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Earthquake Disaster Risk Assessment Analysis In Jailolo Coastal Region

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ABSTRACT

The village, which is located in the Coastal District of Jailolo, West Halmahera, had a considerable impact from the earthquake. This is because the earthquakes that occur are influenced by tectonic earthquakes due to the movement and collision of tectonic plates on land and the seabed. If the collision causes a fault in the seabed, a tsunami can occur. The purpose of this study was to analyze the risk of earthquake disasters in supporting development planning and to produce an earthquake risk map for the coastal area of Jailolo District, West Halmahera. The analytical method used is descriptive quantitative, and the data collection model is a questionnaire with random sampling. The results obtained are in the form of a hazard value using the PGA value and produce the same PGA value, namely > 0.70 gal with a high category for Bobanehena Village, Saria Village, Payo Village, Bobo Village, and Idamdehe Village. The value of vulnerability (physical, social, and economic vulnerability) shows that Bobanehena Village has a high vulnerability index value with a score of 1.9. The capacity index value for the five villages has the same score of 3 and is included in the high class. So that the value of the earthquake risk level with a high class is obtained, namely in Bobanehena Village and Bobo Village. The high level of risk in the two villages is influenced by the frequency of occurrence of earthquakes with high intensity in the area, the impact of losses due to earthquakes is quite high. Earthquake risk reduction efforts will be maximized if a comprehensive earthquake risk assessment analysis is carried out and a commitment from the Government is carried out.

Keywords: coast, disaster, earthquake, Jailolo, risk

ABSTRAK

Desa yang terletak di Pesisir Kecamatan Jailolo, Halmahera Barat memiliki dampak cukup besar dari gempabumi. Hal ini dikarenakan gempabumi yang terjadi dipengaruhi oleh gempa tektonik akibat pergerakan dan tumbukan lempeng tektonik di darat dan dasar laut. Apabila tumbukan tersebut menimbulkan patahan di dasar laut memungkinkan terjadinya tsunami. Tujuan penelitian ini adalah untuk menganalisis risiko bencana gempabumi dalam menunjang perencanaan pembangunan dan menghasilkan peta risiko gempabumi daerah pesisir Kecamatan Jailolo, Halmahera Barat. Metode analisis yang digunakan adalah deskritif kuantitatif, dan model pengambilan data kuesioner dengan *random sampling*. Hasil yang diperoleh berupa nilai bahaya dengan menggunakan nilai PGA dan menghasilkan nilai PGA yang sama yakni > 0,70 gal dengan kategori tinggi untuk Desa Bobanehena, Desa Saria, Desa Payo, Desa Bobo, dan Desa Idamdehe. Nilai kerentanan (kerentanan fisik, sosial, dan ekonomi) menunjukkan bahwa Desa Bobanehena memiliki nilai indeks kerentanan yang tinggi dengan skor 1,9. Nilai indeks kapasitas untuk lima desa memiliki nilai skor yang sama yakni 3, dan termasuk kelas tinggi. Sehingga diperoleh nilai tingkat risiko bencana gempabumi denga kelas tinggi yakni di Desa Bobanehena dan Desa Bobo. Tingkat risiko yang tinggi pada dua desa tersebut dipengaruhi oleh frekuensi terjadinya bencana gempabumi dengan inetnsitas yang tinggi di daerah tersebut, dampak kerugian akibat bencana gempabumi yang cukup tinggi. Upaya pengurangan risiko gempabumi akan menjadi maksimal apabila dilakukan analisis pengkajian risiko bencana gempabumi yang komprenhensif dan komitmen dari Pemerintah.

Kata Kunci: pesisir, bencana, gempa bumi, Jailolo, risiko

INTRODUCTION

Earthquakes are vibrations or shocks that occur and are felt on the surface of the earth originating from within the structure of the earth. The shift occurs as a result of the sudden occurrence of seismic wave energy that occurs due to the deformation of tectonic plates that occur in the earth's crust (Murtianto, 2016; Christianto, 2011) West Halmahera is an area that has the potential to be affected by disasters, one of which is an earthquake. This is because West Halmahera is located at the junction of three plates, namely the Pacific plate, the Indo-Australian plate, and the Eurasian plate, and West Halmahera is located in the ring of fire. In addition to earthquakes can also cause the possibility of a tsunami. If an earthquake and tsunami occur simultaneously, the areas most at risk are those located on the coast. Characteristics of tsunami-generating earthquakes in Indonesia show that 67% of tsunamis are in eastern Indonesia, which is spread evenly from Sulawesi to Papua and from Timor to the Sangihe Talaud Islands (Rahmawati et al., 2017).

Jailolo is one of the areas affected by an earthquake in West Halmahera. Every year Jailolo earthquakes occur, ranging from mild, moderate, to high scales. The worst earthquake occurred in 2015 and continues to this day. The earthquake in 2015 had a small scale but occurred continuously so it was called a swarm earthquake. An earthquake swarm is dangerous because the frequency of occurrence is high and covers a large area.

