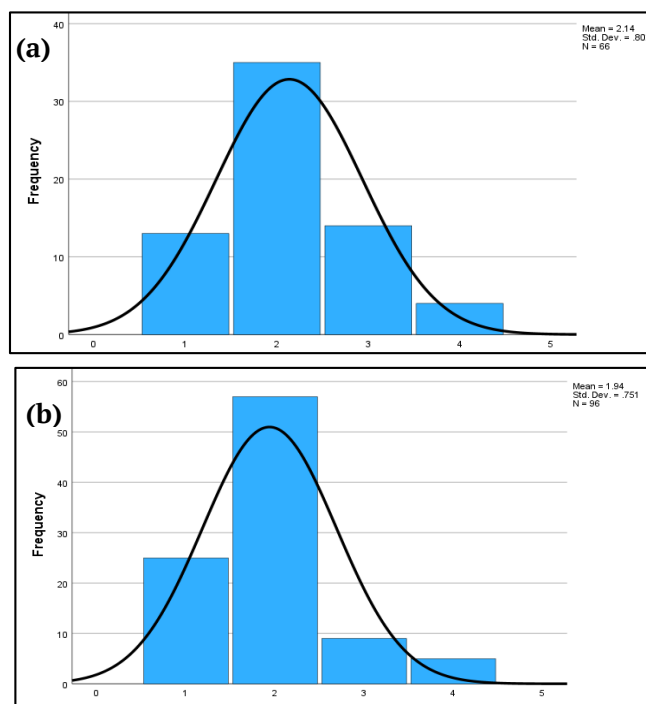


Figure 4. The perceptions about existing facility in Sirombu Tourism Destination: (a) Community; (b) Tourists

Figure 4 shows that the majority of community and tourist respondents strongly disagree and disagree (choosing numbers 1 and 2) that tourist destination facilities and infrastructure arrangements in general are in good condition. This shows that in general, the condition of facilities and infrastructure arrangements based on respondents' perceptions are in poor condition and require restructuring or improvement. The problems of Sirombu Beach tourist destinations based on the perception of tourists who visit are shown in Table 1.

Table 1. Sirombu Tourism Destination problems based on respondent perceptions

Problems	Quantity (People (community))	Quantity (People (tourist))
Environmental cleanliness	50	61
Gathering place (hall)	6	6
Parking	1	5
Toilet	1	7
Restaurant	0	1
Temple	2	2
Accommodation	0	2
Disaster infrastructure	6	10
Other	0	2
Total	162	

Table 1 shows that the majority of respondents are agree that that the main problem of Sirombu Beach tourist destinations is related to environmental cleanliness, namely as many as 61 respondents (tourist) and 50 respondents (community), the second most choose disaster infrastructure, namely as many as 10 respondents (tourists) and 6 respondents (community). The perception of respondents regarding the priority of improving facilities and infrastructure needed by Sirombu beach is shown in the Table 2.

Table 2. Priority infrastructure and facility improvements according to respondents

Improvement Priorities	Quantity (People)	Percentage
Tourists		
Road (Access to location)	28	29%
Parking	14	15%
Toilet	15	16%
Trade (souvenir shops, food stand)	5	5%
Accommodation	6	6%
Disaster facilities	28	29%
Total	96	100%
Community		
Road (Access to location)	38	57%
Parking	3	5%
Trade (souvenir shops, food stand)	4	6%
Disaster facilities	21	32%
Total	66	100%

Table 2 shows that based on the perception of tourists who visit Sirombu Beach, the priority for improving facilities and infrastructure is roads (access to the location) and disaster facilities, which are 29% or 28 respondents each, followed by bathrooms (16%) and parking lots (15%) and These results are in line with the results of community perceptions: road access to tourist sites is the main priority to be improved, which is 58% and the second priority is disaster facilities, which is 32%.

The results of the perception of improvement priorities from the public and tourists show the same tendency that roads (access to tourist destinations) are the top priority and next is disaster facilities. Meanwhile, according to disaster experts from Meteorological, Climatological and Geophysical Agency, the main priority for repairs to infrastructure problems in disadvantaged areas is related to main infrastructure such as electricity, "*.... The problem is always infrastructure such as unstable electricity is our challenge, because we have to provide information using satellite and if we just using satellite as a main option all the costs will be soo expensive*". Mainly, infrastructure development has obstacles in the field of financing.

