CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dimensions ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

ANALYSIS OF POTENTIAL NATURAL DISASTER RISKS IN BULELENG REGENCY

Volume: 4
Number: 6
Page: 1871 - 1887

I Wayan Krisna Eka PUTRA[1], I Gusti Bagus Sila DHARMA[2], Ida Ayu ASTARINI[3], I Wayan Gede Astawa KARANG[4]
[1]Doctoral Student in Environmental Science, Ganesha University of Education, Indonesia
[2,3,4]Udayana University, Indonesia
Corresponding author: I Wayan Krisna Eka Putra
Email: krisna.ekaputra@undiksha.ac.id

Article History:
Received: 2023-10-02
Revised: 2023-10-20
Accepted: 2023-11-17

Abstract:
Buleleng is a regency in the Province of Bali with various potential disaster risks, mainly dominated by natural disasters. This condition is influenced by the topography of the Buleleng Regency area, which has the characteristics of Nyegara Gunung. Namely, to the north is a coastal area, while to the south is a hill area. Based on these conditions, it is necessary to have a risk analysis of natural disasters that can potentially occur so that alternative disaster management can be made. This study aims to determine the potential for disaster risk in Buleleng Regency and the priorities for handling the level of risk and intensity of the threat. The method used in this study is an analysis of potential natural disaster risks obtained from a combination of hazard, vulnerability and capacity data. Threat data was obtained from data released by BNPB from the inarisk.bnpb.go.id, while vulnerability and capacity data were obtained from interviews and secondary data from related agencies. The data obtained was then used in an FGD with BPBD Buleleng Regency, which was then analyzed descriptively and qualitatively. Based on the research results, it was found that the potential for disasters in Buleleng Regency was categorized into 2, namely: disasters that have a high-risk impact are Earthquakes and Tsunamis, while disasters with high incident intensity are floods, extreme weather, extreme waves and abrasion, drought, landslides, flash floods and fires.

Keywords: Threat, Vulnerability, Capacity, Disaster Risk, Disaster Intensity

Cite this as PUTRA, I. W. K. E., DHARMA, I. G. B. S., ASTARINI, I. A., KARANG, I. W. G. A. (2024). "Analysis of Potential Natural Disaster Risks in Buleleng Regency." International Journal of Environmental, Sustainability, and Social Science, 4 (6), 1871 - 1887.

INTRODUCTION

Buleleng is one of the regencies in the Province of Bali, which is geographically located at 08o03'40"- 08o23'00" S and 114o25'55"-115o27'28" E (Central Agency on Statistics/BPS of Buleleng, 2021). Buleleng has various potential disasters whose dynamics tend to have a higher impact. In the last three years, various disasters have occurred in Buleleng Regency, including earthquakes, floods, landslides, droughts, extreme waves and abrasion, extreme weather, epidemics and disease outbreaks, and building/settlement fires. There are so many kinds of disaster events in Buleleng Regency that many people mention Buleleng as a Disaster Mall, which is closely related to the geographical conditions of Buleleng Regency, namely "Nyegara Gunung."

So close is the connection between the geographical conditions of Buleleng Regency and the existing conditions of the disaster events that occurred in Buleleng Regency that it requires severe efforts in terms of disaster management. The most appropriate focus of disaster management to reduce disaster risk is at the pre-disaster level. One of the essential things in the pre-disaster situation

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

is the availability of information on locations with high disaster vulnerability and risk. The need for information on locations with high disaster risk underlies the Regional Disaster Management Agency (BPBD) of Buleleng Regency to carry out disaster risk mapping activities for Buleleng Regency.

Disaster risk mapping for each region has been required in the Law of the Republic of Indonesia No. 24 of 2007 concerning Disaster Management and Republic of Indonesia Government Regulation No. 21 of 2008 concerning Implementation of Disaster Management, which was later supported by Regulation of the Head of the National Disaster Management Agency No. 2 of 2012 concerning Disaster Risk Assessment. It further shows the importance of the availability of disaster risk maps that must be provided by the BPBD of Buleleng Regency, where the source of data on disaster-prone areas plays a vital role.

METHODS

Research. The research location was in the Buleleng Regency area, which consisted of 9 sub-districts, which included 129 villages, 19 sub-districts, and 166 Pekraman villages. The administrative area of Buleleng Regency designated as the research location is presented below.

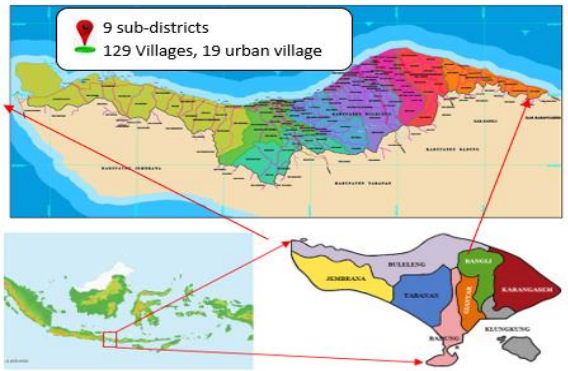

Figure 1. Administrative Area of Buleleng Regency

The data used in this study consists of 3 primary data, namely threat data, vulnerability data and capacity data. The threat data in this study is sourced from official agencies and is legally used in Indonesia, published on the website inarisk.bpnb.go.id. InaRISK is a risk assessment results portal that uses ArcGIS servers as data services that describe the scope of disaster threat areas, affected populations, potential physical losses, potential economic losses and potential environmental damage and is integrated with the realization of the implementation of disaster risk reduction activities as a monitoring tool for reducing disaster risk index (http://www.bnpb.go.id).

The natural disaster threats studied in this study consist of 9 types of threats, namely floods, flash floods, extreme weather, extreme waves/abrasion, earthquakes, forest and land fires, drought, landslides and tsunamis. The steps taken to obtain threat data are as follows.

a. The first step is to open the website inaRISK (inarisk.bnpb.go.id) on a computer browser.
b. Then click the menu tab on the top left and select GIS Service, which will display disaster data throughout Indonesia.