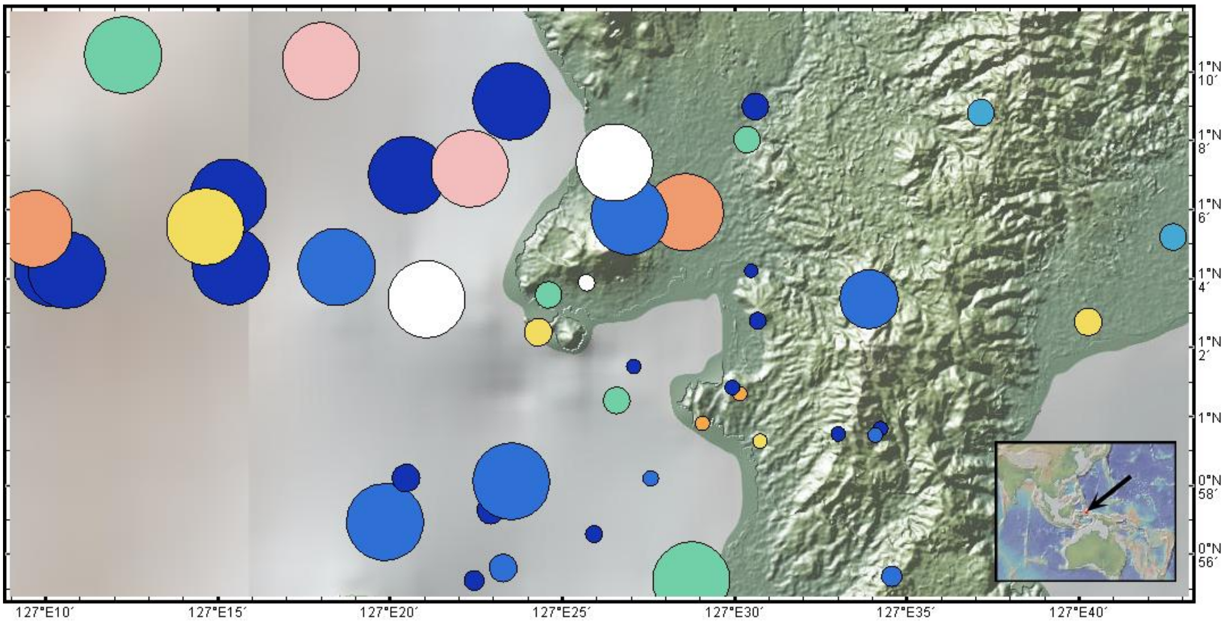

Figure 1. Seismicity map that occurred in Jailolo and surroundings

Villages located on the coast are at great risk of being damaged by the earthquake and tsunami (Dewi et al., 2014; Pratiwi and Arniza Fitri, 2021). Therefore, the village which is located on the

Jailolo Coast of West Halmahera had a considerable impact from the earthquake as shown in Figure 1. This is because the earthquakes that occur are influenced by tectonic earthquakes due to the movement and collision of tectonic plates on land and the seabed. If the collision causes a fault in the seabed, a tsunami can occur. An earthquake accompanied by a tsunami will cause losses to villages on the Jailolo Coast. These losses are not only material losses but also loss of lives.

According to BNPB (2015), the risk is a risk assessment and ranking which is the packaging of the results of an assessment of the hazard, vulnerability, and capability/resilience of an area to disasters to determine the priority scale of actions made in the form of work plans and recommendations to reduce disaster risk. Meanwhile, according to the Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management, Article 1 Paragraph 17 is the potential loss caused by a disaster in an area and a certain period which can be in the form of death, injury, illness, threatened life, loss of sense of security, evacuation. , damage or loss of property, and disruption of community activities.

Risk assessment and ranking is the packaging of the results of the assessment of the hazard, vulnerability, and capability/resilience of an area to disasters to determine the priority scale of actions made in the form of work plans and recommendations to reduce disaster risk (BNPB 2015). Determination of the disaster risk index is done by combining the index values of hazard, vulnerability, and capacity. This process is carried out using spatial calculations so that it can produce a risk map and grid value that can be used in compiling an explanation of the risk map. A risk assessment is carried out to analyze how to reduce the potential for damage and losses that will occur in the future and this is one of the early stages of disaster risk management (Toyfur, M.F., 2015).

For provincial level calculations, the whole process is carried out by following the rules of cartography, namely with minimal analysis using available data input on a scale of 1: 250,000. The resulting results will also follow the scale of analysis used. This provision also refers to the general guidelines for disaster risk assessment that have been set by BNPB in 2012 (Amri et al. 2016). The study of earthquake risk in the Jailolo area that will be carried out uses Peak Ground Acceleration (PGA) data that has been carried out by researchers.

The update in this study is the use of scoring methods, GIS analysis, and quantitative descriptive. The purpose of this study is to analyze the risk of earthquake disasters in supporting development planning and to produce an earthquake risk map for the coastal area of Jailolo District, West Halmahera. Disaster risk classification is very important to determine the post-earthquake situation both in the short and long term (Korkmaz, K. A., 2009).