The results of this study indicate that tourism and disaster-related infrastructure at Sirombu Beach remains very limited compared to applicable standards. The condition of several tourism facilities is damaged and poorly maintained, including gazebos, the Tourist Information Center (TIC), roads, and toilets. Based on the classification of tourism infrastructure proposed by Jovanović et al. (2016), the existing infrastructure at Sirombu Beach fulfills five categories of physical infrastructure, namely lodging, dining facilities,

transportation, communication, water supply, and electricity. In terms of cultural infrastructure or non-structural infrastructure (Marasabessy & Nareswari, 2025), only one of the three identified elements is present, specifically cultural festivals. The other elements—such as cultural heritage exhibitions, art and music festivals, traditional attire and dances, as well as local language and cuisine are not comprehensively developed. Furthermore, service infrastructure, including banks, travel agencies, and tour guides, is absent. Security-related facilities, such as security posts, are also unavailable. Overall, only 6 out of the 12 infrastructure components (50%) identified in the classification are present at Sirombu Beach, encompassing both hard infrastructure and soft infrastructure.

The existing conditions indicate that disaster-related infrastructure at Sirombu Beach consists of seawalls, breakwaters, and a tsunami early warning siren. However, these findings are not fully aligned with the theoretical framework proposed by Hamouda et al. (2024), which emphasizes that the most critical tsunami mitigation strategies involve the implementation of zoning regulations, mapping of critical infrastructure, the provision of clearly designated evacuation routes and signage, identification of optimal evacuation sites, and the development of comprehensive disaster preparedness frameworks. Furthermore, the integration of advanced technologies such as urban planning systems, simulation modeling, and three-dimensional imaging is identified as an effective disaster management approach to reduce tsunami impacts. In addition, Kurosawa (2021) highlights that green infrastructure, such as coastal forests located along shorelines, represents an important alternative strategy for mitigating the impacts of tsunami disasters.

A multi-layered approach has been recognized as an effective strategy for mitigating tsunami impacts, consisting of preventive structures (e.g., breakwaters and sea embankments), spatial planning (e.g., retention areas), and management measures (e.g., evacuation zones and early warning systems) (Agussaini et al., 2022; Tarihoran et al., 2025)). Simulation studies also suggest that combining preventive infrastructure, coastal forests, and strategic road layouts provides the most effective mitigation. Ideally, tsunami-prone areas should implement at least three categories of disaster infrastructure (Oetjen et al., 2022)

However, Sirombu Beach currently possesses only one category—preventive structures such as seawalls and breakwaters—while critical components like evacuation routes, evacuation zones, and monitoring systems are absent. This gap not only increases the vulnerability of the area but also hinders the sustainability of coastal tourism in tsunami-prone regions. The lack of basic infrastructure, both at Sirombu Beach and in West Nias in general, further exacerbates this vulnerability. Interviews with the Tourism Office and the Regional Disaster Management Agency confirm that the development of disaster infrastructure is highly limited due to budget constraints. Questionnaire results support this finding, showing poor infrastructure conditions and highlighting the need for improvements in access roads, environmental cleanliness, and disaster preparedness facilities. These findings underscore the urgency of improving both basic and disaster-related infrastructure to support tourism development that in line with Apriyanti et al. (2024); Luthuli et al. (2021). Adequate infrastructure is essential not only for accessibility but also for enabling the interaction among places, people, cultures, and communities elements that are fundamental to sustainable tourism (Hesna et al., 2023)

For future research, it is recommended to conduct comprehensive studies on assessing the effectiveness of evacuation planning, early warning systems, and green infrastructure, as well as evaluating the economic and social impacts of improved facilities on local communities. Further studies could also explore community engagement in disaster preparedness and the role of technology, such as GIS mapping and real-time monitoring, to enhance the resilience and sustainability of coastal tourism in tsunami-prone areas.

CONCLUSION

This study evaluated the condition of tourism infrastructure and tsunami-mitigation infrastructure at Sirombu Beach Tourism Destination, West Nias Regency. The findings indicate that infrastructure readiness remains insufficient to support sustainable tourism development in a coastal area with high tsunami risk. Based on the assessment framework, only 6 of 12 tourism infrastructure components were available, representing an adequacy level of 50%.

Several existing facilities, including road access, public toilets, the Tourist Information Center (TIC), and gazebos, were found to be damaged or poorly maintained. Environmental cleanliness also emerged as a significant issue affecting the quality and attractiveness of the destination. In terms of disaster-mitigation infrastructure, the available facilities remain limited and are mostly structural, such as seawalls and breakwaters. However, essential evacuation-supporting facilities, including evacuation routes, assembly points, and disaster warning signage, are still absent.

Community and tourist perceptions confirmed the results of the field assessment. Road access improvement and disaster-mitigation infrastructure development were identified as the most urgent priorities. Therefore, the study concludes that tourism infrastructure development at Sirombu Beach must be integrated with disaster-risk-reduction strategies to improve destination safety, accessibility, environmental quality, and resilience.

