

Multi-Risk Analysis of Geological Disasters In The Jailolo Coastal Area As A Disaster Mitigation-Based Tourism Development Strategy

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Abstract: The coast of Jailolo is a tourism area that has the potential of natural resources, namely the potential of village tourism. Developing village tourism potential greatly supports economic activities in increasing community income. The high potential for geological disasters has a negative impact on the Jailolo coastal area, especially village tourism destinations. The low level of community resilience to geological disasters is limited information and a need for more data on disaster risk in the Jailolo coastal area. Therefore, maximum efforts should be made to increase community knowledge related to tourism optimisation, reducing the impact and risk of geological disasters. For mitigation efforts to be maximally and well coordinated, a tourism development strategy is needed on the potential of village tourism on the coast of Jailolo based on disaster mitigation, including multi-risk mapping of geological disasters on the coast of Jailolo. The resulting multi-risk map can be used for safe planning and safe land use and reduces the risk of geological disasters in the Jailolo coastal tourism area. The method used was an exploratory and evaluative survey method with a quantitative approach. Primary data sources were collected by surveying vulnerable communities using questionnaires and interviews to obtain information on capacity. Data processing was carried out in the form of scoring and then mapped with the help of QuantumGIS software. The data analysis technique refers to the Regulation of BNPB No. 2 of 2012 on Disaster Risk Assessment. It uses the Multi Criteria Analysis method with the help of Geographic Information System (GIS) software. The results showed that the Jailolo coastal tourist destination has a high risk of earthquake and tsunami disasters (score 3, red colour). Earthquake and tsunami multi-risk mapping in the Jailolo coastal tourist destination area, West Halmahera, is one of the strategies for developing disaster mitigation-based tourist destinations.

Keywords: coastal; tourism; multi-risk; geological disaster

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Introduction

Coastal areas are defined as areas where land and ocean meet and are still affected by tidal splashes (Beatty et al., 1994 in Sugandhy, 1996), which have multifunctions such as government centres,

settlements, ports, aquaculture, agriculture, and tourism (Pahleviannur et al., 2019). Increased needs and land use in coastal areas cause new problems, such as morphological changes and ecological hazards (Westplat et al., 2017). Tourism potential in coastal

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areas starts with a village's flagship tourism that can increase the local community's income. Natural or artificial disasters can affect areas that become tourist destinations. These disasters can result in unforeseen economic shifts in addition to impacting the reputation of the goal and the experience of tourists (Min et al., 2020).

The Jailolo coastal area is designated as a tourism area stipulated in the Decree of the West Halmahera Number 135 Regent. B of 2017 concerning the arrangement of rural area development in Jailolo District. Tourism is an essential sector because the geological characteristics of the Jailolo coastal area have attractive natural resources, namely the potential of village tourism (Ohello, 2022). Developing village tourism potential greatly supports economic activities in increasing community income. On the other hand, there is the potential for natural disasters originating from land and sea, such as geological disasters (earthquakes and tsunamis). The community is aware of the dangers, but they must still be fully aware of the potential.

Based on its tectonics, the Jailolo coastal area is affected by high seismic activity in the Maluku Sea due to the meeting of three main plates: Philippine Plate, Australian Plate and Eurasian Plate (Figure 1) (Hamilton, 1979; Katili, 1978; Cardwell & Isacks, 1978; McCaffrey et al., 1980; Sukamto et al., 1981). The complex geological characteristics resulting from the confluence of three significant plates lead to a high potential for geological disasters. The earthquake in the Moluccas Sea triggered the tsunami in the Jailolo coastal area. However, the Moluccas Sea is not the only source of earthquakes on the Jailolo coast, as earthquakes on land also have a significant impact (Figure 2). The high potential for geological disasters has a negative impact on the Jailolo coastal area, especially village tourism destinations. The development of village tourism potential on the coast of Jailolo needs to pay attention to the safety of tourists and the community from potential geological disasters. The threat of geological disasters will have a significant negative impact, such as property losses, casualties and trauma for tourists. The probability or potential for loss, loss and injury is strongly influenced by the uncertainty of the occurrence of natural phenomena (Chou & Chiu, 2021).