METHODOLOGY

The research location was conducted in the coastal area of Jailolo District, West Halmahera, namely Bobanehena Village, Saria Village, Payo Village, Bobo Village, and Idamdehe Village as shown in Figure 2. The type of research used is an experimental method with data analysis methods, namely quantitative descriptive, in the form of thematic maps and questionnaires. The data collection model used is proportional random sampling. In its implementation, the risk assessment uses the basic general formula that has been prepared by the 2012 BNPB Regional Regulation, as follows:

$$Risk = Hazard * \frac{Vulnerability}{Capacity} \quad (1)$$

Furthermore, the results of data processing are mapped using QuantumGIS software.

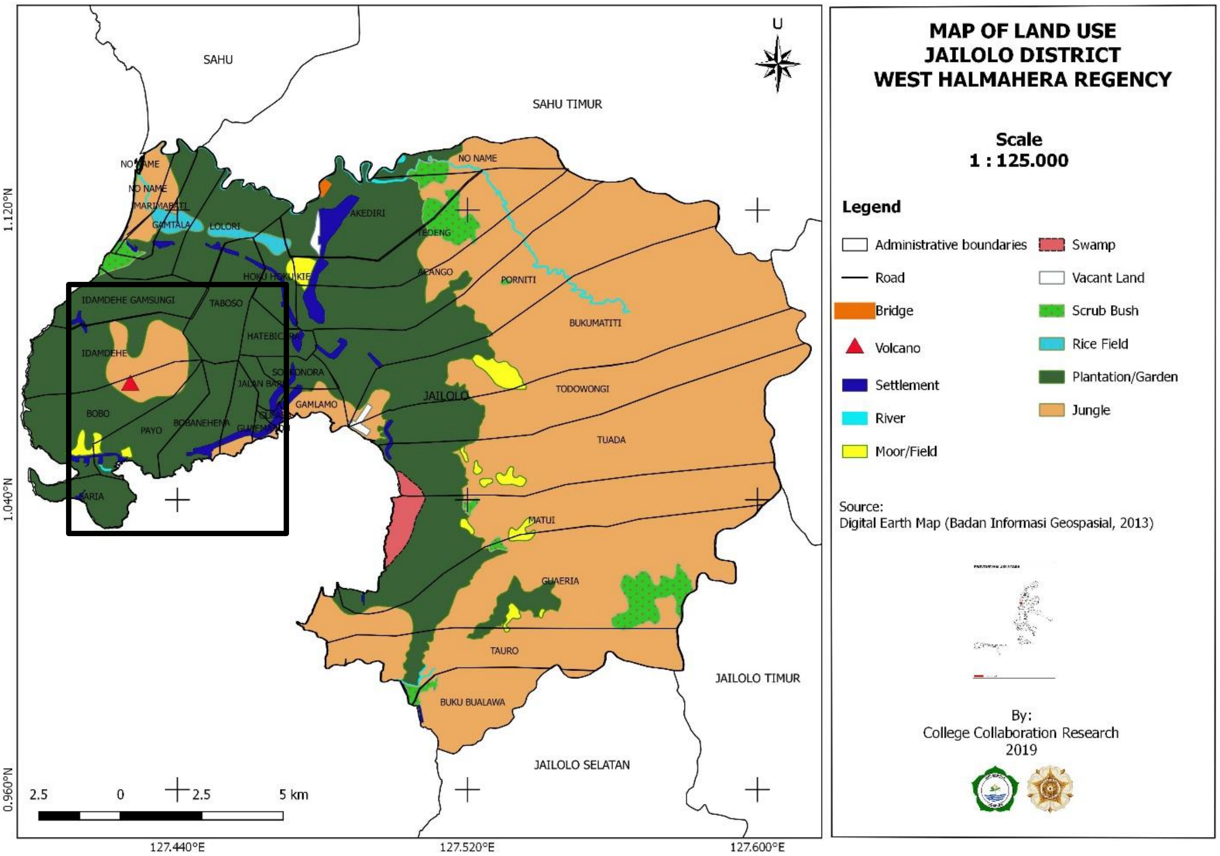

Figure 2. Research location map

The data analysis technique used semi-quantitative analysis with weighting factors based on the Analytic Hierarchy Process (AHP). This methodology has been developed by Thomas L. Saaty started in 1970. Disaster risk assessment is prepared based on predetermined indices, consisting of hazard index, loss index, and capacity index.

Threat Index

The components and indicators for the earthquake threat index can be seen in Table 1.

Table 1. Components of the earthquake hazard index

Disaster	**Component/ Indicator**	**Index Class**			**Total**	**Reference**
		Low	**Currently**	**High**		
Earthquake	1. Earthquake hazard map 2. 2010 earthquake zoning map (validated with incident data)	Low (pga value <0,2501)	Currently (pga value 0,2501 – 0,70)	High (pga value > 0,70)	100%	SNI which refers to the guidelines issued by the National Geological Agency

Hazard maps define areas where certain natural events occur with a certain frequency and intensity, depending on the vulnerability and capacity of the area, which can cause disasters. In this study, the source and hazard map of the 2017 Indonesian earthquake issued by the National Earthquake Study Center was used.

