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Environmental Vulnerability on Tsunami Hazard, Cisolok Village, Sukabumi

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Abstract

Indonesia is one of the countries located in a series of volcanoes or commonly called the ring of fire. This situation later became vulnerable to disaster events in Indonesia. Tsunami is one of the most vulnerable disasters in Indonesia, with the shape of this country with many volcanoes surrounded, one of which is Cisolok Village. This study aims to analyze tsunami hazard areas and analyze environmental vulnerability to tsunami hazards in Cisolok Village. In the tsunami hazard, this paper use the map that has been issued by InaRisk BNPB, for environmental vulnerability three factors are seen, namely land cover, geomorphology and geology. The method used is spatial analysis and descriptive analysis. As a result, the tsunami hazard map shows Inarisk using inundation heights up to 10 meters with three classifications namely low, medium and high. The environmental vulnerability to tsunami map is divided into three classes where 25.67% low vulnerability, 30,69% medium vulnerability dan 43.14% high vulnerability.

Keywords: vulnerable, environmental vulnerable, tsunami

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1. Introduction

Environmental vulnerability is defined as a function of environmental exposure, sensitivity and adaptive capacity. This framework was adopted from the concept of climate change vulnerability suggested by the IPCC [1--3].The concept of environmental vulnerability typically combines two factors namely biophysical and socioeconomic factors [2--5]. Biophysical factors are generally associated with environmental exposure that causes pressure, while socioeconomic factors are generally related to sensitivity, namely exposed units and adaptive capacity, namely the ability to cope with stresses that occur. In addition to physical conditions and natural disasters, non-physical aspects such as population also affect the existence of environmental vulnerability.

Indonesia has a strategic location, which is between the Indian Ocean and the Pacific Ocean. The location of Indonesia then made Indonesia included in the part of the ring of fire. Ring of fire itself is a series of volcanoes (some are still active) that surround the Pacific Ocean. This situation affects disasters that will occur in the territory of Indonesia, one of which is the tsunami. According to BNPB in the 2016 RBI (Indonesian Disaster Risk) `the earthquake and tsunami that occurred was heavily influenced by tectonic fault activity'. In the disaster risk assessment (Sukabumi Regency 2019 - 2023) the highest risk of earthquake disaster is in 21 villages in Sukabumi District, with several high-risk tsunamis in Cikahuripan, Cisolok, Karangpapak and Pasir Baru Villages in Cisolok District. this is caused by the location of the village which is adjacent to the beach with a broad sloping topography [6].

Cisolok village, Cisolok sub-district, Sukabumi Regency, is one of the regions in Indonesia that is crossed by a series of volcanoes and is also crossed by a plate meeting. This does not rule out the possibility of a volcanic eruption or tectonic activity at sea, there will be natural disasters such as tsunamis around Cisolok Village and Cisolok Village itself. Until now, there has not been a tsunami in Cisolok Village, which may be influenced by the location of Cisolok Village in the bay. But quoting from tempo.co [7] Hamzah Latief said, the tsunami at bay is more dangerous because 'the bigger the waves that enter the bay, the accumulated energy'. If the waves have entered the bay, then returned towards the sea but received a boost from the incoming sea waves, the waves will become even greater. Several tsunami incidents that occurred in the bay include, on Seram Island in the 1980s, Maurame Tsunami in 1992 and tsunami in Palu City in September 2018.

Cisolok village itself was chosen by researchers to look at environmental vulnerability to tsunamis, see if a real tsunami occurs, then the likelihood of its occurrence will be large and have an impact on environmental conditions. To anticipate this, the researcher wants to make a map of the environmental vulnerability to tsunamis, which may be a warning for coastal communities in the future. The purpose of this research is to analyze the tsunami hazard area in Cisolok Village, Cisolok Subdistrict, Sukabumi District and analyze the environmental vulnerability to tsunamis in Cisolok Village, Cisolok Subdistrict, Sukabumi District. To see the tsunami vulnerability in Cisolok Village, modeling was used using the ArcMap 10.5 application. This modeling is carried out to see areas of low to high tsunami vulnerability affected by the tsunami..

