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Coastal Area Management Based on Disaster Mitigation: A Case Study in Purworejo Regency, Indonesia

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Abstract - Indonesia is an archipelago blessed with the wealth of coastal resources, but also with the risk of natural hazards including tectonic earthquake and tsunami. This potential risk is high in the Purwodadi Subregency, Purworejo Regency, Indonesia, because of its location in an active subduction zone at the edge of the Indian Ocean. Therefore, this study was conducted in the region located on the southern coast of Java Island. The high probability of disaster in the area needs a proper coastal management strategy and mitigation measures. Hence, this study aims to establish an appropriate policy using the strength-weakness-opportunity-threat (SWOT) analysis. Furthermore, the data obtained from this novel analysis include the population and social vulnerability, geological conditions, land-use allocation, and disaster strategies. Each is carefully assessed and then incorporated into the matrix to obtain the result. In addition, the alternative strategies used are the development of disaster mitigation facilities, infrastructure, and institutional strengthening.

Keywords: SWOT analysis, geology, strategy, natural hazard, coast

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Introduction

Background

Some areas in Indonesia have a high risk of earthquake and tsunami. The last term originated from the Japanese words "tsu" (harbour) and "nami" (wave), meaning the ocean waves caused by tectonic earthquake, landslide, or volcanic eruption that occured through marine media (Diposaptono, 2015; Rahayu *et al*., 2016). The southern coast of Java, Indonesia, is geologically prone to tsunami, because it is located at the confluence of the Eurasian and Indo-Australian Plates.

Therefore, the movement of these two plates often causes a great earthquake that triggers a tsunami. In the past three decades, there have been three major disasters on the southern coast of Java. In 1994, a tsunami occurred in Banyuwangi, East Java, and 2006 in Pangandaran, West Java (Rahmawan *et al*., 2012; Rahayu *et al*., 2016). Furthermore, another one occurred in 2018, in the waters of Tanjung Lesung, Banten, killing hundreds of people and damaging infrastructure (Rohani and Ramadhan, 2019). Other disasters that occurring in Purworejo Regency, Central Java, is in the southern coast. Those were

landslide, flash flood, earthquake, tidal wave, hurricane, and drought. In addition, earthquake has the highest number of disasters which is 319, followed by flood 138 times and landslide 119 times.

Landslide is one of the most common disasters occuring in Indonesia, caused by meteorological and geomorphological factors. Moreover, Purworejo is one of potential areas where landslide can occur due to its geomorphological condition included in the Menoreh Hills (Sudaryatno *et al*., 2019). Furthermore, in Purwodadi Subregency, flood and landslide are the most common hazards which took place twenty-seven and twenty-six times respectively.

The occurrences of hazard in Purworejo Regency, especially in the coastal area of Purwodadi Subregency and researched location, need a proper management and disaster mitigation strategy. Hence, efforts to minimize the impact need to be implemented based on the Minister of Home Affair Regulation No.33/2006 concerning the general guidelines of disaster mitigation (Ministry of Home Affairs, 2006). Therefore, potential risk can be reduced through precautionary measures before occuring to ensure the safety of people living in coastal areas.

The Purworejo area which lies in a direct contact with the sea has a lot of great geo-tourism potential. Purworejo is an area where marine tourism can be developed, which is in the regional planning of Purworejo Regency for 2001 - 2005 of which one of the priorities is the development of the southern area. Based on the RTRW (Spatial Plans) of Central Java Province Regulation No. 21/2003, Purworejo Regency is designated as one of the development areas for Integrated Marine Areas (Yovita *et al*., 2015).

This research aims to obtain the stategies of disaster mitigation by assessing and analyzing the required parameters. This study focuses on several criteria of the studied area, including society, government, and local natural conditions. Thus, the recommendation of the disaster mitigation can be obtained.

Geological and Stratigraphical Settings

Purwodadi Subregency is located on the border of two pieces of the regional geological map. Most of the western region spread on the geological map sheet of Kebumen (Asikin *et al*., 1992), while a portion of the eastern region belongs to the geological map sheet of Yogyakarta (Rahardjo *et al*., 1995). The Pesisir Selatan of Kebumen Regency is composed of alluvium material. Alluvium content in the western part is bounded by limestone karst areas in the Karangbolong region, which is part of the Southern Mountains. The base of this karst area consists of old andesite breccias that are covered in dissonance by layers of limestone. Limestone from the Sentolo Formation and Old Andesite breccias inserted in tuff layers can be found in the northern part. Judging from its geohydrological conditions, the Kebumen Coast is included in the Kebumen-Purworejo Groundwater Basin area (Purnama, 2017). Based on the geological map, there was no geological structure in Purwodadi Subregency. However, faults are found 1 km in the north of the Purwodadi Subregency and 1.3 km in the northeast.