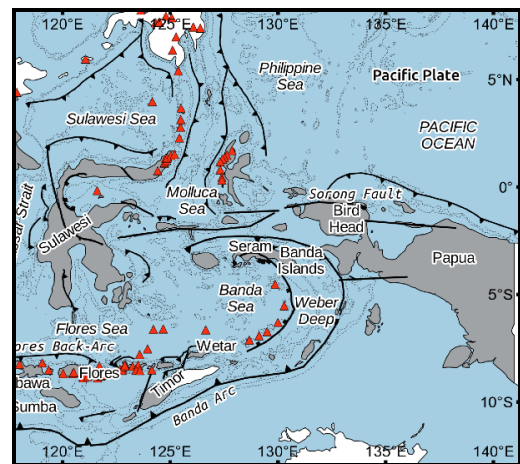


Figure 1. Tectonics of Halmahera (1).

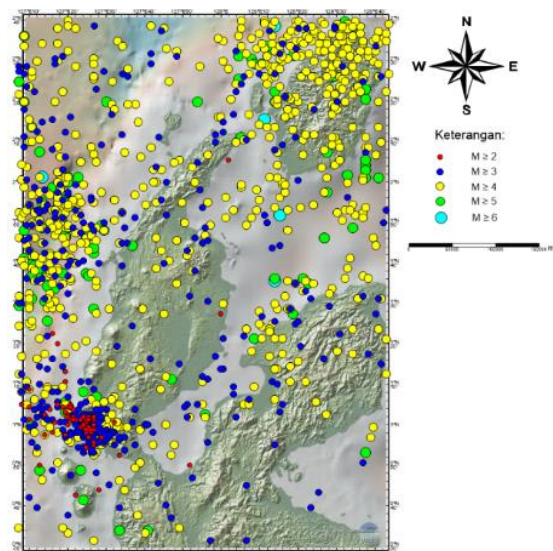


Figure 2. Seismicity map of Halmahera region (Ningrum et al., 2018)

The low level of community resilience to geological disasters in tourist areas is an important issue to study because it will lead to the potential for more significant casualties, the complexity of tourist areas, and a fatalistic view of disasters (Valerie & Leanza, 2015). The cause of low community capacity for geological disasters is limited information and the need for more data on disaster risk in the Jailolo coastal area. Therefore, the government has yet to consider risk factors in spatial utilisation and natural disaster-based regional development. Maximum efforts should be made to increase public knowledge about tourism optimisation, reducing the impact and risk of geological disasters. For mitigation efforts to be maximally and well coordinated, it is necessary to develop a tourism strategy on the potential of village tourism on the coast of Jailolo based on disaster

mitigation, including multi-risk mapping of geological disasters on the coast of Jailolo. The resulting multi-risk map can be used for safe planning and safe land use and reduces the risk of geological disasters in the Jailolo coastal tourism area.

Method

The multi-risk mapping of geological disasters in the Jailolo coast is overlaid with microtremor data from previous research. The type of hazard studied is geological hazard, including earthquakes and tsunamis. The method used is an exploratory and evaluative survey method with a quantitative approach. The research data variables needed are hazard index, vulnerability index and capacity index. Primary data sources were collected through direct surveys of vulnerable communities using questionnaires and interviews to obtain information on capacity. For secondary data sources in this research, microtremor data, maps of the Regional Spatial Plan (RTRW), geological maps, land use maps, District data in figures from the Central Bureau of Statistics (BPS), DEM SRTM images, and disaster event data are needed.

Data processing is done by scoring and then mapped with the help of QuantumGIS and ArcGIS software. The data analysis technique refers to Regulation of BNPB No. 2 of 2012 on the multi-risk assessment of earthquake and tsunami disasters using Geographic Information System (GIS) software, namely QuantumGIS and ArcGIS software. Disaster risk is described as a function of hazard, vulnerability and coping capacity. The calculation uses the equation written as follows:

$$R \approx H * \frac{V}{C}$$

Disaster risk assessment now considers one form of risk and various types of hazards and is known as multi-risk assessment. Multi-risk analysis of various disasters is one of the initiatives of comprehensive disaster management (Sunarto et al., 2017).