Vulnerability Index

The vulnerability index used in this study is only the parameters of social vulnerability, economic vulnerability, and physical vulnerability. The indicators used in the analysis of social vulnerability are information on the exposed population such as population density, sex ratio, poverty ratio, the ratio of people with disabilities, and age group ratio (Table 2).

Table 2. Components of the social vulnerability index

Parameter	Weight (%)	Class			Score
		Low	Currently	High	
Population density	60	< 500 life/km^2	500 – 100 life/km^2	1000 life/km^2	
Gender ratio (10%)					
Poverty ratio (10%)					Class/ Class max value
Disabled people ratio (10%)	40	<20%	20 – 40%	>40%	
Age group ratio (10%)					

Equation of Social Vulnerability Index:

$$Social\ vulnerability: \left(0.6 * \frac{log\left(\frac{population\ density}{0.01}\right)}{log\left(\frac{100}{0.01}\right)}\right) + (0.1 * Gender\ ratio) + (0.1 * poverty\ ratio) + (0.1 * disabled\ people\ ratio) + (0.1 * age\ group\ ratio) \quad (2)$$

The indicators used for economic vulnerability are the area of productive land in rupiah (rice fields, plantations, agricultural land, and ponds) and GRDP. The area of productive land can be obtained from the land use map and converted using Table 3 and the equation below:

Table 3. Components of the Economic Vulnerability Index

Parameter	Weight (%)	Class			Score
		Low	Currently	High	
Productive land	60	<50 million	50 - 200 million	>200 million	Class/ Class max value
PDBR	40	<100 million	100 - 300 million	>300 million	

Economic Vulnerability Index Equation:

$$Economic\ Vulnerability : (0.6 * productive\ land\ score) + (0.4 * \ PDRB\ score) \quad (3)$$

The indicators used for physical vulnerability are the density of houses (permanent, semi-permanent, and non-permanent), the availability of buildings/public facilities, and the availability of critical facilities. House density is obtained by dividing the built-up area or village area and divided by area (in hectare) and multiplied by the unit price of each parameter. The conversion parameters of the physical vulnerability index for earthquake disasters are shown in Table 4 and equation 4.

Table 4. Components of the physical vulnerability index

Parameter	Weight (%)	Class			Score
		Low	Currently	High	
House	40	<400 million	400 - 800 million	>800 million	Class/ Class max value
Public Facilities	30	<500 million	500 million – 1 B	>1 B	
Critical Facilities	30	<500 million	500 million – 1 B	>1B	

Physical Vulnerability Index Equation:

$$Physical\ Vulnerability : (0.4 * House\ Score\ ) + (0.3 * Public\ Facilities\ Score) + (0.3 * Critical\ Facilities\ Score) \quad (4)$$

Capacity Index

The Capacity Index is obtained based on the level of regional resilience at a time. The indicators used in the assessment of the capacity index in the questionnaire consist of rules and institutions for earthquake disaster management, early warning and earthquake risk assessment, disaster education, reduction of basic risk factors, and development of preparedness at all levels. The capacity index conversion parameters and equations can be shown in table 5.

Table 5. Capacity index components index

Parameter	Weight (%)	Class			Score
		Low	Currently	High	
disaster management rules and institutions early warning and disaster risk assessment disaster education reduction of basic risk factors preparedness development at all levels	100	< 0,33	0,33 – 0,66	> 0,66	Class/ Class max value

Capacity Index Equation:

Capacity Index : $(1.0 * capacity\ score)$

The research design can be seen in the flow chart as shown in Figure 3.

