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Formulation of Framework for Evacuation of Tsunami Disaster after COVID-19 Pandemic on the South Coast of Watulimo, Trenggalek

Fadhilatus Shoimah[1], Fadly Usman[1], Septiana Hariyani[1]

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Abstract: The research aims to identify and design the latest theory-based tsunami disaster evacuation after the COVID-19 pandemic. Analysis of temporary shelters and analysis of evacuation routes were used in research with scoring techniques and network analysis techniques. The conceptual framework related to tsunami disaster evacuation after the COVID-19 pandemic has been compiled in research and can be used as material for consideration to formulate government policies and determine contingency plans and operational plans that will be carried out in the event of a tsunami disaster following the COVID-19 pandemic. Parameters of temporary shelter variables that must be considered are building function, the number of floors, building capacity, road location, building area, distance from the beach, and building construction. The capacity of the temporary shelter before the COVID-19 pandemic was obtained from the building area divided by the minimum space requirement per person of 1.64 m^2. After the COVID-19 pandemic, the minimum space requirement per person combined with a physical distance of 2 m, the total area required will be 6 m^2/person. Meanwhile, the parameters of the evacuation route variables that must be considered are road width, travel time, road pavement conditions, and road class.

Keywords: Disaster Response, Evacuation, Tsunami, COVID-19, Trenggalek

INTRODUCTION

The coastal area of Watulimo District is included in a tsunami-prone area that is directly adjacent to the Indian Ocean, the subduction zone of the Indo-Australian Plate, and the Eurasian Plate, which results in geological processes and high-intensity seismic activity that can trigger tsunamis (Trenggalek, 2012; Usman et al., 2020; Usman, Hariyani, et al., 2021). The high population density, population growth rate, female population, under-five and elderly people, people with disabilities, people with low education, poor households, built-up areas, and building density, and the low area of mangrove forests increase the vulnerability of coastal communities in Watulimo District to the tsunami disaster (Badan Nasional Penanggulangan Bencana, 2012; Hariyani et al., 2019; Shoimah et al., 2018). Public knowledge about the threat of a tsunami disaster is still lacking, so the capacity of the coastal community of Watulimo District in dealing with the tsunami disaster is low (Usman et al., 2020). A Tsunami Early Warning System and tsunami evacuation route signs have been installed in Watulimo District, but they have not been integrated with tsunami disaster evacuation that is understood by the community.

[1] Department of Regional and Urban Planning, Brawijaya University

Correspondence: fadhilatus@student.ub.ac.id

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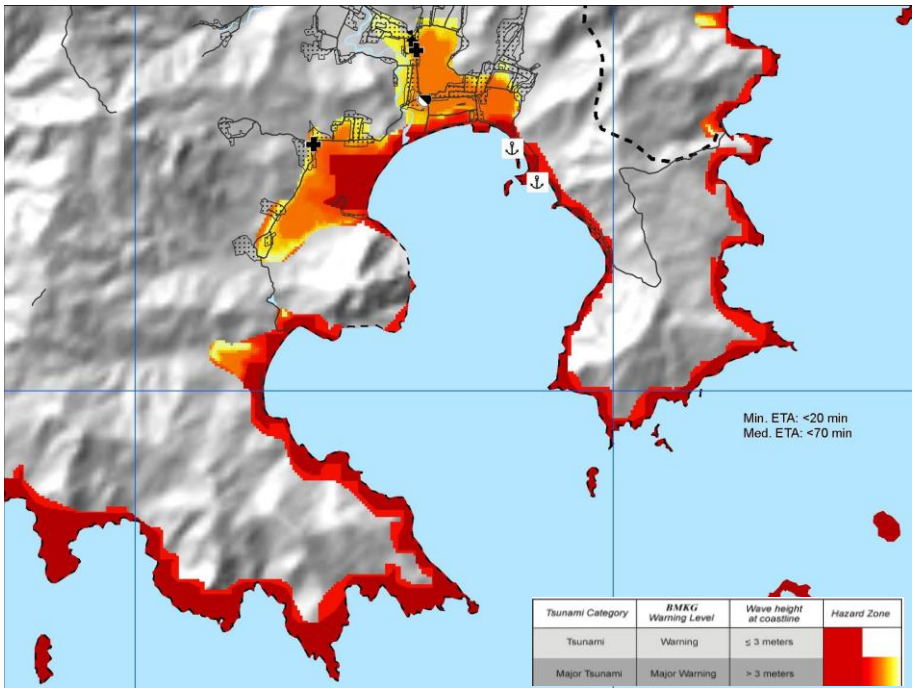