The rock material formation comprises of alluvium deposits in the north and the coastal deposits in the south of the Purwodadi Subregency. The alluvium deposits are composed of pebbles, gravels, sands, silts, and clays, whilst the fine−medium sand constructs the coastal deposits. Bronto (2007) stated that the Purworejo Plain was arranged by river alluvium deposits in the north and the coastal deposits in the south. Besides, Purwodadi Subregency consists of the distribution of young coastal alluvium deposits and present-day alluvium deposits in the north, also the distribution of young beach alluvium deposits in the southern part.

Methods and Materials

Methods

The study was conducted in Purwodadi Subregency, Purworejo Regency, Central Java Province

of Indonesia (Figure 1). Landscape characteristics of Purworejo Regency are mountains/hills and plains. The mountainous/hilly landscape is an area prone to landslide (Bemmelen, 1949; Karnawati, 2005; Widiastutik and Buchori, 2018; Purworejo Government, 2019). Purworejo Regency which is located on the southern coastline of Java Island and directly adjacent to the Indian Ocean, makes the Purworejo sea area has high waves (Biantara *et al.*, 2016). Purwodadi Subregency is a coastal area designated as an Integrated Maritime Area, but this area is prone to geological disasters like earthquake and tsunami (Purworejo Government, 2011).

Disaster mitigation measures need to be carried out so that the affected communities can be reduced. The SWOT analysis (strengths, weaknesses, opportunities, and threats) was used, since it was a simple and flexible tool to help evaluate internal strengths and weaknesses, as well as external opportunities and threats. Some studies that use strategy analysis in disaster mitigation are landslides (Puri and Khaerani, 2017) and floods (Asrofi *et al.*, 2017). In the SWOT matrix, there are four types of strategies, namely SO (integrating strengths and opportunities), ST (integrating strengths and threats), WO (combining weaknesses and opportunities), and