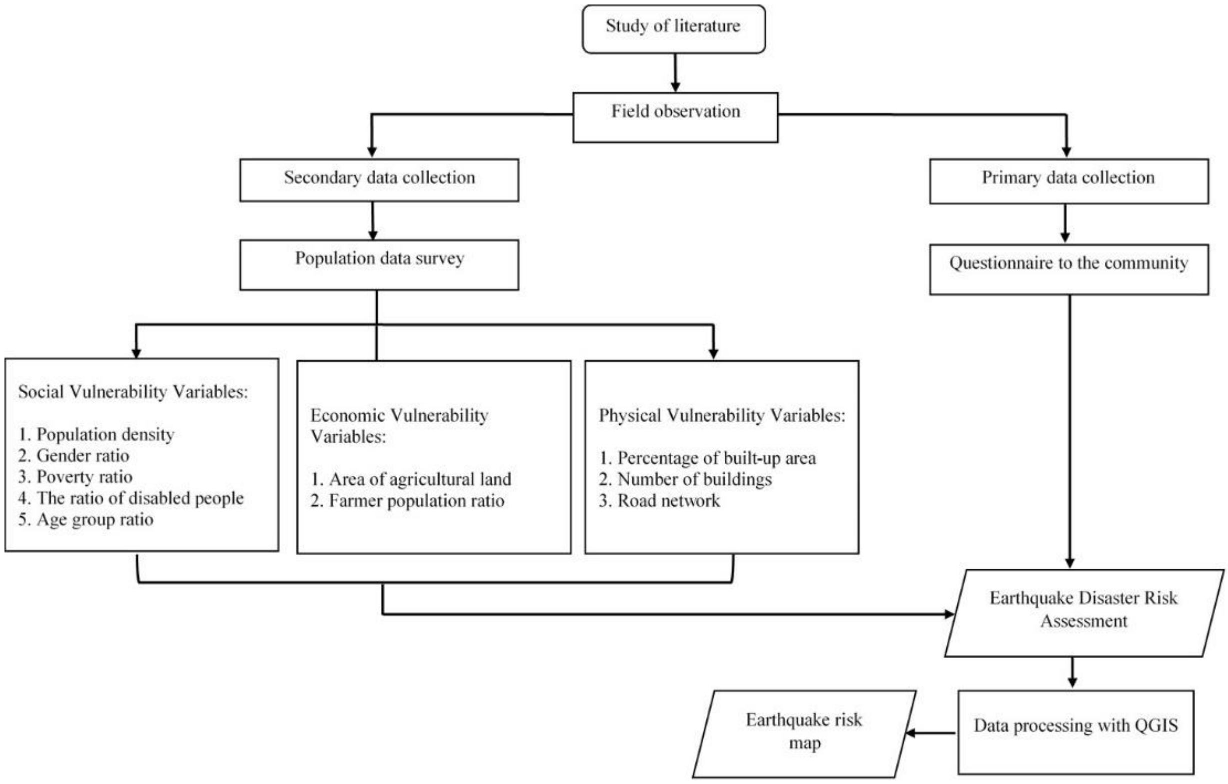

Figure 3. Research design flowchart

RESULTS AND DISCUSSION

Earthquake Hazard

According to (Motiram 2014), hazard is a physical event, phenomenon, human activity that has the potential to destroy. A hazard has the probability of occurrence over a certain period and in a certain area and has a certain intensity. Earthquake hazard is made based on the analysis of the intensity of shocks on the surface obtained from the data on the intensity of shocks in the bedrock (Peak Ground Acceleration/PGA).

Based on the Peak Ground Acceleration (PGA) value in earthquake classification, the hazard values in five Coastal Villages (Bobanehena Village, Saria Village, Payo Village, Bobo Village, and Idamdehe Village) that we studied had the same PGA value, namely, the PGA value > 0.70 gals, so it is classified as a high index value. In this earthquake hazard classification, the reference PGA value from the Peak Ground Acceleration (PGA) Map for the West Halmahera region was shown in Figure 4.