The analysis method obtains the multi-risk characteristics of geological disasters in a specified research object. Multi-risk is generated from the weighting of the risk index variables of each disaster. The weighting is then calculated and produces a disaster multi-risk map. The equation for obtaining a disaster multi-risk map is as follows:

$$Multi - Risk Disaster (earthquake risk index * weight) + (tsunami risk index * weight)$$

Result and Discussion

Environmental Characteristics of Jailolo Tourism Destination

Jailolo is one of the central tourist destinations in West Halmahera, known for its stunning natural

beauty and fun visitor activities (Figure 3). Jailolo is located on Halmahera Island, which has exciting and complex geological characteristics. Jailolo's unique geological conditions provide the basis for its stunning natural beauty but pose geological risks such as earthquakes and tsunamis. Therefore, visitors and locals should always be aware of potential geological hazards and follow warnings and instructions provided by local authorities to maintain safety.

Tourism destinations in earthquake and tsunami-prone areas can have great potential but must be managed carefully to minimise risks and protect visitors and locals. It is important to note that tourism development in disaster-prone areas should prioritise safety and sustainability. Local authorities and disaster mitigation experts need to work together to ensure that emergency, evacuation and safety infrastructure plans are in place and effective. In addition, education to visitors on safe behaviour in disaster situations is essential.

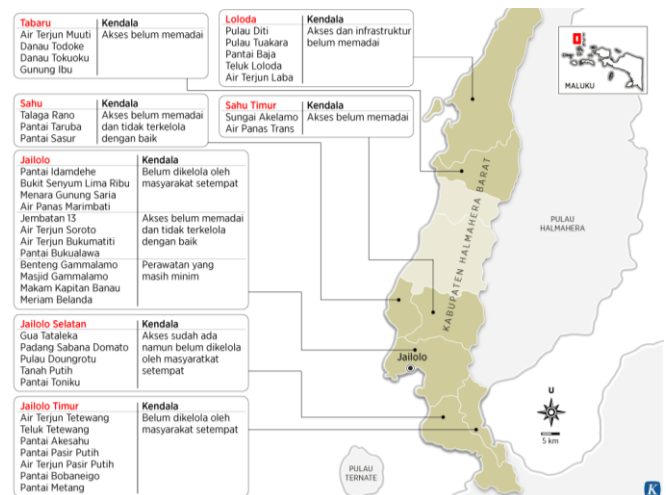


Figure 3. Potential and constraints of tourism development in West Halmahera

Earthquake and Tsunami Disaster Risk

The impacts of earthquakes and tsunamis, in addition to the loss of life and property damage, can also cause instability in local social, political and economic systems (Paripurno, 2008). Localised side effects can sometimes contribute to the damage when an earthquake occurs. In addition to the magnitude and distance to the epicentre, local geological conditions significantly impact the level of damage (Mosidi et al., 2004). Hence, there is a need for earthquake and tsunami risk maps. Risk maps are essential for disaster risk reduction initiatives as they show vulnerable areas and the level of disaster risk.

The variables used for earthquake and tsunami disaster risk mapping are hazard, vulnerability and community capacity to earthquake and tsunami

disasters. The hazard value from the Inarisk data is the hazard value, which is displayed as an earthquake hazard map (Figure 4a). The tsunami vulnerability map can provide further analyses, such as evacuation routes and other policies that can be considered. The method used in mapping the level of tsunami vulnerability uses the method of Haghizadeh et al., 2017, namely with the parameters of slope, altitude, coastline distance, and river distance. After that, it was calculated and weighted to produce a map of the level of tsunami disaster vulnerability (Figure 4b). It was found that the seven (7) research areas located in the Jailolo coastal tourist destination, namely Tuada Village, Gufasa, Guaemaadu, Galala, Bobanehena, Bobo and Gamtala, have a high earthquake hazard value (score 3, red colour). Likewise, for tsunami disasters, the villages of Tuada, Gufasa, Guaemaadu, Galala, Bobanehena, Bobo and Gamtala have high tsunami hazard scores (score 3, red colour).