Source: (Center, 2012)

Figure 1. Tsunami Hazard Map Watulimo District

Settlement areas near the coast and tourist areas have a high risk of being affected by a tsunami because they are centers of community and tourist activities (Usman, Hariyani, et al., 2021). The location of community settlements has a linear pattern following roads and beaches, and community activities centered in tsunami-prone coastal areas can increase the vulnerability of coastal communities in Watulimo District. Watulimo Subdistrict is a strategic area with the main function of Minapolitan Capture Fisheries (Perikanan, 2011). The Watulimo minapolitan area is equipped with various infrastructures such as the Prigi Nusantara Fishing Port, Fish Auction Place, and Pemindangan Center. There is a plan to develop the new maritime city of Prigi, marked by the construction of a commercial port and Jalan Lintas Selatan. Tourism potential in Watulimo District is Prigi 360 Beach, White Sand Beach, Karanggongso Beach, Mutiara Beach, Simbaronce Beach, Mbangko'an Beach, Damas Beach, Ngrembang Beach, Tiluh Beach, Wonojoyo Beach, and Cengkrong Beach as well as plans to develop conservation ecotourism destinations. mangroves in Karanggandu Village.

The World Health Organization officially announced the COVID-19 outbreak as a global pandemic in early March 2020. The COVID-19 pandemic has spread massively throughout the country, regardless of villages, cities, mountains, and coastal areas, all are affected including the 3 villages on the south coast of Watulimo District (Usman, Chalim, et al., 2021). The development of the COVID-19 pandemic cases in Karanggandu, Prigi, and Tasikmadu Villages on March 18th, 2021, was recorded as follows.

Table 1. Development of COVID-19 Pandemic Cases in Karanggandu, Prigi, and Tasikmadu Villages 18/3/2021

	Karanggandu Village	Prigi Village	Tasikmadu Village
Cumulative cases	12	21	41
Active Cases	11	6	30
Recovered Cases	-	13	-
Death Cases	1	2	11

Source: (Watulimo, 2021a, 2021b, 2021c)

Theory

Tsunami comes from the word *tsu* which means port and *nami* which means wave, so in short, a tsunami is a harbor wave (Ilyas, 2006). Tsunamis are large sea waves caused by underwater geological processes in the form of earthquakes, volcanic eruptions, landslides, and falling meteors in the sea (Hamzah et al., 2000; Kurniawan et al., 2011; Usman & Rahim, 2017). Tectonic earthquakes are the main cause of tsunamis in Indonesia (Usman et al., 2019). Thus, people in the earthquake area will receive a natural warning, namely the earthquake. If the community feels a strong shaking or an earthquake that swings weakly but for a long time, the community should immediately evacuate independently to a temporary shelter without waiting for tsunami early warnings or evacuation orders from the authorities.