CATRA RESEARCH INSTITUTE
• ISSN 2720 - 9644 (print)
• ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi Crossref ROAD INDEX COPERNICUS Indonesia OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

Figure 2. Disaster Data Throughout Indonesia

c. Next, several data formats can be downloaded; for data needs with the "raster" extension, select View in ArcMap, and the data will be downloaded directly to the computer.
d. The next step is to open the downloaded data (for example) with the Index_Bahaya_Banjir extension in the ArcGis application, then add the Buleleng Regency/City Administration shop data as the area's boundaries to be analyzed.

Figure 3. Display of Raster Format Data

e. The data coverage that has been downloaded still consists of all regions of Indonesia, so a regional selection process is needed according to the required area, namely Buleleng Regency. The steps are to click the search menu and use the Extract by Mask tool in AcrGis software.

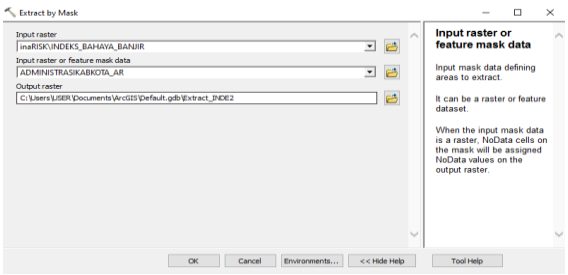

Figure 4. Tools Extract by Mask

f. The following results from selecting the flood hazard index in Buleleng Regency, which is then classified as a disaster hazard index using reclassify tools.

CATRA RESEARCH INSTITUTE
• ISSN 2720 - 9644 (print)
• ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dimensions ROAD INDEX COPERNICUS Indonesia OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

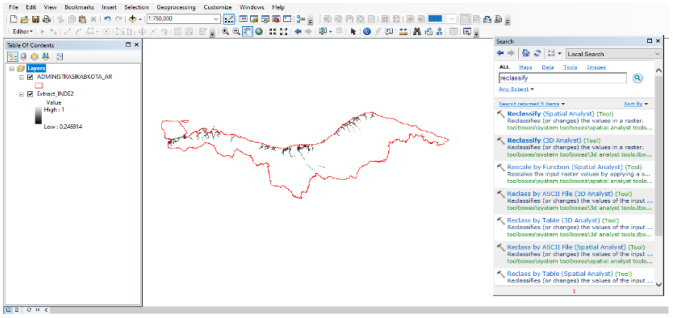

Figure 5. Potential Flood Hazards in Buleleng Regency

g. Then, select the input raster, the flood hazard data for the Buleleng district from the previous election's results, and select classify. Select three classes according to the BNPB Head Regulation, click the percent symbol, enter the three scores from top to bottom and highest down, and click ok.

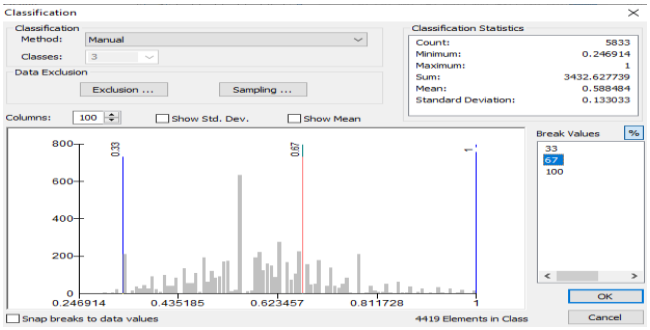

Figure 6. The Process for Determining Hazard Level Criteria

h. The following is data from the results of flood hazard classifiers in Buleleng Regency, which will be used as the primary hazard index data in compiling a disaster risk assessment. Likewise, other hazards by the potential hazards in Buleleng Regency are carried out through the same process.

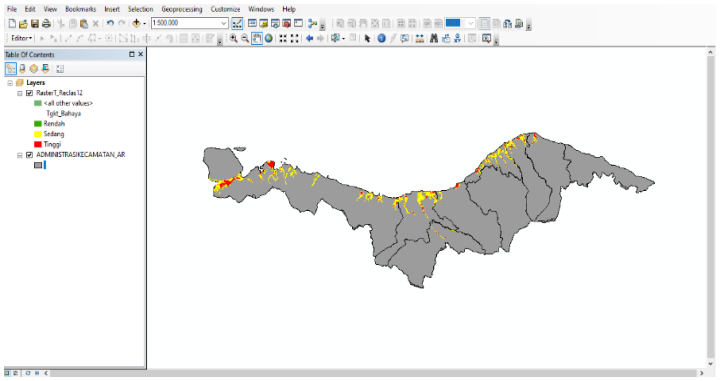

Figure 7. Map of the Flood Hazard Level in Buleleng Regency

Furthermore, vulnerability data was obtained from BPS Buleleng Regency and village potential data, while capacity data was obtained from interviews with BPBD Buleleng Regency.

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

Data Analysis. Analysis of the data used to define the risk of natural disasters that have the potential to occur in Buleleng Regency uses the guidelines recommended by the National Board for Disaster Management (BNPB). The stages of data analysis carried out are as follows.

a. Determining the threat level which indicates the level of exposure of the population to the hazard. Not all hazards threaten the population; therefore, the higher the threat level, the more the population is exposed.

Table 1. Conclusion of threat level

Threat Level		Exposure Population Index		
		Low	Medium	High
Hazard Index	Low			
	Medium			
	High			

b. Determine the level of loss that shows the damage to buildings, houses, productive land and the environment against the threat level. The higher the loss level, the higher the potential for losses due to a disaster.