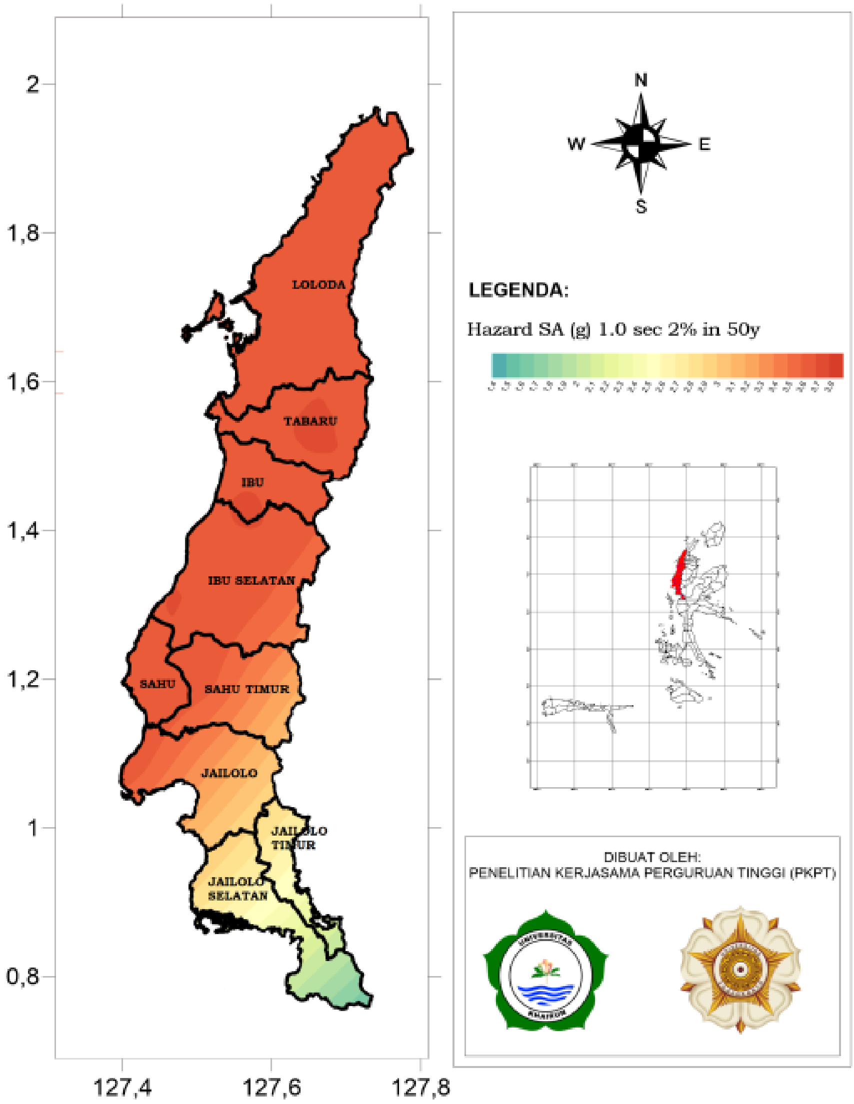

Figure 4. PGA map in West Halmahera (Ningrum et al. 2020)

Vulnerability

Physical Vulnerability

Physical vulnerability in the village is measured using 3 indicators of vulnerability, namely the percentage of the built area (public facilities and critical facilities), number of buildings, and road network. An area with high vulnerability if it has a high number of buildings or a high percentage of built area. The number of buildings is obtained through digitizing the image map. The road network is used as a route for the evacuation process in the event of an earthquake. A good road network will make it easier for people to save themselves.

Based on the scoring results obtained 2 villages with low physical vulnerability, 1 village with moderate physical vulnerability, and 2 villages with high physical vulnerability as shown in table 6. Villages belonging to the high vulnerability class are Bobo Village and Bobanehena Village. This is because the two villages have a high percentage of built-up areas. For villages with medium and low vulnerability classes, the land use in this area is still in the form of plantations and fields, and the percentage of built-up areas is low. In line with the research of

(Desmonda and Pamungkas 2014), the physical vulnerability of earthquakes is influenced by the type of construction (permanent) and the density of the building.

Table 6. Physical vulnerability indicator data

Village	Built-up area (m^2)	Percentage of built-up area per village (%)	House Density (m^2)	Number of Buildings	Percentage Number of buildings per village (%)	Score	Class
Saria	68.234	0,8	0,02	165	23,9	1,0	Low
Idamdehe	127.197	1,6	0,02	179	26,0	1,0	Low
Payo	362.908	4,5	0,08	410	59,5	2,0	Currently
Bobo	265.565	3,3	0,03	318	46,2	2,6	High
Bobanehena	450.698	5,6	0,11	578	83,9	2,6	High

Social Vulnerability

The most important indicators of social vulnerability are population size and density. This vulnerability is directly proportional to the population, meaning that the more population and population density, the higher the level of social vulnerability. (Nurmaya et al. 2019) and Habibi, M and Buchori, I (2013). The scoring results can be seen in Table 7.

Table 7. Data on social vulnerability indicators

Village	Population density (life/km^2)	*Sex Ratio*	Score	Class
Bobanehena	503,7	15%	0,9	Currently
Saria	148,43	8%	0,7	Low
Payo	130,6	12%	0,7	Low
Bobo	38,91	28%	0,8	Currently
Idamdehe	42,93	37%	0,9	Low

Indicators of social vulnerability of the five villages include low to moderate class, this is due to the medium number and density of the population and the few vulnerable groups in these villages. In addition, the pace of regional development in the five villages is slow. This is known from the lack of village facilities and infrastructure.

Economic Vulnerability

Indicators of economic vulnerability that are very influential in the analysis are the area of agricultural land and livelihoods. This is because the condition of the research area is mostly plantations and fields and the people's livelihood is gardening or farmers. The scoring results obtained a class that shows a medium to high class. Villages with high economic vulnerability classes are Idamdehe Village and Bobanehena Village.

Capacity

Husein and Aidil Onasis (2017) state that capacity is the ability of resources such as prevention, reducing the impact of disasters, preparedness, and self-defense skills during emergencies, which are owned by individuals or groups of people in an area that can be utilized to minimize disaster risks that occur. According to (Amri et al. 2016), regional capacity refers to the National Disaster Management System in Law Number 24 of 2007 concerning disaster management.

Meanwhile, the regional capacity assessment refers to the Regulation of the Head of the National Disaster Management Agency No. 03 of 2012 concerning Guidelines for Regional Capacity Assessment in Disaster Management. The capacity index was obtained from questionnaire data based on indicators in the Hyogo Framework for Actions (Hyogo Framework for Action). The results of the capacity index are in the form of scores based on the level of regional resilience at a time when affected by an earthquake. A capacity index score was obtained for five villages with the same score of 3 and included in the high class.

Risk

The risk values in the five research villages were categorized as low to high class. The research village that has the lowest risk level is Saria Village. This is due to the influence of the low total vulnerability index value in Saria Village, while the hazard and capacity values are high. For the research villages with a moderate risk level, namely Idamdehe Village and Payo Village. As for the high-risk level, there are two villages studied, namely Bobahena Village and Bobo Village. The high level of risk in the two villages is influenced by the frequency of occurrence of earthquakes with high intensity in the area, the impact of losses due to earthquakes is quite high. an earthquake risk map can be seen in Figure 4.