An epidemic is a pandemic of an infectious disease in a community where the number of sufferers has increased significantly more than the usual conditions at a certain time and in a certain area and can cause a catastrophe (Badan Nasional Penanggulangan Bencana, 2008). A COVID-19 pandemic is an event of the spread of disease caused by the Ribo Nucleat Acid virus type SARS-CoV-2 or it is called Coronavirus Disease 2019 (COVID-19) (Usman, Chalim, et al., 2021). If an earthquake with the potential for a tsunami occurs during the COVID-19 pandemic, tsunami evacuation must be prioritized to save the lives of the community. In carrying out independent evacuations to temporary shelters, as much as possible the community must pay attention to health protocols, maintain cleanliness, and must follow the social restriction policies in their respective areas that apply after the threat of a disaster has ended, with direction and guidance from the authorities, the community can move to the final shelter, or if conditions allow the community to return home. If the community has to stay in the final shelter longer, the authorities should provide better medical and medical support. This guide can be used as a reference and adapted for the evacuation of other disasters as well as evacuation during emergency response.

Disaster preparedness plans during the COVID-19 pandemic include at least:

1. An overview of the hospital's location
   Evaluating whether the hospital that handles COVID-19 patients is in a disaster threat area or not. If so, please consider transferring to another hospital that is far from a possible threat of disaster.
2. Preparation of temporary and final shelter
   The capacities of the temporary and final shelters that have been determined need to be reviewed so that the community can continue to implement distancing. If necessary, increase the number of temporary shelters and final shelters and carry out routine disinfection before a disaster. Temporary shelters and final shelters that are added must be located in areas safe from the threat of disaster and can take advantage of places that are currently empty due to COVID-19, such as schools, student dormitories that are currently closed, offices where employees work from home, empty government guesthouses, empty hotel because there are no tourists, and so on. The Regional Disaster

Management Agency, and Regional Government, together with the community must prepare evacuation sites by ensuring the availability of cleanliness facilities such as clean water, hand washing equipment, soap, and/or hand sanitizers. This can trigger other potential problems regarding difficulties in procuring and distributing goods, such as clean water, hand washing equipment, soap and/or hand sanitizers, masks, thermometers, personal protective equipment, and compartment separation boxes allocated for refugees in temporary shelters. Thus, precautionary measures such as self-help procurement should be considered (Sakamoto et al., 2020).

Source: ("14 Evacuation Centers Became Unusable amid Japan Rain Disaster," 2020; Reynolds, 2020)

Figure 2. Evacuation of Flood Disaster in Japan's Kumamoto Prefecture in July 2020

3. Facilities, infrastructure, and protocols for social workers
   The Regional Disaster Management Agency together with the Regional Government and the community needs to prepare facilities, infrastructure, and protocols so that social workers who will provide evacuation support (volunteers from the community as much as possible) remain protected. You do this by providing a backup of Personal Protective Equipment used when helping with evacuation and a thermometer as part of First Aid equipment for accidents.
4. Evacuation plans and health protocols
   The Regional Disaster Management Agency needs to prepare evacuation plans and health protocols for the community. The general public is expected to continue to ensure health protocols and maintain personal hygiene and their surroundings during the evacuation. For this reason, the Regional Disaster Management Agency needs to conduct socialization regarding this matter from an early age, before a disaster threat occurs. For the use of masks, there is no need to use a medical mask, you can use a cloth mask that you made yourself.
5. Evacuation based on the classification of people affected by COVID-19, as follows:
   a. Patient Under Supervision:
      It is better if COVID-19 patients are not treated in areas with high disaster risk so that patient mobilization is not necessary when a disaster occurs because this can cause the spread to occur. If the hospital is located in a disaster threat area, the Regional Disaster Management Agency and Local Government need to prepare a special evacuation protocol to evacuate patients and medical workers.
      1) Re-check the hospital building code so that it meets the disaster-resistant building code.