Table 2. Conclusion of Loss Rate

Loss Level		Loss Index		
		Low	Medium	High
Threat Level	Low			
	Medium			
	High			

c. Determine the level of capacity that shows the comparison between the threat level and the capacity index. The higher capacity level shows that the region has an excellent capacity to deal with threats.

Table 3. Conclusion of Capacity Level

Capacity Level		Capacity Index		
		Low	Medium	High
Threat Level	Low			
	Medium			
	High			

d. Determining the level of disaster risk which shows the comparison between the level of loss and the level of capacity. The higher the level of risk, the more the capacity of the region to reduce losses due to disasters is still low.

Table 4. Conclusion of Disaster Risk Level

Disaster Risk Level		Capacity Index		
		Low	Medium	High
Loss Level	Low			
	Medium			
	High			

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

The provisions of the analysis used to determine the level of disaster risk: if the level of loss is in the low class and the level of capacity is in the low class, then the level of disaster risk is in the medium class. If the loss level is in the moderate class and the capacity level is in the medium class, the risk level is in the medium class. If the loss level is in the high class and the capacity level is in the high class, then the conclusion is that the risk level is in the medium class.

RESULT AND DISCUSSION

Following the mandate of RI Law No. 24 of 2007 concerning disaster management, it is necessary to have a disaster management plan in each region. Such planning requires data and information on disaster risk in an area at a particular time to make disaster management policies by stakeholders. On this basis, the availability of disaster occurrence data is essential information to assess the potential hazards in an area. Based on information from the BPBD of Buleleng Regency, there have been various disaster events in the last three years, which are recapitulated in the following table.

Table 5. Recapitulation of Disaster Events

No	Disaster Event	Year		
		2021	2022	2023*
1	Earthquake	1		4
2	Flood	5	18	15
3	Landslide	41	55	48
4	Drought	-	2	-
5	Extreme Waves and Abrasion	3	4	3
6	Extreme Weather	6	5	10
7	Epidemics and disease outbreaks	-	1	-
8	Building/Residential Fire	3	1	-
9	Other Events	112	268	227
	Total Events	171	354	308

**Data as of June 2023: Source: BPBD Buleleng (2023)*

In addition to the incident data presented in the table, it should be noted that the earthquake in Buleleng Regency significantly impacted fatalities. Specifically for earthquake disaster data that impacts a tsunami, history records that there have been earthquakes in Buleleng Regency that partly triggered a tsunami since 1815. The following is a record of earthquakes in the Bali Island region that directly impacted the Buleleng Regency area (BPBD Buleleng, 2023).

1. The north Bali earthquake of 22 November 1815 triggered a tsunami (10,253 people died).
2. The 1818 north Bali earthquake triggered a 3.5 m tsunami.
3. The north Bali earthquake of 13 May 1857 triggered a 3.4-meter tsunami (36 people died).
4. The north Bali earthquake of 21 January 1917 triggered a 2-meter tsunami (1,500 people died).
5. Seririt Bali Earthquake 14 July 1976 (536 people died, 850 people were seriously injured, and more than 3,200 people were slightly injured).
6. Karangasem earthquake December 17, 1979 (5 people died, 34 people were seriously injured, and 250 people were slightly injured).
7. Karangasem earthquake January 2, 2004 (1 person died).

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi Crossref ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

8. Nusa Dua-Denpasar earthquake Oct. 13. 2011 (50 injured).

To minimize hazard risks and the impacts that will arise, local governments, communities, the private sector, and the business world need to develop and implement various efforts in disaster management and disaster risk reduction. The participation of these various parties will indirectly help the implementation of disaster management in Buleleng Regency. Based on the hazard, vulnerability and capacity data analysis results in Buleleng Regency, the potential level of natural disaster risk in Buleleng Regency can be described as follows.

Flood Disaster. Areas that are included in flood-prone areas are areas with flat topography and are located around rivers or drainage canals. The determination of the flood hazard class is analyzed based on the inundation height value. Quoted from the 2019 BNPB Flood Risk Assessment Development Module, areas with an inundation height of less than 75 cm are included in the low hazard category. Areas with an inundation height of 75 - 150 cm are included in the moderate hazard category, and areas with inundation heights above 150 cm are included in the high hazard category (BNPB, 2019). Buleleng Regency is an area traversed by many rivers. Based on the topography, areas with flat topography are concentrated in the northern part directly adjacent to the Bali Sea, so it has the potential for flooding.

A flood event is the inundation of generally dry land caused by several things, including water overflow due to high rainfall. In some conditions, floods can become disasters that damage the environment and even claim human lives. Most of the lowlands in Buleleng Regency have a moderate to high flood risk potential, as visualized below.

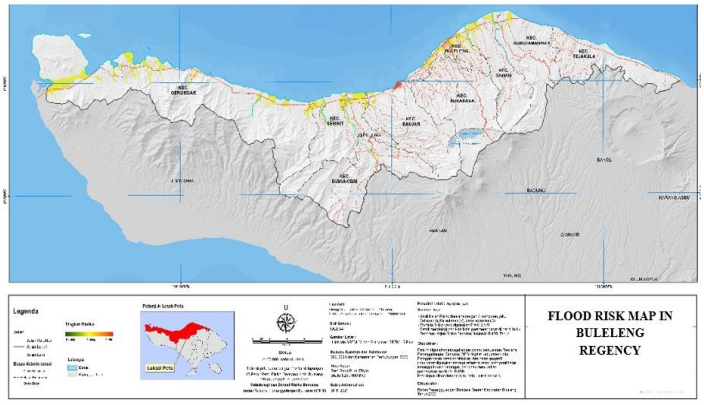

Figure 8. Flood Risk Map

Buleleng, Gerokgak and Seririt sub-districts are sub-districts with a high level of risk. It is greatly influenced by the level of vulnerability in the three sub-districts, mainly due to the number of residents and the distribution of public and critical facilities. Flood events tend to occur in areas with lower topography than the surroundings. According to records from the BPBD, the dominant flood events occurred in villages with lower topography and coincided with the rainy season. The recent flood events paralyzed transportation activities are the floods in Buleleng District, especially in the Singaraja City area.