RECOMMENDATIONS

Based on the findings, several recommendations are proposed. First, local government and relevant stakeholders should prioritize the improvement of road access to Sirombu Beach, as accessibility is a key factor in supporting tourism development and emergency evacuation. Second, existing tourism facilities, particularly public toilets, gazebos, and the Tourist Information Center (TIC), should be rehabilitated and maintained regularly to improve visitor comfort and destination quality.

Third, waste management systems need to be strengthened through the provision of adequate waste-disposal facilities, routine cleaning programs, and community-based environmental management. Fourth, tsunami-mitigation infrastructure should be developed more comprehensively by establishing clear evacuation routes, assembly points, disaster information boards, and warning signage in strategic locations. These facilities are essential to improve tourist and community preparedness in the event of a tsunami.

Fifth, coordination among government agencies, tourism managers, disaster-management institutions, and local communities should be enhanced to ensure that tourism development and disaster-risk-reduction planning are implemented in an integrated manner. Finally, future research should expand the scope of analysis by incorporating evacuation modeling, carrying-capacity assessment, and comparative studies across multiple coastal tourism destinations. Such studies are important to strengthen the understanding of sustainable tourism resilience in tsunami-prone areas.

ACKNOWLEDGEMENT

The author sincerely acknowledges the support and assistance provided by the local government of West Nias Regency; West Nias Regional Disaster Management Agency, the Public Works and Public Housing Office of West Nias, and the West Nias Regency Tourism Office.

REFERENCES

- Agarwal, R., Mehrotra, A., Mishra, A., Rana, N. P., Nunkoo, R., & Cho, M. (2024). Four decades of sustainable tourism research: Trends and future research directions. *International Journal of Tourism Research*, 26(2), 1–14. <https://doi.org/10.1002/jtr.2643>
- Agussaini, H., Sirojuzilam, Rujiman, & Purwoko, A. (2022). A New Approach of the Tsunami Mitigation Strategies for the City of Banda Aceh, Indonesia. *Indonesian Journal of Geography*, 54(1), 62–69. <https://doi.org/10.22146/ijg.66500>
- Apriyanti, M. E., Sumaryoto, & Meirinaldi. (2024). The Importance of Tourism Infrastructure in Increasing Domestic and International Tourism. *International Journal of Research in Vocational Studies (IJRVOCAS)*, 3(4), 113–122. <https://doi.org/10.53893/ijrvocas.v3i4.46>
- Badan Nasional Penanggulangan Bencana. (2023). Indeks Risiko Bencana Indonesia (IRBI) Tahun 2022. In *Pusat Data Informasi Komunikasi Bencana, BNPBBencana, BNPB* (Vol. 01). <https://inarisk.bnpb.go.id/BUKU-RBI-2022/mobile/index.html#p=10>
- Berliandaldo, M., Prasetyo, A., & Sakti, V. P. I. (2023). Kebijakan Pengembangan Pariwisata Tangguh Bencana Melalui Kolaborasi dan Manajemen Pariwisata Kebencanaan Terintegrasi. *Abdimas Pariwisata*, 1(1), 26–32. <https://doi.org/10.36276/jap.v4i1.422>