2. Literature Review

Hazard refers to natural events that can affect different places one by one or in combination (coastline, hillside, earthquake fault, etc.) at different times. According to Badan

Nasional Penanggulangan Bencana [8] hazard is a situation, condition or biological, climatological, geographical, geological, social, economic, political, cultural and technological characteristics of a community in a region for a certain period of time which has the potential to cause casualties and damage.

Tsunamis are tidal waves caused by earthquakes at sea, underwater volcanic eruptions or sea avalanches [9]. According to the International Institute for Geo-Information Science and Earth Observation [10] a tsunami is a series of waves generated in a body of water by vertically implusive interference in water. Tsunamis are generally produced by various processes such as earthquakes, land and sea landslides, volcanic eruptions, meteorological events, and the impact of extra-terrestrial objects [11, 12].

According to the Volcanic and Geological Disaster Mitigation Center [13] the speed of a tsunami depends on the depth of the sea. In the deep sea, tsunamis will have high speeds with low wave heights. When a tsunami wave reaches shallow water, the speed of the tsunami decreases and the height of the tsunami increases and is destructive. According to ITC [10] a tsunami is a wave of shallow water, that is a wave whose wavelength is much longer than the depth of the water traversed. Tsunamis in waters or deep seas have long wavelengths and low amplitude. But after touching land the tsunami speed will slow down and the amplitude of the waves will increase dramatically.

UNISDR [14] said vulnerability is a characteristic and condition of a community, system or asset that makes it vulnerable to the impact of a hazard. Vulnerability represents the tendency or predisposition of a community, system, or asset that will be affected by certain hazards [14--16]. Vulnerability or vulnerability is defined as the potential attributes of a system to respond to hazard events[17].

Environmental vulnerability is a concept related to the tendency of the environment and natural resources to suffer damage or loss [18, 19]. A system's vulnerability is a measure of the tendency to change a system that must face threats to any situation or relationship that can damage a system and produce an adaptive response there [16, 20].

The British Society for Geomorphology says geomorphology is the study of land forms, processes, forms, and sedimentation on the surface of the earth. Geomorphology according to Van Zuidam [21] is the study of the shape of the earth's surface and the processes that take place on the surface of the earth since the earth was formed until now.

Geology is a science that investigates the sequential changes that occur in organic and inorganic materials[22]. Geology is the science that discusses the properties and materials that make up the earth, the structure, the processes that work well inside the earth's surface, its position in the universe and the history of its development [17].

3. Methods and Equipment

Broadly speaking, this research was conducted to look at the vulnerability of the environment to tsunamis which were carried out by looking at areas exposed to tsunamis and the level of environmental coolness in Cisolok Village. The method used in this research is spatial descriptive analysis using geographic information systems. To see the tsunami hazard in Cisolok Village, a tsunami hazard model that has been carried out by BNPB was taken using the InaRisk website.

Meanwhile, to obtain environmental vulnerability in Cisolok Village, adapted from research conducted by Grigio et al., (2006) [20]. The variables used to obtain maps of environmental vulnerability are geomorphology, geology and land use. The predetermined variable is then given a value that ranges from 1 to 3 with a difference of 0.5. This value is given based on the level of stability of each parameter.

Table 1: Stability Value *[16]*.

Class	Relationship of podogenesis / morphogenesis	Value
Stable	podogenesis	1
Stable intermediately	Balance between podogenesis and morphogenesis	2
Unstable	morphogenesis	3

The identified class is distributed among the dominant situations of the podogenesis process (values close to 1), the erosive dominant situation changes the shape of the relief (value 2), and the situation is dominated by morphogenesis (value 3). Values with these criteria are used to determine geomorphological values and geomorphological values.

Table 2: Geomorphological Vulnerability Level *[23]*.

Class	Value
High Cliff	1
Medium Cliff	2,5
Low Cliff	2,5
Beach building	3
Beach barrier	3

The weighting carried out for vegetation diversity given value is a value of 3 for diversity / species that are just starting, value 2 for environments with moderate biodiversity, value 1 for high species diversity.

The weight given pays attention to how much a variable is vulnerable to external interference. The value of one is given to variables that are considered quite stable

TABLE 3: Geological Vulnerability Level *[16]*.