2) Providing special marks for Patients Under Supervision, such as bracelets with special colors.
3) If evacuated to a temporary shelter and final shelter, place the patient under supervision in a place/room separate from the others.
4) Medical officers need to be informed of the place and route of each evacuation for Patients Under Supervision and non-Patients Under Supervision and given training in caring for patients in emergencies.
5) It is necessary to assign social workers and volunteers who are trained to be able to assist in the evacuation of patients under surveillance during an emergency and equip medical personnel and volunteers with personal protective equipment and first aid equipment in accidents including adequate thermometers.
6) Ensure the availability of hygiene and sanitation equipment so that it can apply Clean and Healthy Behavior in the care centers in temporary shelters.

b. People Under Supervision:
1) The Regional Disaster Management Agency needs to coordinate with the Health Office to have data and know the locations of Supervision Insiders who live in disaster-prone zones.
2) Giving special marks to people with the status of Supervision Insider during the evacuation, such as giving ribbons with special colors on the hands, masks with special marks, or other signs
3) It is necessary to establish a temporary shelter and a final shelter for people under supervision. Ensure that people under surveillance are in 1 temporary shelter by preparing a special place for them so that the temporary shelter for people under surveillance is separated from healthy communities or people without symptoms.
4) It is necessary to consider plans for evacuation routes and plans for evacuation places where the Insiders and members of the healthy community are separated.
5) Supervision Persons need to be informed of their place and route of evacuation.
6) It is necessary to assign social workers (volunteers from the community as much as possible) to help evacuate people in surveillance during an emergency and equip volunteers with personal protective equipment and first aid equipment in accidents including thermometers.
7) Ensuring a Clean and Healthy Lifestyle in the temporary shelter.

c. People Without Symptoms:
They can evacuate in the same place while observing health protocols and maintaining personal hygiene. If during a disaster evacuation there are people without symptoms who have symptoms of fever (=38°C) or a history of fever or symptoms of respiratory system disorders such as cold/sore throat/cough, then they should be isolated separately in a temporary shelter until the threat of disaster is over and can be handled more continued by medical personnel.

METHODS

In conducting a disaster evacuation analysis, a disaster risk analysis is first carried out to determine safe areas/areas that are not at risk of a tsunami disaster in Watulimo District. (Usman et al., 2017). The use of GIS in various phases can be illustrated as planning, mitigation,

preparedness, and emergency response activities. The use of GIS allows emergency management to cope with the onset of a disaster. So data must be prepared and made to determine the size and space of emergency management allocations so that action can be taken in the event of a disaster (Mukhopadhyay & Bhattacherjee, 2015). The emergency data when a disaster occurs, among others, is related to temporary shelters and evacuation routes. The spatial data will make it easier for the community to reach temporary shelters (Usman et al., 2019).

3.1 Temporary Shelter Analysis

An analysis of temporary shelters is carried out to assess, select, determine, and evaluate potential public buildings that can be used as temporary shelters when a tsunami occurs on the coast of Watulimo District (Usman et al., 2020, 2017). The classification calculation in the temporary shelter analysis uses the scoring technique. The total scoring results of all parameters will show the most suitable temporary shelter on the coast of Watulimo District, to eliminate buildings that are not suitable for temporary shelter.

All parameters in the temporary shelter analysis are mapped in GIS, because almost all parameters used have a spatial component or coordinate location (Mansourian et al., 2006). The important role of GIS in evacuation planning has been described in several research results (Balram & Dragicevic, 2006). Network analysis for temporary shelter analysis uses service area analysis to determine the minimum area the community can reach the closest temporary shelter based on the distance from the residential area (Usman et al., 2019; Usman & Sari, 2019).

The recommended potential building height as a temporary shelter should have a height of >3 m or ≥2 floors (Consultants, 2007). The temporary shelter that will be determined must be able to serve and accommodate according to the space requirements of the community (Usman & Sari, 2019). This is because the temporary shelter is planned to function not only for the safety of refugees but also as a first-aid post and also as a reconstruction station for disaster-affected areas. (Kurniawan et al., 2011).

The capacity of the temporary shelter before the COVID-19 pandemic was obtained from the building area divided by the minimum space requirement per person of 1.64 m^2 (Usman et al., 2020). After the COVID-19 pandemic, the minimum space requirement per person is combined with 2 m of physical distancing, so the total area required will be 6 m^2/person. Thus, the number of people that can be accommodated in the temporary shelter will be reduced from 1/3 to 1/4 of normal conditions (Sakamoto et al., 2020).