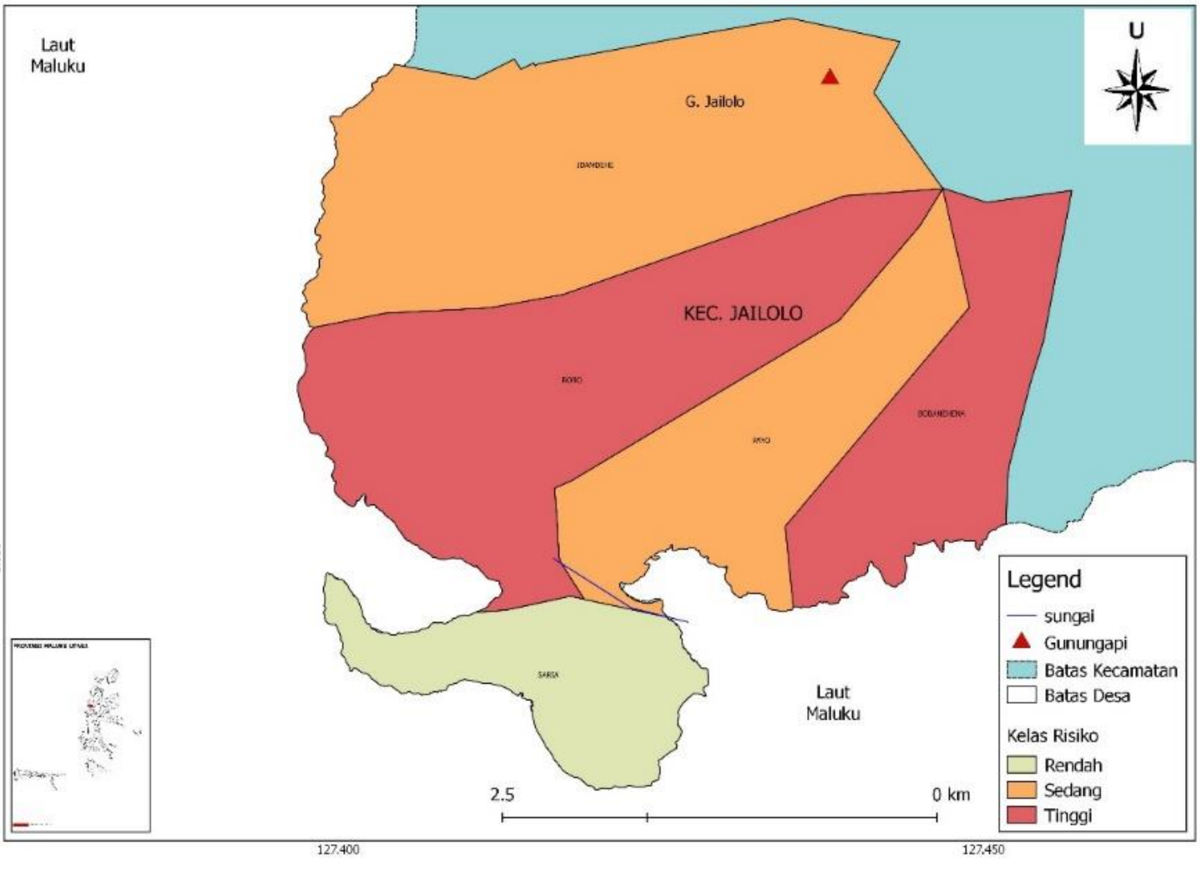

Figure 5. Risk map in the coastal area of Jailolo District, West Halmahera

Earthquake Risk Reduction Efforts

Based on Perka BNPB No. 2 of 2012 Disaster risk assessment efforts are basically to determine the magnitude of the 3 risk components and present them in spatial and non-spatial forms for easy understanding. Disaster risk assessment is used as the basis for implementing disaster management in an area to reduce disaster risk. Disaster risk reduction efforts include; 1) minimizing regional threats, 2) reducing the vulnerability of threatened areas, and 3) increasing the capacity of threatened areas.

The results of the disaster risk assessment can be used by the government, government partners, and the general public (Dixit et al. 2013). The government can use it as a basis for formulating disaster management policies. This policy will later become the basis for the preparation of a Disaster Management Plan which is a mechanism for mainstreaming disaster management in development plans. Government partners can use it as a basis for providing assistance or direct technical intervention to exposed communities to reduce disaster risk. The assistance and intervention of partners must be carried out in coordination and synchronization with government programs in the implementation of disaster management. And the general public can be used as a basis for formulating practical actions in the context of preparedness, such as drawing up plans and evacuation routes, making decisions on residential areas, and so on.

Disaster risk assessments can be carried out by any institution, be it academics, the business world or NGOs, or other organizations as long as it remains under the responsibility of the government and local governments using the methods established by BNPB.