- BMKG. (2019). Katalog Tsunami Indonesia Tahun 416-2018. In *Pusat Gempa Bumi dan Tsunami Kedeputan Bidang Geofisika*.
- Hamouda, A., Hassan, M., & El-gharabawy, S. (2024). *Enhancing tsunami resilience and evacuation strategies: A case study of coastal disaster preparedness and heritage protection of the Bibliotheca Alexandrina area*. 50(June), 366–375. <https://doi.org/10.1016/j.ejar.2024.09.001>
- Hesna, Y., Suraji, A., & Lenggogeni, S. (2023). *The Role of Tourism Infrastructure in Tourism Development: A Literature Review*. 5(1), 1–8. <https://doi.org/10.12962/jifam.v5i1.20526>.
- Ibrahim, Syamsidik, Azmeri, Hasan, M., Irwansyah, A., & Al Farizi, M. D. (2023). Assessing tsunami vertical evacuation processes based on probabilistic tsunami hazard assessment for west coast of Aceh Besar, Indonesia. *Geoenvironmental Disasters*, 10(1). <https://doi.org/10.1186/s40677-023-00238-5>
- Jovanović, S., & ILIC, I. (2016). Infrastructure As Important Determinant Of Tourism Development In The Countries Of Southeast Europe. *Ecoforum Journal*, 5(1), 288–294.
- Katadata Insight Center (KIC). (2022). *Pantai dan Laut, Destinasi Wisata Akhir Tahun Paling Disukai Masyarakat Indonesia*. <https://databoks.katadata.co.id/layanan-konsumen-kesehatan/statistik/7f90ecf96ef6b5e/pantai-dan-laut-destinasi-wisata-akhir-tahun-paling-disukai-masyarakat-indonesia>
- Kurosawa, T. (2021). Facility against tsunamis and green infrastructure a case study of post-disaster reconstruction after the Great East Japan Earthquake Facility against tsunamis and green infrastructure a case study of post-. *Coastal Engineering Journal*, 63(3), 200–215. <https://doi.org/10.1080/21664250.2021.1877916>
- Luthuli, M., Qwatekana, Z., Zondi, N., & Ndlovu, T. (2021). Interconnectedness of road infrastructure and tourism development: Perspectives from residents and enterprises Interconnectedness of road infrastructure and tourism development: Perspectives from residents and enterprises. *Turkish Online Journal of Qualitative Inquiry (TOJQI)*, 112(September). <https://doi.org/12.2719-2739>.
- Marasabessy, F., & Nareswari, A. (2025). A literature review: Tsunami disaster mitigation in urban areas. *International Journal of Disaster Management*, 8(1), 57–80. <https://doi.org/10.24815/ijdm.v8i1.43988>
- Mustafa, N., Lenggogeni, S., & Yeni, Y. H. (2025). *Exploring Community Resilience , Emotional Solidarity and Place Attachment for Disaster Preparedness (Case Study : Rural Destination in West Sumatera)*. 6(4), 2522–2533. <https://doi.org/10.38035/jemsi.v6i4.4580>.
- Oetjen, J., Sundar, V., Venkatachalam, S., Reicherter, K., Engel, M., Schüttrumpf, H., & Sannasiraj, S. A. (2022). A comprehensive review on structural tsunami countermeasures. In *Natural Hazards* (Vol. 113, Issue 3). Springer Netherlands. <https://doi.org/10.1007/s11069-022-05367-y>
- Pahleviannur, M. R., Wulandari, D. A., Sochiba, S. L., & Santoso, R. R. (2020). Strategi Perencanaan Pengembangan Pariwisata Untuk Mewujudkan Destinasi Tangguh Bencana Di Wilayah Kepesisiran Drini Gunungkidul. *Jurnal Pendidikan Ilmu Sosial*, 29(2), 116–126. <https://doi.org/10.23917/jpis.v29i2.9692>
- Purwanto, N. I., Poluan, R. ., & Takumansang, E. D. (2017). Perencanaan Wilayah Pesisir Berbasis Mitigasi Bencana Di Kecamatan Sanana Kabupaten Kepulauan Sula Provinsi Maluku Utara. *Spasial*, 4(3), 1–8. <https://doi.org/https://doi.org/10.35793/sp.v4i3.17295>
- Rahmafitria, F., Puspito, H., Setiyorini, D., Hindayani, P., & Ramadhan, A. (2024). the Role of Destination Image and Risk Perception on Interest in Revisiting Disaster-Prone Coastal Destinations. *Journal of Environmental Science and Sustainable Development*, 7(1), 480–495. <https://doi.org/10.7454/jessd.v7i1.1227>
- Syetiawan, A., Arini, D., Dewi, R. S., Gularso, H., & Nugraha, W. (2020). Potential of lidar bathymetry technology for coastline large-scale mapping acceleration in Indonesia. In *ACRS 2020 - 41st Asian Conference on Remote Sensing*.
- Tarigan, J. (2005). Kerusakan Akibat Tsunami dan Gempa Northen Sumatra 26 Desember 2004 terhadap Banda Aceh dan Sirombu Nias Barat. *Jurnal Sistem Teknik Industri*, 6(3), 180–189.
- Tarihoran, M., Mutiawati, C., & Fisaini, J. (2025). Evaluating tsunami evacuation routes and shelter capacity using GIS and travel time analysis in Aceh Besar, Indonesia.

-
- International Journal of Disaster Management*, 8(2), 141–156.
<https://doi.org/10.24815/ijdm.v8i2.33645>
- UNWTO. (2019). International Tourism Highlights, 2019 Edition. In *United Nation World Tourism Organisation*. <https://doi.org/https://doi.org/10.18111/9789284421152>
- Yahya, N. F., Sahabuddin, R., Amin, A. N., Sulolipu, A. A., & Makassar, U. N. (2025). Analysis Of Coastal Tourism Development Strategy. *Economics and Business Journal (ECBIS)*., 2(6), 513–522. <https://doi.org/https://doi.org/10.47353/ecbis.v2i6.199>
- Yumantoko. (2019). Kolaborasi Para Pihak Dalam Penanganan Destinasi Wisata Terdampak Bencana Di Taman Nasional Gunung Rinjani. *Jurnal Penelitian Kehutanan*, 3(1), 15–28. <https://doi.org/10.20886/jpkf.2019.3.1.15-28>