3.2 Evacuation Route Analysis

The classification calculation in the evacuation route analysis uses a scoring technique. Analysis of evacuation routes that are good, safe, and easily accessible to the public using network analysis with GIS. Network analysis is an extension of GIS that can be used for selecting the best route (Kurniawan et al., 2011; Suharyanto et al., 2012). Network analysis is an analysis tool for processing network data that forms a particular system/pattern. In the research, the pattern formed is the evacuation route by considering the shortest distance from the community location to the temporary shelter (Usman et al., 2020). Network analysis can be used for modeling traffic in emergencies in dynamic situations, including speed limitation and direction regulation (Hariyani et al., 2019).

Evacuation by vehicle can sometimes cause congestion and can interfere with the evacuation process of other communities (Sutikno et al., 2010). During the evacuation process, refugees are advised not to use vehicles (Usman et al., 2020). The evacuation scenario in the study was

carried out on foot. The study used the standard speed of people walking when the evacuation was 1 m/s.

FINDINGS AND DISCUSSION

Evacuation is the process of rescuing a community from a dangerous area to a safer place, to reduce the vulnerability of the health and life of the affected community. Each community must run away from the beach and understand the direction of evacuation to save themselves (Usman et al., 2020, 2017). Early evacuation of the community independently, quickly, and accurately to a safer place is the most appropriate tsunami disaster mitigation strategy in dealing with emergency situations (Usman et al., 2020, 2017; Usman & Murakami, 2012; Usman & Sari, 2019). Based on tsunami modeling (Center, 2012), The estimated time of arrival for a tsunami is around 20 minutes or there is only a maximum golden time of 20 minutes from the first earthquake. 20 minutes is the maximum travel time for the community to evacuate, so the worst-case scenario can occur if the evacuation warning is delayed (Usman et al., 2017). Preparation, testing, and training of an appropriate evacuation plan are required as part of disaster preparedness. However, evacuation planning is a complex issue involving many aspects of behavior and management (Saadatseresht et al., 2009).

There are 2 types of evacuation methods when a tsunami occurs, namely vertical and horizontal. Horizontal evacuation is an evacuation carried out by going away from the coast to a safer place. The horizontal method requires a safe and fast evacuation route. Meanwhile, vertical evacuation is evacuation carried out by climbing hills or taller and stronger buildings such as towers, trees, or shelters that have been built by the government (Usman et al., 2020).

4.1 Temporary Shelter

A temporary shelter is a gathering point for the community for 2-3 hours to then be moved to a safer place, namely the final shelter using the principles of disaster management (Usman & Sari, 2019). A temporary shelter is an existing building that has been agreed upon and designated as a safe disaster evacuation site, which is still possible and sufficient to accommodate several people in it (Kurniawan et al., 2011; Usman et al., 2014). When evacuating, the distribution of people to temporary shelters must be based on the capacity and the closest distance the community can reach (Wu et al., 2006). Temporary shelter is needed when the tsunami arrives faster than the evacuation process. When the tsunami arrived, the community arrived safely at the temporary shelter (Suharyanto et al., 2012).

4.2 Evacuation Route

The evacuation route is the shortest way to a safe area designated for people living in disaster areas (Consultants, 2007). The evacuation route map is needed as a guide for the community during emergency evacuation and is used to support logistical distribution for people in disaster areas (Samudro et al., 2012). Determination of the evacuation route aims to minimize the spread of the evacuation process evenly which occurs due to community panic when the tsunami disaster comes (Suharyanto et al., 2012).