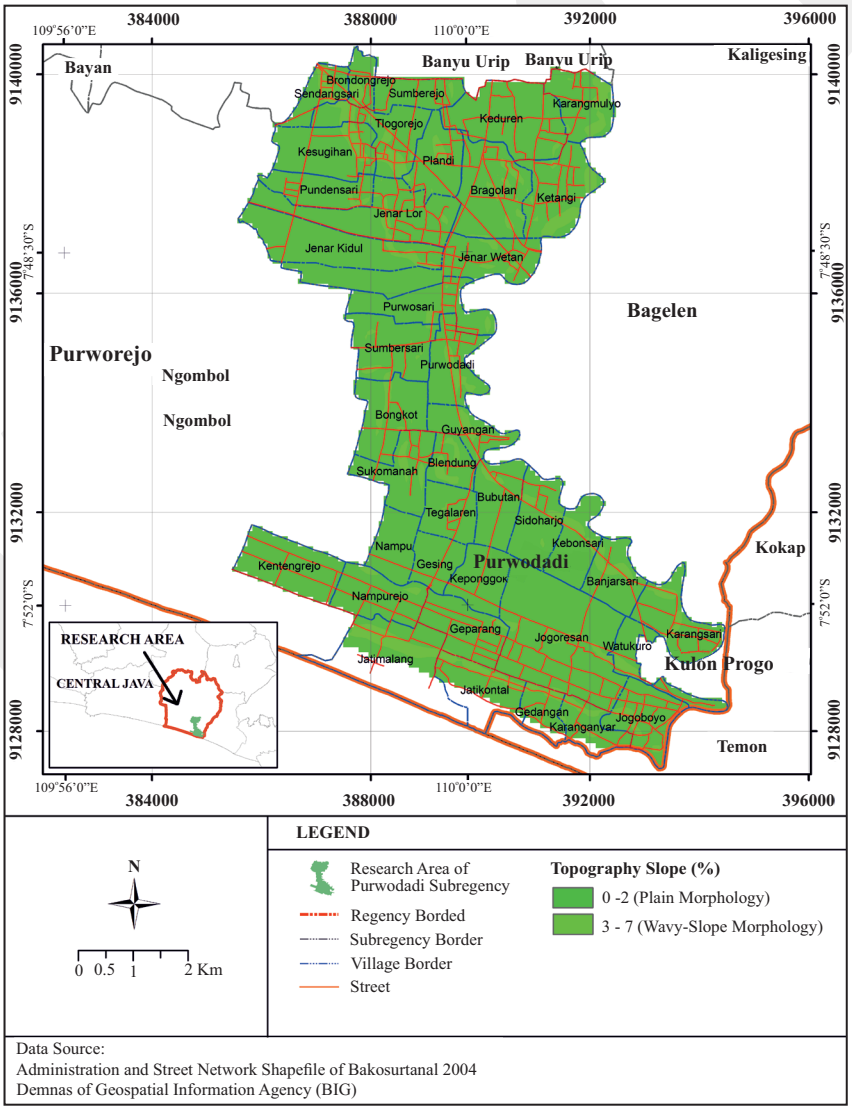

Figure 1. The studied area, located in Purwodadi Subregency, Purworejo Regency, Central Java. (Source: National Mapping and Survey Coordination Bureau, 2004).

WT (combining weaknesses and threats) (Fitri *et al*., 2017).

Materials

The data collected are literature review, interview, field observation, and documentation. The interviews were conducted with experts in the relevant government agencies dealing with the disaster problems, namely the Regional Disaster Management Agency, the Public Work Agency, and the Social Service Agency of Purworejo Regency. Besides, the secondary data were obtained from the Regional Development and Planning Agency, the Regional Management Agency, the Public Work Agency, and the Social Service Agency of Purworejo Regency. The disaster-related data were also compiled from the regional government working plan, the potential statistics of villages in Purworejo, and the spatial plan of Purworejo Regency for 2011 - 2031 (Purworejo Government 2011 and 2019).

Result

Population and Social Vulnerability

The number of female population is greater than the male population in 2015 - 2019, with a sex ratio of 98.42%. The total population in 2015–2019 is 193,660 people (Figure 2).

The population of productive age (15 - 60 years) is of 26,846 inhabitants. The population of women over 20 years old is 1,119. Otherwise, elderly population (60 years and over) is 7,787 people and children aged 0 - 14 years are 10,145 people. While the total population is 363,179. The most vulnerable groups in a disaster emergency are women, especially young girls, pregnant women, breastfeeding women, children, people with disabilities, and elderly people (Teja, 2018). Thus, the total population which is vulnerable to disasters in this region is around 19,051 people (Figure 3).

Geological Condition

Geological conditions in Purworejo Regency consist of lithology/rocks, stratigraphy, and geological structures. These three aspects of geology are very important concerning several phenomena that occur in the nature, especially landslide, drought, and flood which mainly occur in the Purwodadi, Bayan, Bagelen, and Ngombol Subregency. The lithology proportion in the form of sedimentary rocks and volcanic rocks (60.1%) can be found in the northern and eastern parts of Purworejo Regency, in areas with high topography, whilst 39.9% in the form of alluvium spread-