The main factors causing variations in the percentage of flood-prone areas in Buleleng Regency are topographical conditions, population density and rainfall. The topography of the area lower than the surrounding area will have a higher chance of experiencing flooding.

Flash Flood Disaster. Flash floods are major floods that occur suddenly due to overflowing discharge that exceeds the flow capacity of the river due to high-intensity rain concentrations and often carry avalanche material or the collapse of natural dams, which are triggered by avalanche

CATRA RESEARCH INSTITUTE
• ISSN 2720 - 9644 (print)
• ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi Crossref ROAD INDEX COPERNICUS Indonesia OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

material in the upstream area of the river. The level of risk for flash floods in all sub-districts in Buleleng Regency is a high-risk class, so areas with a history of disasters need to prepare to anticipate flash floods, especially near rivers, as has happened in Tejakula District. And in Gerokgak District. The flash flood disaster is still relatively early to occur in Buleleng Regency. The recorded incident of flash floods that occurred in Tejakula District in early 2017 is an essential record for the government to remain responsive to flash floods. Flash floods usually come suddenly with rock/slide material and mud and inundate the area. Flash floods usually occur in areas close to rivers where the headwaters have the potential for landslides with moderate to high intensity, as shown in the following figure.

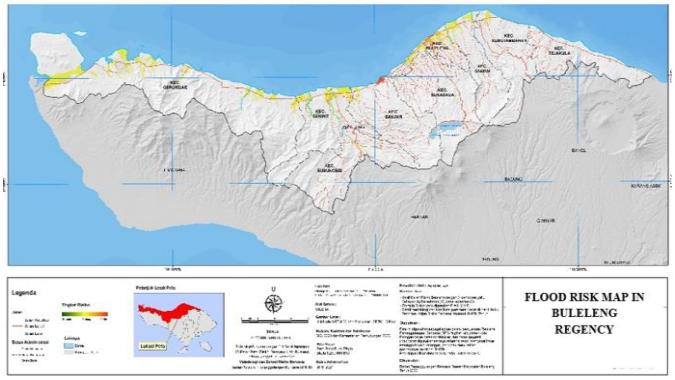

Figure 9. Flash Flood Disaster Risk Map

It is known that in Buleleng Regency, several watersheds have the potential to carry high water discharge such as rivers which are the Salak Watershed, Banyupoh Watershed, Taman Watershed, Pakecor Watershed, Madan Watershed, Musi Watershed, Gerokgak Watershed, Banyraras Watershed, Saba Watershed, Pasut Watershed, Buleleng watershed, Beji watershed, Dalem watershed, and Sangkutu watershed. Apart from focusing on rivers with high flow rates, flash floods can also occur in relatively small rivers/seasonal rivers whose upper reaches have the potential for landslides with moderate to high levels of potential, but because there are obstacles along the river flow that cause river water to overflow in discharge high, resulting in flash floods. It happened in Musi Village, Gerokgak District, in early 2016, as presented in the following figure.

Source: Bali Tribune, 2016 and Field Documentation, 2022

Figure 10. Flash Floods in Musi Village and River Conditions When There Was No Disaster

CATRA RESEARCH INSTITUTE
• ISSN 2720 - 9644 (print)
• ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi Crossref ROAD INDEX COPERNICUS Indonesia OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

Based on the results of the field survey show that the seasonal river area does not have the potential for flash floods because, besides small rivers, usually the water discharge flowing through the river during the rainy season is also not too large; even in the dry season, the river is dry. However, due to landslides in the upper reaches and along the river, several bridges have the potential to block the flow of water so that the water carrying landslide material will overflow and flash floods will occur.

Extreme Weather Disaster. Extreme weather is an extreme meteorological phenomenon, primarily a weather phenomenon that can potentially cause disaster, destroy the order of social life, or cause loss of life. The potential for extreme weather hazards is in areas with high land openness and sloping plains, as visualized in the following figure.

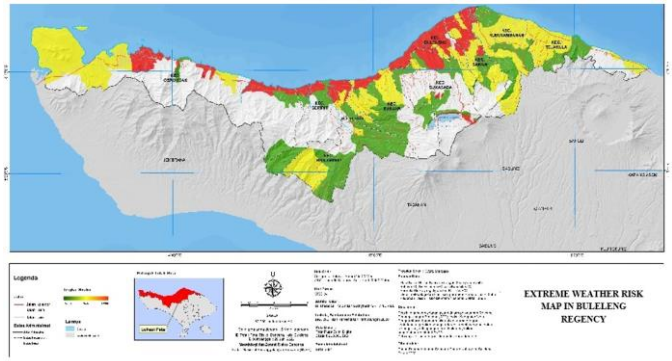

Figure 11. Extreme Weather Disaster Risk Map

The risk of extreme weather disasters in all districts is in the high-risk class, especially on the north coast. The coastal area is relatively flat and has high land openness. During high rainfall, strong winds in coastal areas have the potential to occur. Based on the extreme weather hazard map, it can be seen that all sub-districts have moderate potential, except for the Buleleng sub-district, which has high-risk potential. This high-risk potential is due to the higher vulnerability in Buleleng District compared to other districts. Extreme weather disasters in Buleleng Regency usually occur in January to February, which coincides with the peak of the rainy season. The impact of this disaster caused the collapse of the roofs of residents' houses, including other infrastructure. It is tough to predict the location of this extreme weather event. However, considering the data on events that have hit Buleleng Regency, the public must remain vigilant against extreme weather disasters to minimize disaster risk.