CONCLUSION

Based on the results of the research that has been done, it can be concluded as follows: 1) Hazard values in five coastal villages (Bobahena Village, Saria Village, Payo Village, Bobo Village, and Idamdehe Village) obtained the same PGA value, namely PGA value > 0.70 gals, and classified as high hazard index value; 2) Vulnerability scores (physical, social, and economic vulnerability) indicate that Bobanehena Village has a high vulnerability index score with a score of 1.9; 3) The value of the capacity index for five villages has the same score of 3 and is included in the high class; 4)The high-risk level is found in two villages, namely Bobahena Village and Bobo Village. The high level of risk in the two villages is influenced by the frequency of occurrence of earthquakes with high intensity in the area, the impact of losses due to earthquakes is quite high.

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REFERENCES

Amri, M. R., Yulianti, G., Yunus, R., Wiguna, S., Adi, A. W., Ichwana, A. N., ... & Septian, R. T. (2016). *Risiko Bencana Indonesia*. Jakarta: *Badan Nasional Penanggulangan Bencana.*

BNPB. (2015). Badan Penanggulangan Resiko Bencana Kajian Risiko Bencana Maluku Utara 2016 - 2020. Jakarta: Badan Nasional Penanggulangan Bencana

Christianto, J. (2011). *Gempa Bumi, Kerusakan Lingkungan, Kebijakan dan Strategi Pengelolaan*. Yogyakarta: Liberty Yogyakarta.

Desmonda, N. I., & Pamungkas, A. (2014). Penentuan Zona Kerentanan Bencana Gempa Bumi Tektonik di Kabupaten Malang Wilayah Selatan. *Jurnal Teknik ITS*, *3*(2), 107-112. http://dx.doi.org/10.12962/j23373539.v3i2.7232

Dewi, C., Armijon, & Fadly, R. (2014). Analisis Pembuatan Peta Zona Rawan Bencana Tsunami Pada Daerah Pesisir (Studi Lokasi: Pesisir Kota Bandar Lampung). In *Prosiding Sembistek 2014*, *1*(02), 740-753.

Dixit, A. M., Yatabe, R., Dahal, R. K., & Bhandary, N. P. (2013). Initiatives for Earthquake Disaster Risk Management in The Kathmandu Valley. *Natural Hazards*, *69*(1), 631-654. https://doi.org/10.1007/s11069-013-0732-9

Habibi, M., & Buchori, I. (2013). Model Spasial Kerentanan Sosial Ekonomi dan Kelembagaan Terhadap Bencana Gunung Merapi. *Teknik PWK (Perencanaan Wilayah Kota)*, *2*(1), 1-10.

Husein, A., & Onasis, A. (2017). *Menajemen Bencana*. Jakarta: Pusat Pendidikan Sumber Daya Manusia Kesehatan.

Korkmaz, K. A. (2009). Earthquake Disaster Risk Assessment and Evaluation For Turkey. *Environmental Geology*, *57*(2), 307-320. https://doi.org/10.1007/s00254-008-1439-1

Murtianto, H. (2016). Potensi Kerusakan Gempa Bumi Akibat Pergerakan Patahan Sumatera di Sumatera Barat dan Sekitarnya. *Jurnal Geografi Gea*, *10*(1), 80-86. https://doi.org/10.17509/gea.v10i1.1667.g1126

Motiram, B. H. (2014). *Earthquake Risk Assessment, Loss Estimation and Vulnerability Mapping for Dehradun City, India*. University of Twente, Enschede, The Netherlands.

Ningrum, R. W., Suryanto, W., Fauzi, H., & Mei, E. T. W. Mapping of PGA Value Using PSA Method in West Halmahera Nort Maluku. *Jurnal Teknosains*, *9*(2), 116-126. https://doi.org/10.22146/teknosains.41483

Nurmaya, A., Setiawan, M. A., & Purwanto, T. H. (2019). Dinamika Spasial dan Temporal Kerentanan Sosial Terhadap Dampak Bencana Gempa Bumi Studi Kasus: Dusun Jogo. *Majalah Ilmiah Globe*, *21*(2), 71-78. http://dx.doi.org/10.24895/MIG.2019.21-2.915

Pratiwi, D., & Fitri, A. (2021). Analisis Potensial Penjalaran Gelombang Tsunami di Pesisir Barat Lampung, Indonesia. *Jurnal Teknik Sipil*, *8*(1), 29-37. https://doi.org/10.21063/JTS.2021.V801.05

Rahmawati, N. I., Santosa, B. J., Setyonegoro, W., & Sunardi, B. (2017). "Pemodelan Tsunami di Sekitar Laut Banda dan Implikasi Inundasi di Daerah Terdampak. *Jurnal Sains dan Seni ITS, 6*(2), 33–36. http://dx.doi.org/10.12962/j23373520.v6i2.25864

Toyfur, M. F. (2015). Indicators Identification for Developing Earthquake Risk Disaster Model for Roads. In *International Conference on Coastal and Delta Areas* (Vol. 1, No. 1, pp. 219-225).