a condition in which a group or community becomes helpless when exposed to threats that have a negative impact (Rif'an & Tyawati, 2020). It is known that the research locations, namely Tuada, Gufasa, Guaemaadu, Galala, Bobanehena, Bobo and Gamtala Villages for earthquake disaster vulnerability have moderate earthquake vulnerability scores (score 2, yellow colour). This is because, although not located in a highly active earthquake zone, areas near tectonic faults or seismic activity zones have a higher risk of earthquakes than those outside these zones. For tsunami disaster vulnerability, it is known that Tuada, Gufasa, Guaemaadu, Galala, Bobanehena and Bobo villages have high vulnerability scores (score 3, red colour), and Gamtala village has a low vulnerability score (score 1, green colour). Areas with high vulnerability to tsunami disasters are located along the coast or islands near subduction zones or active tectonic faults. Meanwhile, the low vulnerability to tsunami disasters is due to the geographical location of Gamtala Village, which is far from zones of earthquake activity or tectonic faults that have the potential to trigger tsunamis.

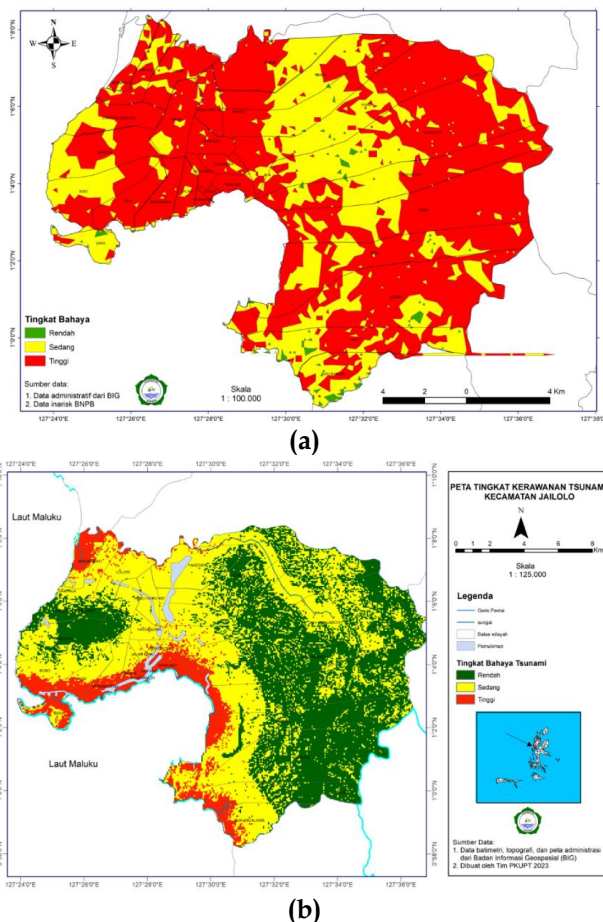


Figure 4. (a) Earthquake Hazard Map based on Inarisk data, (b) Tsunami Hazard Level Map

The vulnerability variable used for earthquake and tsunami disasters uses data from Inarisk, which is then mapped in Figure 5a and Figure 5b. *Vulnerability* is