Class	Value
Alluvium	3
Tuff Citorek	3
Dasit	1

TABLE 4: Land Cover Vulnerability Level *[24]*.

Class	Value
Water	1
Tourist attraction	1
Settlement	2
Paddy field	3
shrubs	1,5
Open field	3
Farm	2

when exposed to outside interference and the value of three is given to variables that are considered to be unstable against outside interference. After weighting, then each variable is entered into the calculation of environmental vulnerability. Calculation of environmental vulnerability is done by referring to [24];

$$\text{VA} = (\text{geom}) \times 0,2 + (\text{geo}) \times 0,1 + (\text{uso}) \times 0,5 \tag{1}$$

Where:

VA: Environmental Vulnerability

Geom: Geomorphology

Geo: Geology

Uso: Land cover

Land cover in this calculation has a large value because this land cover is the focus of research. The environment referred to in this study are all factors that affect organisms, can be either living factors and non-living factors [25] While environmental vulnerability in question is the depletion of natural resources and increasing damage to natural resources [26].

4. Results

4.1. Tsunami

The tsunami hazard created by BNPB takes into account surface roughness as seen from ground cover, slope and distance from the coastline. After calculation, standardization is carried out into three classes, namely low, medium and high class. Low class shows the chance of occurrence and low intensity of danger while high class shows high chance of occurrence and intensity. If we look at the distribution of tsunami hazard and the altitude of the area, the height of the tsunami run up used is approximately 0-10m. The distribution of tsunami inundation in Cisolok Village reached 52.12 Ha along the coastline. The area of tsunami hazard in the high class is 27.6 Ha, the medium class is 20.35 Ha and the low class is 4.16 Ha.

In Figure 1 it can be seen that the distribution of extensive tsunami flows is in the western part of Cisolok Village. This can be caused by existing physical conditions. The shape of the slope in Cisolok Village shows that the western part of the village has a sloping shape and is quite extensive about 10 meter in distance. While in the eastern part of the village the slope shows a more steep shape. Therefore, tsunamis are not easy to spread further north.

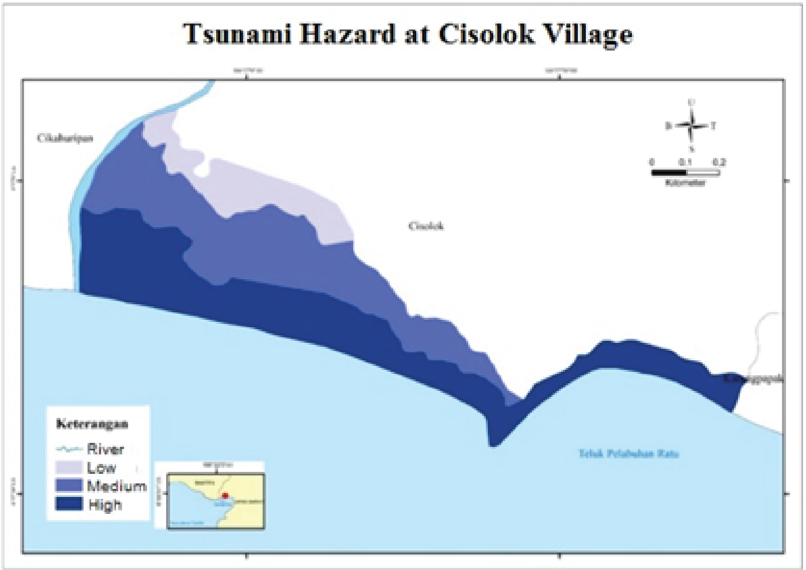

Figure 1: Tsunami Hazard.

Land cover also affects the spread of tsunami flows. Broadly speaking, land cover in Cisolok Village is agriculture and plantation. Meanwhile, the settlement is linear, following the shape of the road. Land cover such as rice fields cannot withstand tsunami wave flow because it has a small hardness value of 0.025. The buildings that can withstand the flow of tsunamis in Cisolok Village are mostly located in the north of the village which has a higher topography than the south. This caused the tsunami to continue to spread in the western part of Cisolok Village.