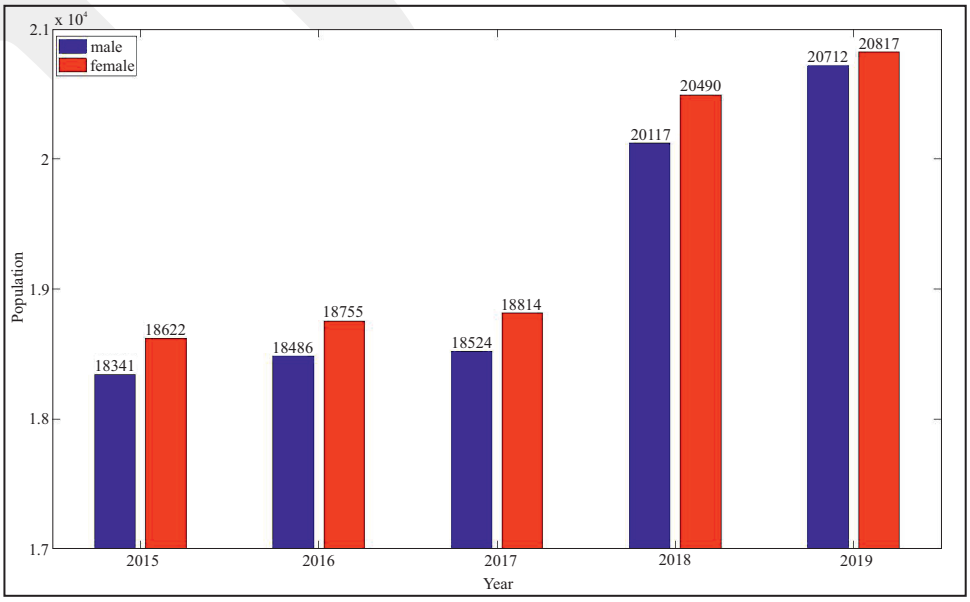

Figure 2. Distribution of gender population in Purwodadi Subregency by 2015 - 2019.

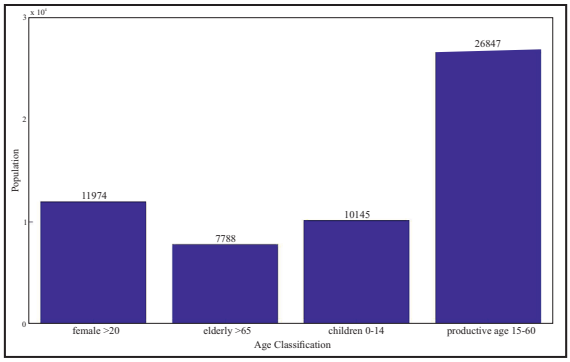

Figure 3. Age classification of the population in Purwodadi Subregency in 2019.

ing in areas with low topography in the south and west of Purworejo Regency.

The composition of the rocks in the Purworejo Regency follows the stratigraphic system in the South Serayu Mountains in the north and Menoreh Mountains in the east. Based on the process, Purworejo Regency itself has four landforms, which are structural, fluvial, marine, and denudational processes. Lithologically, Puwodadi Subregency is dominated by pumice (Purworejo Government, 2019).

Climatic Condition

Lying in a tropical country, Purworejo Regency has two seasons namely dry and rainy seasons. The air temperature ranges between 19 - 28ºC with the average rainfall per year ranging from 620 mm to 3,720 mm/year (Purworejo Government, 2019). The rainfall in Purwodadi Subregency in the last five years ranged between 2,080 mm to 3,477 mm/year (Figure 4).

Land Use

The use of land (in 2019) in Purwodadi Subregency has four categories: 2,742 ha is paddy field, 1,984 ha is building or yard, 325 ha is land area, and 10 ha is state forest, whilst the rest is in the form of grasslands and ponds. The area of irrigated paddy fields in Purworejo Regency is 27,677.14 ha, while the area of rain-fed rice is 2,949.83 ha (Table 1).

Disaster Anticipatory Efforts

Anticipatory efforts carried out in the Purworejo Regency, especially Purwodadi Subregency is an early warning system for natural disaster, tsunami early warning system, safety equipment for signs and river evacuation and normalization routes (Purworejo Government, 2019). Thus, in 2018, the disaster management facility and infrastructure was carried out in the form of 19 EWS Tsunami Early Warning System (EWS) and the Early Warning System Procurement which