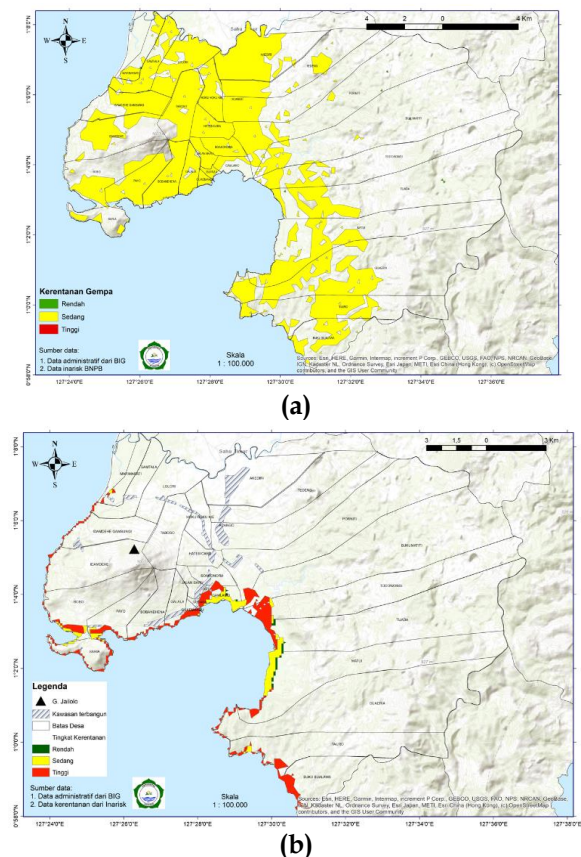


Figure 5. Vulnerability Map (a) earthquake disaster based on Inarisk data, (b) tsunami disaster based on Inarisk data.

The power to handle something is known as capacity. This power comes from physical strength, social awareness, economy and culture (PSBA, 2017). The community capacity variable for earthquake and tsunami disasters was assessed directly in the field with the help of a questionnaire to the community. This was then used to map the strength of the community towards earthquake and tsunami disasters (Figure 6). A medium category (score 2, yellow colour) was obtained for the value of community capacity for earthquake and tsunami disasters. Community capacity in the medium category is influenced by already having a basic understanding of the dangers of earthquakes and tsunamis and making some preparatory efforts. Further education, training and emergency planning efforts can still improve their capacity to deal with disasters.

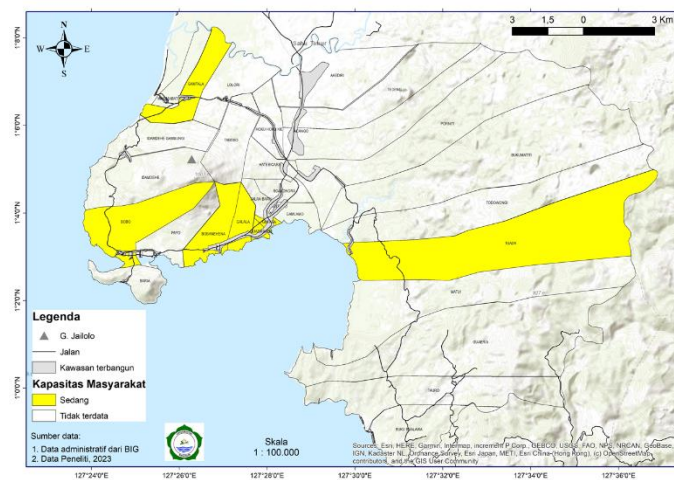


Figure 6. Map of Community Capacity for Earthquake and Tsunami Disasters

The risk analysis for the Jailolo coastal tourist destination area resulted in high earthquake and tsunami disaster risk (score 3, red colour), as shown in Figure 7. The high earthquake and tsunami disaster risk assessment combines all variables in a comprehensive analysis to identify and understand existing and potential risks. The results of these risk assessments can be used to develop appropriate mitigation strategies, emergency response planning and other preventive measures to reduce risks and protect communities from disaster impacts. Multi-risk assessment is an approach in disaster science that simultaneously examines and analyses different types of natural or human disaster risks. The main objective of multi-risk assessment is to understand and identify the interactions and joint impacts of different risks that may occur in a particular area or location. Local development planning should always incorporate multi-risk reduction strategies. Avoiding the "trap" of reducing the hazard of one type of hazard while increasing the risk of another will be very beneficial (Mardiatno, 2009).