Table 2. Parameter Evakuasi Bencana

Variable	Sub Variable	Parameter	Source
Tsunami Disaster Evacuation after COVID-19 Pandemic	Temporary Shelter	Building Function	(Suharyanto et al., 2012; Usman et al., 2020)
		Number of Floors	(Suharyanto et al., 2012; Usman et al., 2020, 2017)
		Building Capacity	(Sakamoto et al., 2020; Suharyanto et al., 2012; Usman et al., 2020, 2017; Usman & Murakami, 2011; Wu et al., 2006)
		The location from the Road	(Suharyanto et al., 2012; Usman et al., 2020, 2017)
		Building Area	(Suharyanto et al., 2012; Usman et al., 2020, 2017)
		Distance from the Beach	(Usman et al., 2020; Wu et al., 2006)
		Building Construction	(Suharyanto et al., 2012; Usman et al., 2020, 2017; Usman & Murakami, 2011)
	Evacuation Road	Road Width	(Kurniawan et al., 2011; Suharyanto et al., 2012; Usman et al., 2020)
		Travel Time	(Usman et al., 2020)
		Road Materials	(Suharyanto et al., 2012; Usman et al., 2020)
		Road Class	(Kurniawan et al., 2011; Usman et al., 2020)

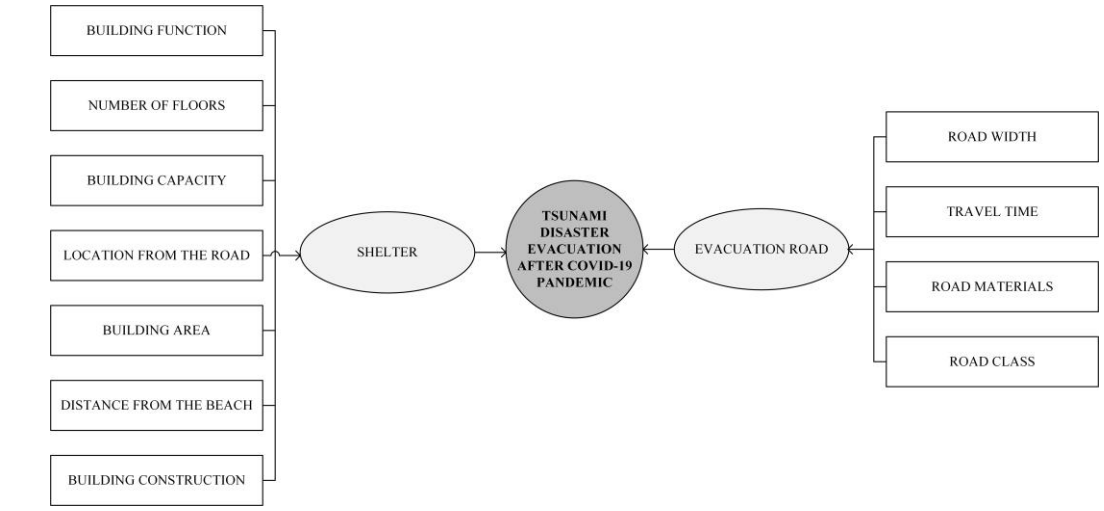

Figure 3. Conceptual Framework for Evacuation of Tsunami Disaster After COVID-19 Pandemic

CONCLUDING REMARK

The conceptual framework related to tsunami disaster evacuation after the COVID-19 pandemic has been compiled in research and can be used as material for consideration to formulate government policies and determine contingency plans and operational plans that will be carried out in the event of a tsunami disaster following the COVID-19 pandemic. The parameters of the temporary shelter variables that must be considered include the function of the building, the number of floors, the building capacity, the location of the road, the area of the building, the distance from the beach, and the construction of the building. The capacity of the temporary shelter before the COVID-19 pandemic was obtained from the building area divided by the minimum space

requirement per person of 1.64 m^2. After the COVID-19 pandemic, the minimum space requirement per person is combined with 2 m of physical distancing, so the total area required will be 6 m^2/person. Meanwhile, the parameters of the evacuation route variables that must be considered are road width, travel time, road pavement conditions, and road class.

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