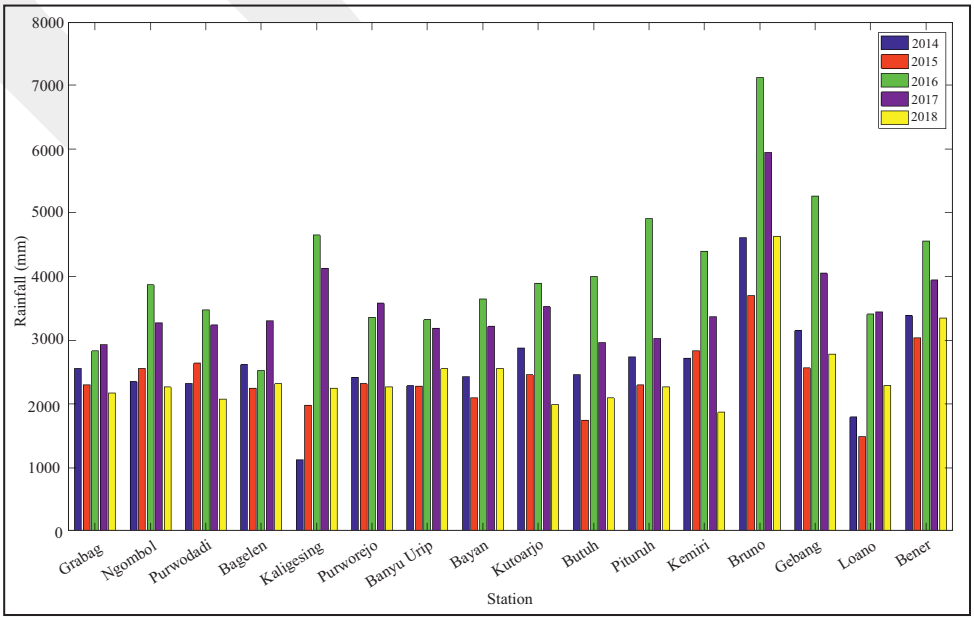

Figure 4. Rainfall measurement for each station in Purwodadi Subregency from 2014 - 2018.

Table 1. Land Use in Purwodadi District, Purworejo Regency in 2015−2019

Land Use	Rice field (Ha)	Building (Ha)	Garden (Ha)	Forest (Ha)	Others (Ha)
2015	2731	1984	325	10	346
2016	2731	1984	325	10	346
2017	2731	1984	325	10	346
2018	2742	1984	325	10	346
2019	2742	1984	325	10	346

previously had thirteen EWS to become twenty EWS (Purworejo Government, 2019). Graph of Natural Disaster Anticipation/Mitigation Efforts in Purwodadi District is presented in Figure 5.

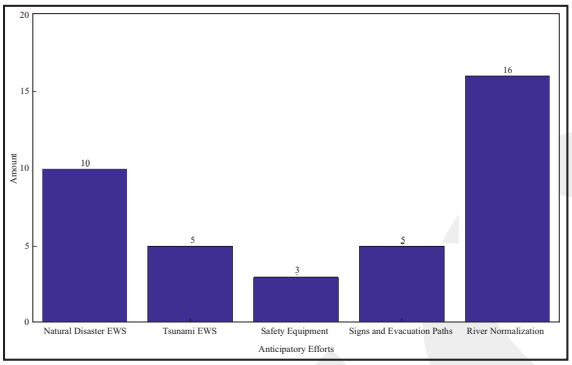

Figure 5. Graph of natural disaster mitigation in Purwodadi District.

Discussion

Population and Social Vulnerability

The number of population in the researched area is increasing every year. It creates a higher population density in the recent year than five years before. High population density gives the effect of social vulnerability to communities in potential disaster areas. Areas with densely populations represent a higher chance of casualties and property loss.

Elderly (60 years old and over) population and children (0 - 14 years old) are ones of variables of social vulnerability. When a disaster process occurs, the elderly population and children have the low ability to survive, they can only depend on a productive age people. The high female population, especially in the age of a mother (>20 years), is considered to have a lower ability in the evacuation process, because it has a physical weakness than male population, so women also indicate social vulnerability in a disaster area (Hapsoro and Buchori, 2015).

Geological Condition

Geological conditions in Purworejo Regency define the method of natural disaster mitigation and also define natural resources to explore. This method, mentioned as environmental geology, should be used by the community to create sustainable development in the area. Disaster aspects must also be examined so that the local government can carry out appropriate natural disaster mitigation. Geological aspects of the environment include geological resources and natural disasters. Geological resources include soil, water, and rock (Isnawan *et al*., 2017).

Climatic Condition

Climatic conditions in an area affect the potential of the area, both the potential of disasters and the potential of natural resources. The average regional rainfall was calculated using the Thiessen method (Mawardi, 2012). The average rainfall in the Purwodadi Subregency area is 2,751 mm/year which is classified high. Hence, it has the potential to cause flood and landslide.

Land Use

The ongoing land-use change in Purworejo Regency is less controlled. Land conversion takes place, for example land for agriculture has changed to non-agriculture such as for housing and settlements. If the water catchment area decreases, it will cause disasters such as flood and landslide.

Land-use change also occurs in Purwodadi Subregency which is a coastal area. Mangrove areas which function is to protect the coast from wave and abrasion are cut down and converted into fish and shrimp ponds, settlements, and agricultural areas (Yovita *et al*., 2015; Rahayu *et al*., 2018; Purworejo Government, 2019). If this continues, it is possible that coastal areas will be directly affected if a tidal wave occurs.