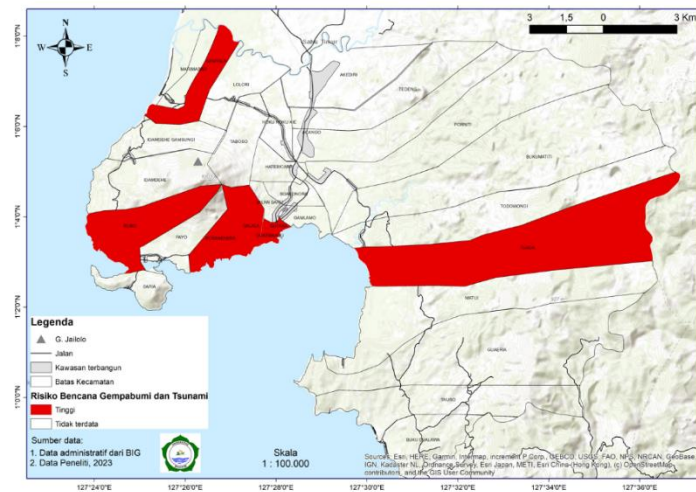


Figure 7. Multi-risk Map for Earthquake and Tsunami Disasters at The Coastal Tourist Destination Jailolo, West Halmahera

Jailolo Coastal Tourism Destination Development Strategy Based on Disaster Mitigation

Earthquake and tsunami multirisk mapping in the Jailolo coastal tourist destination area, West Halmahera, is one of the strategies for developing disaster mitigation-based tourist destinations. This is an initial and essential step to maintain the sustainability of tourism by minimising the risk of natural disasters in the region. Jailolo, located in West Halmahera, Indonesia, has excellent potential as a coastal tourism destination but is also vulnerable to earthquakes, tsunamis, and volcanic activity. The basis of implementing management in an area for disaster risk reduction is disaster risk assessment (Ningrum et al., 2021). Therefore, it is necessary to find other strategies that can be used to develop Jailolo tourist destinations by considering disaster mitigation.

Other strategies that need to be considered for the development of Jailolo coastal tourist destinations based on disaster mitigation include:

1. Preparation of Evacuation Plan: Every tourist destination in Jailolo should have a good evacuation plan that can be used in emergencies. This plan should be easily accessible to tourists and locals.
2. Community Education and Awareness: Community education on disaster risks, preventive measures and emergency response plans is essential. Education and awareness programmes can involve schools, communities and the tourism industry.
3. Early Warning: Installing effective early warning systems for earthquakes, tsunamis, and other natural disasters is necessary. Early warnings

should be integrated into the tourism infrastructure and be easily accessible to tourists and locals.

4. Disaster Resistant Buildings and Infrastructure: All tourist infrastructure, including hotels, restaurants and other public facilities, should be designed and constructed to withstand earthquakes and tsunamis. This includes the use of earthquake-resistant technology and appropriate materials.
5. Training of Tourism Staff and Managers: All tourism staff and managers should undergo emergency measures and disaster response training. They should know how to act and assist tourists in emergencies.
6. Nature Conservation: The development of tourist destinations in Jailolo should consider nature and ecosystem conservation. Strict environmental protection measures can also help reduce disaster risks.
7. Dissemination to Tourists: Travellers should be provided with information on disaster risks, precautions, and how to respond to emergencies.
8. Collaboration with Related Parties: Strong cooperation between the government, tourism sector, disaster scientists, and local communities is critical to implementing these disaster mitigation strategies.
9. Periodic Evaluation: This disaster mitigation strategy should be evaluated periodically and adjusted to new risk analysis and mitigation technology developments.

Developing disaster mitigation-based tourism destinations requires long-term commitment and cooperation from various parties. By integrating disaster mitigation factors into tourism planning and development, Jailolo can become a safe and sustainable tourist destination while protecting the local community from potential disasters.

Conclusion

From the results obtained, it can be concluded that the Jailolo coastal tourist destination has a high risk of earthquake and tsunami disasters (score 3, red colour). Earthquake and tsunami multirisk mapping in the Jailolo coastal tourist destination area, West Halmahera, is one of the strategies for developing disaster mitigation-based tourist destinations.

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