4.2. Environmental Vulnerability on Tsunami Hazard

The spread of environmental vulnerability from environmental vulnerability is very low marked with pink to very high environmental vulnerability marked with dark red. In the calculation of environmental vulnerability, three factors are used in accordance with the adaptation of previous research conducted by Grigio et al., (2006) [20]. These three factors are land cover, geomorphology, and geology. These three factors have different effects on environmental vulnerability.

The results of these calculations show that the low environmental vulnerability in Cisolok Village has an area of 13.96 Ha, a medium vulnerability of 16.69 Ha and a high vulnerability of 23.46 Ha. At high tsunami hazard, most of the environmental vulnerabilities included in it are low class environmental vulnerabilities. In moderate tsunami hazards, the vulnerability classes included in the medium hazard classification are mostly medium hazards. For low class tsunami hazards, most of the environmental vulnerabilities included in the low hazard classification are high and medium class.

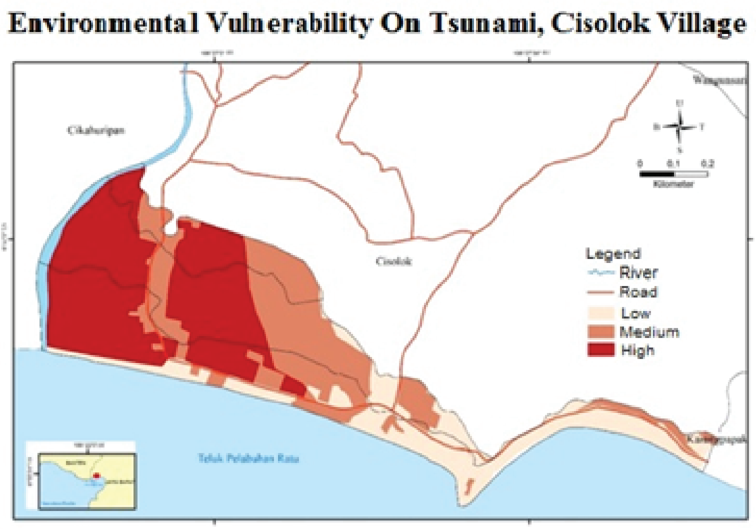

Figure 2: Environmental Vulnerability on Tsunami Hazard.

Geomorphological units related to environmental vulnerability even though they do not have a large value, geomorphological units can affect environmental vulnerability. This is because these geomorphological units can influence changes in the shape of the environment. From this geomorphological unit, it can be seen the characteristics of the environment according to what has been classified by van zuidam [13].

The geological conditions of an area can also affect environmental vulnerability. This rock type then determines what plants will be on it because there is a process between the rocks and pressure from outside or inside the earth. Geological conditions determine the shape of origin of an area.

When viewed from the use of land, most of the land use in Cisolok Village is farmland, shrubs and settlements. Based on the weighting in table 4 he level of agricultural vulnerability has a high vulnerability value of 3. This value indicates that the use of paddy farming land is the use of land which is included in the land use that is just beginning. The damage that occurs is likely to be large because it is included in the weighting classification where the land use conditions are unstable. Judging from the physical condition where in the lowlands and sloping tsunami waves flow freely into the land which can then spread easily because there is no barrier to the water waves entering the surface.

5. Conclusion

Based on the tsunami hazard created by Inarisk, the height of the tsunami estimated to hit the village of Cisolok reached a distance of 10 meters and expanded to the western part of the village due to sloping and low physical conditions. Although in Cisolok Village there is no tsunami hazard data, the possibility of a tsunami hazard occurring is included as a high tsunami hazard. This can be seen from the physical condition of Cisolok Village which has a sloping lowland and minimal sea wave barrier, which makes tsunami spread easy.

Environmental vulnerability to tsunamis is created by sum up variables such as geomorphology, geology, and land use. It was found that the environmental vulnerability in Cisolok Village by 25.67% was a low environmental vulnerability, 30.69% was a moderate environmental vulnerability and 43.14% was a high environmental vulnerability. It can be seen from the variables and counted area that environmental vulnerability in Cisolok Village is high.

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Conflict of Interest

The authors have no conflict of interest to declare.

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