Extreme Wave Disaster and Abrasion. Extreme waves are high waves caused by the effects of tropical cyclones around Indonesia and have a solid potential to cause natural disasters. Indonesia is not a tropical cyclone trajectory, but the presence of tropical cyclones will strongly influence solid winds and high waves accompanied by heavy rain. Meanwhile, abrasion erodes the beach by the destructive power of sea waves and ocean currents. Shoreline damage due to abrasion is triggered by disruption of the natural balance of coastal areas. Although natural symptoms can cause abrasion, humans are often cited as the primary cause (http://www.bnpb.go.id).

Based on the history of its occurrence, the entire coastal area of Buleleng Regency is an area prone to being affected by extreme waves, which are presented below.

CATRA RESEARCH INSTITUTE
• ISSN 2720 - 9644 (print)
• ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dimensions ROAD INDEX COPERNICUS Indonesia OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

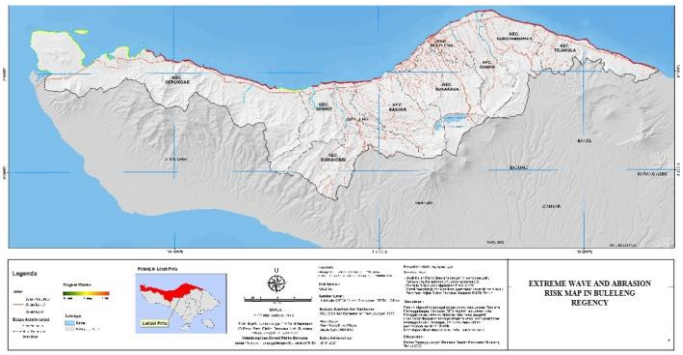

Figure 12. Extreme Wave and Abrasion Disaster Risk Map

Analysis of sea level height data found that during the rainy season, December-February, there has been a phenomenon of sea level spikes, which tend to reach a height of 2 m. Extreme waves occur during the rainy season and sometimes during the dry season. Extreme waves caused flooding and building damage in coastal areas. Information from extreme wave events needs to be a momentum that must be watched out for as disaster mitigation in coastal areas, especially from the results of interviews with the BPBD Buleleng confirmed that Buleleng Regency has a high risk of extreme wave threats and abrasion.

Earthquake Disaster. Earthquakes are vibrations or shocks on the earth's surface caused by collisions between the earth's plates, active faults, volcanic activity or rock debris (http://www.bnpb.go.id). The tectonic setting in the Back Arc basin, coupled with rock breakthroughs and quaternary rock lithology, which are not compact, make Buleleng Regency highly prone to earthquakes. Overall, the earthquake disaster risk in Buleleng Regency with a disaster risk level is in the low-risk class, and some are high, so areas with a history of disasters need to prepare to anticipate earthquakes, as shown below.

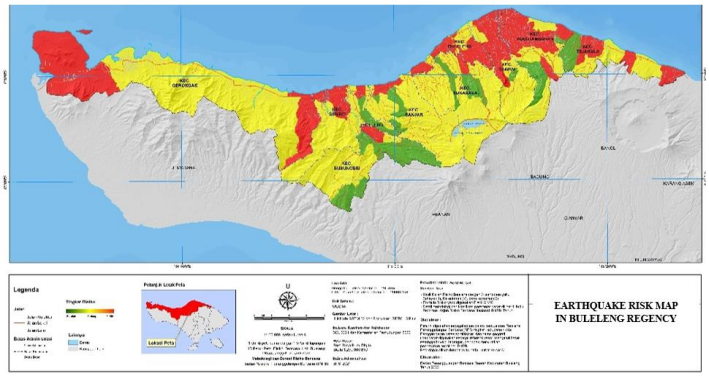

Figure 13. Earthquake Disaster Risk Map

Based on this map, it is known that most areas of Buleleng Regency are at high risk because of vulnerability to earthquakes, which is still high, especially in densely populated areas. The higher the community's vulnerability, the higher the level of disaster risk experienced.

Forest and Land Fire Disaster. Forest and land fires are surface fires that ignite potential combustible materials (e.g., trees, shrubs, etc.). The fire then spreads erratically, slowly burning organic matter through the pores of the peat and through the roots of shrubs/trees whose tops are on fire. Based on its parameters, the potential hazard of forest and land fires in Buleleng Regency is known to be in the moderate class, mainly occurring in dry areas such as in Gerokgak District. The

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

high forest and land fires are influenced by land cover in the form of forest and the prolonged dry season. In addition, land clearing by humans is also very influential in triggering forest and land fires. The distribution of potential risks for forest and land fires is presented in the following figure.

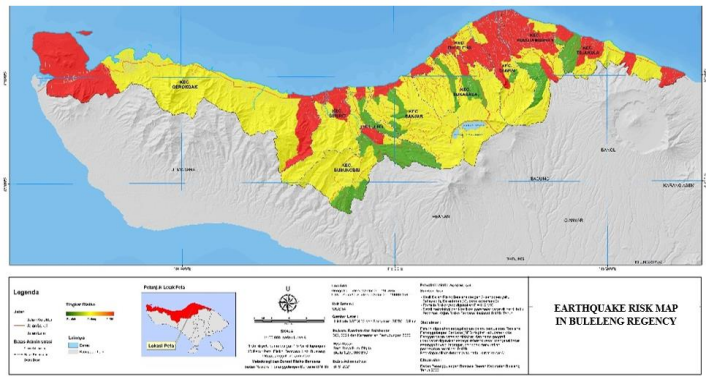

Figure 14. Forest and Land Fire Disaster Risk Map

The risk level for forest and land fires is low to high-risk. The sub-district with the highest risk is the Gerokgak sub-district, while other sub-districts are still in the low to moderate category. It needs to be watched out for because, in the Buleleng Regency area, many forests, plantation land, and shrubs are quickly burned, especially during a prolonged dry season. Besides being triggered by human activities, forest and land fires are also caused by dry and hot weather.