Disaster Anticipatory Efforts

The amount of disaster anticipatory efforts in the researched area does not meet the standard of infrastructure for disaster management in areas prone to flood, tide, and drought (Purworejo Government, 2011). As the high risk area, the effort of disaster anticipation needs to be increased. The other non-engineering measures should be the strengthening the monitoring and early warning system by building more observation stations in the coast (Fang *et al*., 2017).

Disaster Mitigation Strategy

Mitigation is an activity carried out before a disaster occurs, intending to prevent and to reduce the impact caused by the disaster (Dodo *et al*., 2004). The government agency which has the task to carry out the disaster mitigation is the BPBD (Regional Disaster Management Agency). The duties of the Purworejo Regency BPBD are following The Act No.24/2007 concerning Disaster Management and Regional Regulation No.5/2015 concerning Disaster Management Systems in Regions. Some strategies that can be done in disaster mitigation in Purworejo Regency are grouped into the following SWOT components:

- Strength
  - o There is adequate budget
  - o There is a legal basis
  - o There is information and institutional systems
- Weakness
  - o There is inadequate quality and quantity of human resources
  - o There is minimal facilities and infrastructures
- Opportunity
  - o Cooperation with other parties
  - o High enthusiasm of the community
  - o Development of disaster evacuation routes
- Threat
  - o Uneven distribution of volunteer groups
  - o Low knowledge and apathetic attitude to wards disaster

These elements are then incorporated into the SWOT matrix to make the strategy more easily to be implemented as can be shown in Tables 2 and 3.

Table 2. SWOT Matrix for The Disaster Mitigation Strategy

EFAS \ IFAS	Strength	Weakness
	1 There is a sufficient budget (S_1) 2 The existence of a legal basis (S_2) 3 Strengthening information systems and institutions (S_3)	1 The quality and quantity of Human Resources (HR) that are lacking (W_1) 2 Minimalize facilities and infrastructure (W_2)
Opportunity	**S-O strategy**	**W-O strategy**
1 Cooperation with other (O_1) 2 High public enthusiasm (O_2) 3 Development of disaster evacuation routes (O_3)	1 Development of disaster evacuation areas with available budget (S_1 O_3) 2 Strengthening the institutional system in collaboration with other parties (S_3 O_1)	1 Disaster mitigation training for officers through collaboration with other parties (W_1 O_1) 2 Strengthening facilities and infrastructure by developing disaster evacuation routes (W_2 O_3)
Threat	**S-T strategy**	**W-T strategy**
1 Uneven distribution of volunteer groups (T_1) 2 Low knowledge and apathetic attitude towards disaster (T_2)	1 The use of the budget used to recruit volunteer groups that spread more to each disaster-prone area (S_1 T_1)	1 Enhancing HR capacity by coordinating various parties (W_1 T_1) 2 Increased public knowledge of disasters (W_1 T_2)

Table 3. Review Alternative Strategies in Disaster Mitigation

No	Strategy Alternative SO	Review
1	Development of disaster evacuation areas with available budget	Development of disaster evacuation areas in the form of existing roads and/or emergency roads to locations not affected by disasters
2	Strengthening the institutional system in collaboration with other parties	BPBD cooperates with other agencies related to disaster mitigation
	Strategy Alternative WO	
3	Disaster mitigation training for officers through collaboration with other parties	Officers are facilitated with training on continuous disaster preparedness
4	Strengthening facilities and infrastructure by developing disaster evacuation routes	EWS addition, an arrangement of evacuation routes, evacuation rooms, and relief routes
	Strategy Alternative WT	
5	Increased public knowledge of disasters	Disaster mitigation training for people living in disaster-prone areas
	Strategy Alternative ST	
6	The use of the budget used to recruit volunteer groups that spread more to each disaster-prone area	Recruitment of volunteer groups prepared for disaster preparedness in various regions

Conclusions

This research emphasizes on the SWOT analysis to obtain the disaster mitigation strategies, which was assessed from the required parameters in the studied area. Therefore, it can be concluded from analysis that six alternative strategies can be applied to optimize the existing schemes, some of which include developing an evacuation area, adding and maintaining an early warning system with the available budget. In addition, mitigation training for officers and communities around the prone area is required in order to prevent victims should a disaster occur.

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