Drought. Drought is a disaster caused by lower rainfall levels than average rainfall. In general, droughts can be grouped into four types, namely meteorological, agricultural, hydrological, and socio-economic droughts. The potential risk of drought in Buleleng Regency is presented in the following figure.

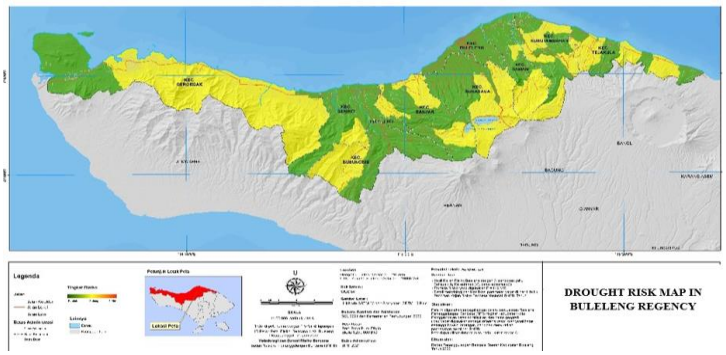

Figure 15. Drought Disaster Risk Map

The level of risk of drought, in general, is in the low category. This drought has an impact on productive land in the form of rice fields or agricultural land and community plantations that are threatened with crop failure. This potential disaster risk can be used to prepare and prevent more significant disaster losses for the next few years. Droughts in Buleleng Regency have involved various parties to supply clean water to the community. Moreover, the long dry season will significantly impact the higher potential risk of drought disaster, which requires efforts to be handled by the government.

Landslide Disaster. Landslides are mass movements of either soil, rock, or a mixture of the two down a slope due to gravity. Landslides occur when the slope is unable to support the load on

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

it. The causes can vary, including heavy rains, volcanic activity, earthquakes, river erosion, changes in water level, human activities, or a combination of these factors. The distribution of the potential risks of landslides in Buleleng Regency is presented in the following figure.

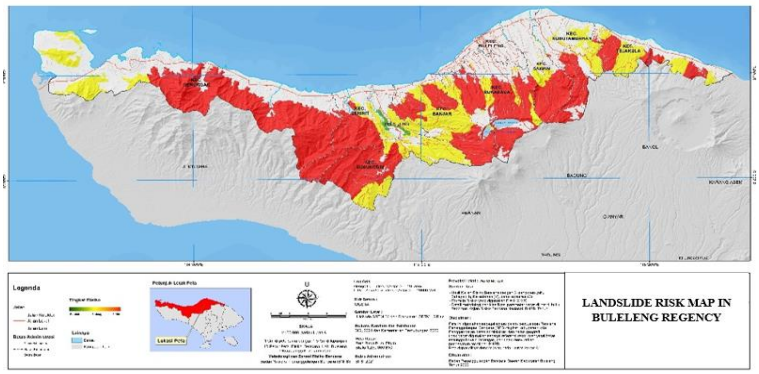

Figure 16. Landslide Disaster Risk Map

The level of risk of landslides, in general, is in the medium-risk class. Districts that have a high level of risk are Gerokgak and Sukasada Districts. Banjar, Busungbiu, Kubudindingan, Sawan, Seririt, and Tejakula sub-districts are at a moderate risk level, while the rest are at a low-risk level. Landslides generally occur in mountainous areas with a slope greater than 30%. The steeper the slope, the greater the possibility of landslides. Sudden or gradual changes in a slope's composition, structure, hydrology or vegetation cause landslides. According to Ella et al. (2008), these changes can be natural or caused by humans and cause disturbances in the balance of the materials on the slopes. Slope balance disturbances can be in the form of (a) increased water content due to heavy rains or rising groundwater, (b) loss of vegetation due to deforestation, (c) vibrations due to earthquakes, eruptions, machine movements and traffic, and (d) load build-up by rain, volcanic material or seepage from irrigation and sewage systems.

Areas with a high potential for landslides are spread across all sub-districts in Buleleng Regency. One of the sub-districts, namely Sukasada Sub-District, is the sub-district that is most often in the spotlight, especially the occurrence of landslides along the Singaraja-Denpasar route, precisely in Gitgit Village. The geographical conditions of the southern part of Buleleng Regency almost have a uniform topography. However, several differences cause landslides to occur more frequently in Sukasada District, especially in Gitgit Village. One of them is due to the slope-cutting activities for the road, which makes the slope along the road very steep, as visualized below.

CATRA RESEARCH INSTITUTE
• ISSN 2720 - 9644 (print)
• ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi Crossref ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

Source: Disaster Study Document, 2017

Figure 17. Illustration of Slope Change and Load Addition due to Slope Cutting, Heavy Vehicle Loads and Examples of Landslide Disaster Events;

In addition, the construction of shortcut roads at the top, especially in Sukasada District, will affect the hydrological cycle and water absorption. It also needs to be of concern to the government to mitigate landslides, the most frequent disaster in Buleleng.

Tsunami Disaster. A tsunami is a disaster with the character of a fast-onset disaster or a type of disaster with a fast process. The tsunami is one of the disaster threats for coastal areas, as is the case for Buleleng Regency, which also has a coast. This disaster is generally triggered by an earthquake at sea, which causes a vertical shift on the seabed. The distribution of potential disaster risk levels in Buleleng Regency is presented in the following figure.

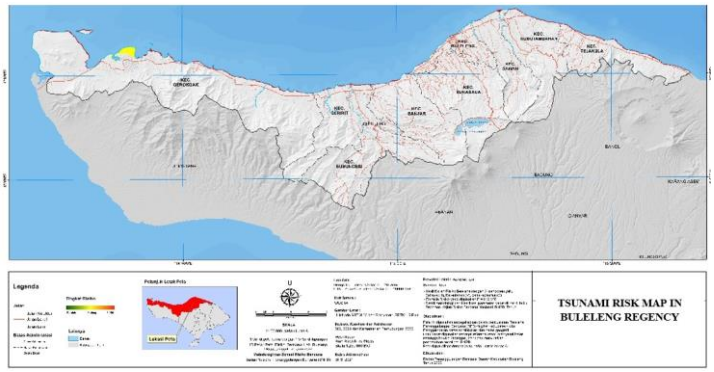

Figure 18. Tsunami Disaster Risk Map

In general, the potential for tsunami risk in Buleleng Regency is in the high category because the level of vulnerability in the affected area is in the high category. Even though in terms of disaster event data in the last five years, there is no potential for a tsunami in Buleleng Regency if you pay attention to long-term historical data, namely: The North Bali earthquake on 22 November 1815 triggered a tsunami (10,253 people died); The 1818 north Bali earthquake triggered a 3.5-meter tsunami; The north Bali earthquake of 13 May 1857 triggered a 3.4-meter tsunami (36 people died); and the North Bali Earthquake on January 21, 1917, triggered a 2 meter tsunami (1,500 people died),

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dbi ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics

giving insight that the Buleleng Regency government must always conduct outreach and education to coastal communities potentially affected by a tsunami. Apart from that, maintenance of existing early warning tools should always be considered to ensure that these tools function properly (BPBD, 2023).

Referring to the results of the analysis of potential natural disaster risks in Buleleng Regency, nine (9) types of disasters have the potential to occur, namely earthquakes, droughts, extreme weather, forest and land fires, floods, flash floods, extreme waves, and abrasion, tsunamis, and landslides. Due to these potential hazards, it is known that the level of vulnerability and regional capacity strongly influence the disaster risk level. A comprehensive point of view is needed to conclude the root causes of each hazard using spatial analysis and field surveys so that the handling is correct on target.

The following table shows that the identification of priority disaster potential is determined based on information on classifying risk classes in the high category.

Table 6. Summary of Potential Disaster Risks in Buleleng Regency

Hazard Type	Hazard Class	Vulnerability Class	Capacity Class	Risk Class
Flood	Medium	Medium	Medium	Medium
Flash Flood	High	Medium	Medium	High
Extreme Weather	Low	High	Medium	Medium
Extreme Wave and Abrasion	High	Medium	Medium	High
Earthquake	Low	High	Medium	High
Forest and Land Fire	Medium	High	Medium	High
Drought	Medium	High	Medium	High
Landslide	Medium	High	Medium	High
Tsunami	High	Medium	Medium	High

Based on the results of an analysis carried out by a disaster study in Buleleng Regency, it is known that almost all types of disaster risk classes in Buleleng Regency have priorities that must be addressed because they are in the red zone or have a high risk except for flooding and extreme weather. As a mitigation effort, special attention is needed to avoid more significant losses. Based on the results of public discussions, the priorities to be dealt with in more detail in this disaster management plan document are based on the following considerations.

Table 7. Matrix of Determining the Priority of Disasters to be Handled

Disaster priority handled		Trends in Disaster Events		
		Decrease	Fixed	Increase
Disaster Risk Level	Low			
	Medium		Extreme weather	Flood
	High		Flash Floods, Extreme Waves and Abrasion of	Earthquakes, Droughts, Landslides

ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE

	Forest and Land Fire, Tsunamis

Referring to the figure and considering the probability, impact, number, and coverage area indicators of the affected area, several types of disaster threats will be described in more detail in this disaster management plan.

Floods, Landslides, Earthquakes, Tsunamis, Droughts

The types of disasters that are prioritized and will be prepared for disaster management efforts in Buleleng Regency do not intend to ignore other types of disasters, which are also very important for handling efforts. The selection of the five types of disasters is not only based on probability, the extent of the impact, and the magnitude of the resulting impact; it is also influenced by the fact that managing these types of disasters requires related parties in their mitigation efforts. Disaster management efforts will be more focused and well-coordinated in the future. One of the future efforts that can be made to minimize the potential for disaster risk is to minimize potential vulnerabilities. It aligns with the results of research conducted by Roukounis and Tsihrintzis (2022), who reviewed 46 articles and found various physical and social vulnerabilities that can be controlled to reduce disaster risk. Likewise, the research results of Permatasari (2021) and Rachman and Arifki (2022) include many other researchers who are still studying regional vulnerability, which is intended as an option for everyone to participate in making efforts to reduce the level of regional vulnerability. Apart from that, this can also be done by increasing regional capacity as recommended by Koem et al. (2019), Saiman et al. (2022), and Oktari (2019), as well as other researchers who emphasize that capacity building is an effort that can be made to reduce potential disaster risk in an area.

CONCLUSION

The implementation of disaster management policy directives requires the participation of all parties, from the government down to the community level. The involvement of all disaster-related stakeholders in Buleleng Regency and the community can support efforts to implement countermeasures, which can be initiated through an analysis of potential disaster risks. Based on the results of the analysis, it is known that in Buleleng Regency, there are nine types of potential risks of natural disasters consisting of floods, flash floods, extreme weather, extreme waves and abrasion, earthquakes, forest and land fires, drought, landslides, and tsunamis. The results of this analysis have also been discussed, and it is known that at least five levels of disaster risk need to be prioritized in preparing disaster management plan documents, namely the risks of floods, landslides, earthquakes, tsunamis, and droughts. The results of this potential disaster risk analysis can become the basis for directives for clear and comprehensive disaster management. It is intended to minimize further the loss of life and losses caused by the disaster in Buleleng Regency, bearing in mind that there is still a considerable gap in terms of the scope and distribution of disaster events compared to the number of existing human resources.

REFERENCES

BNPB. (2019). Modul Teknis Kajian Risiko Bencana BNPB.
BPS Buleleng. (2021). Kabupaten Buleleng dalam Angka 2020.
BPBD Buleleng. (2023). Laporan Kejadian Bencana.

CATRA RESEARCH INSTITUTE
• ISSN 2720 - 9644 (print)
• ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dimensions ROAD INDEX COPERNICUS OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

De Bosschere, K. O. E. N. (2023). Climate Change is Here to Stay, So We Had Better Prepare for it. HiPEAC Vision 2023, 196.

Ella Yulaelawati, P., & Usman Syihab, P. (2008). *Mencerdasi Bencana: Banjir, Tanah Longsor, Tsunami, Gempa Bumi, Gunung Api, Kebakaran.* Jakarta: Grasindo. Field Documentation, 2022.

Hopkinson, C. S., Ariel E. L., M. A., Alan P. C., & Skip J. V. B. (2008). Forecasting Effects of Sea Level Rise and Windstroms on Coastal and Inland Ecosystems. *Journal Front Ecol Environ*. HAL 255-263: The Ecological Society of America. https://doi.org/10.1890/070153

http://www.bnpb.go.id inarisk.bnpb.go.id

Irwan, I., Ridha, N. R., Katili, D. I., & Mar'atuljannah, U. N. A. (2023). Risk Factor Analysis of Occupational Diseases in Computer Users. *International Journal of Environmental, Sustainability, and Social Science, 4*(5), 1295-1301.

Jasour, Z. Y., Reilly, A. C., Tonn, G. L., & Ferreira, C. M. (2022). Roadway Flooding as a Bellwether for Household Retreat in Rural, Coastal Regions Vulnerable to Sea-Level Rise. Climate Risk Management, 36. https://doi.org/10.1016/j.crm.2022.100425

Koem, S., Akase, N., & Muis, I. (2019). Peningkatan Kapasitas Masyarakat dalam Mengurangi Risiko Bencana di Desa Bandung Rejo Kabupaten Gorontalo. *Aksiologiya: Jurnal Pengabdian Kepada Masyarakat, 3*(2), 176-184. https://doi.org/10.30651/aks.v3i2.1815

Marfai, M. A., Nursakti A. P., Taufik H., Anang W. N., & Muammar, G. (2011). *Model Kerentanan Wilayah Pesisir Berdasarkan Garis Pantai dan Banjir Pasang.* Yogyakarta: Magister Perencanaan Pengelolaan Pesisir dan Daerah Aliran Sungai, Fakultas Geografi Universitas Gadjah Mada Yogyakarta.

McEvoy, S., Haasnoot, M., & Biesbroek, R. (2021). How are European countries planning for the rise of sea levels? Ocean and Coastal Management, 203. https://doi.org/10.1016/J.OCECOAMAN.2020.105512.

Nicholls, R. J. (2003). Case Study on Sea Level Rise Impact. Organization for Economic Co-operation and Development.

Oktari, R. S. (2019). Peningkatan kapasitas desa tangguh bencana. *Jurnal Pengabdian kepada Masyarakat (Indonesian Journal of Community Engagement), 4*(2), 189-197. https://doi.org/10.22146/jpkm.29960

Peraturan Pemerintah Nomor 21 Tahun 2008 tentang Penyelenggaraan Penanggulangan Bencana (Lembaran Negara Republik Indonesia Tahun 2008 Nomor 42, Tambahan Lembaran Negara Republik Indonesia Nomor 4828).

Peraturan Kepala Badan Nasional Penanggulangan Bencana Nomor 2 Tahun 2012 tentang Pedoman Umum Pengkajian Risiko Bencana.

Permatasari, N., Ashari, F. R., & Ismail, N. (2021). Contribution of perceived social support (peer, family, and teacher) to academic resilience during COVID-19. *Golden Ratio of Social Science and Education, 1*(1), 01-12. https://doi.org/10.52970/grsse.v1i1.94

Roukounis, C. N., & Tsihrintzis, V. A. (2022). Indices of Coastal Vulnerability to Climate Change: A Review. *Environmental Processes, 9*(2), 29. https://doi.org/10.1007/s40710-022-00577-9

Saiman, S., Hijri, Y. S., & Hadi, K. (2022). Pendampingan dan Pelatihan Peningkatan Kapasitas Desa Tangguh Bencana sebagai Upaya Pengurangan Risiko Bencana (PRB) Berbasis Masyarakat di Desa Gajahrejo Kecamatan Gedangan Kabupaten Malang. *Society: Jurnal Pengabdian Masyarakat, 1*(2), 65-73. https://doi.org/10.55824/jpm.v1i2.79

Saputra, K. A. K., Dharmawan, N. A. S., Kawisana, P. G. W. P., & Larasdiputra, G. D. (2023). Potential Carbon Tax in Indonesia: A Literature Review. *International Journal of Environmental, Sustainability, and Social Science, 4*(6), 1670-1677.

CATRA RESEARCH INSTITUTE
ISSN 2720 - 9644 (print)
ISSN 2721 - 0871 (online)
IJESSS
INTERNATIONAL JOURNAL OF ENVIRONMENTAL, SUSTAINABILITY AND SOCIAL SCIENCE
Indexed By : GARUDA Google dimensions ROAD INDEX COPERNICUS Indonesia OneSearch ISJD sinta 4 EBSCO Clarivate Analytics WEB OF SCIENCE

Undang-Undang Nomor 24 Tahun 2007 tentang Penanggulangan Bencana (Lembaran Negara Republik Indonesia Tahun 2007 Nomor 66, Tambahan Lembaran Negara Republik Indonesia Nomor 4723).

Zainuri, M., Helmi, M., Novita, M. G. A., Kusumaningrum, H. P., & Koch, M. (2022). Improved Performance of Geospatial Model to Access the Tidal Flood Impact on Land Use by Evaluating Sea Level Rise and Land Subsidence Parameters. *Journal of Ecological Engineering, 23*(2), 1–11. https://doi.org/10.12911/22998993/144785.

Yunus. (2010). *Metode Penelitian Kontemporer.* Yogyakarta: Pustaka Pelajar.