Tsunami risk reduction in the new normal era based on community building in Watulimo, Indonesia

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Abstract. The coastal area of Watulimo District is included as a tsunami-prone area that is directly adjacent to the Indian Ocean. The Indian Ocean is the subduction zone of the Indo-Australian Plate and the Eurasian Plate, which results in geological processes and high-intensity seismic activities that can trigger tsunamis. On the other hand, in the new normal era, the coast of Watulimo District includes a high-level COVID-19 zone with 74 cumulative cases, comprising 6 active cases, 54 recovered cases, and 14 deaths. The study aimed to examine the level of capacity of coastal communities in Watulimo District, Trenggalek Regency, based on five livelihood capitals (natural capital, financial, physical, human, and social capital) to reduce tsunami disaster risk in the new normal era. The analytical method used in this research consisted of scoring analysis and pentagon assets analysis. The capacity of the coastal community in Watulimo District shows that the sub-villages with high capacity are Gading, Prigi, and Ketawang Sub-villages. On the other hand, the sub-villages with medium capacity are Gandu, Tirto, Gendingan, Sumber, and Gares Sub-villages. Meanwhile, the sub-village with low capacity is Karanggongso Sub-village, due to the low human capital and social capital. Therefore, in efforts to reduce disaster risk, the area that needs to be prioritized for handling is Karanggongso Sub-village through improvements in social conditions, one of which is by prioritizing education levels, such as training related to the threat of the tsunami disaster and the COVID-19 outbreak.

1. Introduction

Tsunamis are large sea waves caused by underwater geological processes in earthquakes, volcanic eruptions, landslides, and meteor falls in the sea [1,2]. The coastal area of Watulimo Sub-district is included as a tsunami-prone area that is directly adjacent to the Indian Ocean [3,4] Indian Ocean is the subduction zone of the Indo-Australian Plate and the Eurasian Plate, which results in geological processes and high-intensity seismic activities that can trigger tsunamis [5,6]. The last modeling of the tsunami disaster in Watulimo District was carried out in 2012 by the German Aerospace Center [7]. Tsunami modeling is based on several indicators, such as bathymetry, epicenter, wave speed, current depth, wave height, inundation length, topography (elevation and slope), and land cover [8,9,10]. As a result, the coastal area of Watulimo District has a low, medium, and high tsunami level [7] (Figure 1.).

Watulimo District has a low capacity regarding its regional resilience and community preparedness to face tsunami disasters [4]. The Karanggandu, Prigi, and Tasikmadu Village Governments have not
introduced disaster risk reduction aspects in their planning documents, for instance, the Village’s Medium-Term Development Plan, and have not allocated a contingency budget for the disaster sector, resulting in a low level of regional resilience to the tsunami disaster on the coast of Watulimo District [11,12,13]. In addition, public knowledge related to the tsunami disaster is still relatively low, which has implications for the inadequate preparedness of the coastal community in Watulimo District to face the tsunami disaster [6].

![Figure 1. Tsunami hazard map of Watulimo District](source)

The COVID-19 outbreak has spread massively throughout the country, whether in villages, cities, mountains, and coastal areas. All are affected nonetheless, including the three villages on the south coast of Watulimo District [14]. Therefore, Watulimo District is included in the moderate zone, with 143 positive cases of COVID-19, comprising 114 recovered cases, and 18 deceased cases as per 18 March 2021 [15]. According to the development of COVID-19 outbreak cases in the coastal villages of Watulimo District—Karanggandu, Prigi, and Tasikmadu Villages—there were 74 cumulative cases, comprising 6 active cases, 54 recovered cases, and 14 deaths [16,17,18]. From the 18 deceased cases due to the COVID-19 outbreak in Watulimo District, coastal villages have 77% or 14 deceased cases. Therefore, it can be concluded that the three coastal villages of Watulimo District are in the high-risk COVID-19 zone.

Disaster risk is the potential loss caused by a disaster in an area within a specific period of time and can be in the form of death, injury, illness, threatened lives, the loss of sense of security, displacement, damage or loss of property, and disruptions of community activities [19]. Capacity is the ability of a region/community to take action to reduce the level of threat and the level of losses due to disasters [20]. Community capacity in research often adopts the livelihood assets (natural, financial, physical, human, and social capitals) [21,22]. The relationship between community capacity and disaster risk can be illustrated that the higher the capacity, the lower the disaster risk.

2. Methodology

2.1. Population and Sample

A population is an entire observation that is of concern to the researcher [23]. The research population is all households in the villages threatened by tsunami disasters in Watulimo District with a total of 9,912 families. Unfortunately, the research conducted did not allow data on the entire population, so the
study used samples to represent the existing population. A sample is a part of a certain number of inhabitants taken from a population examined in detail [24]. The calculation of samples employed the Michael Is technique, which produced 370 respondents as the number of samples to be studied.

The research analysis unit is the villages, so the respondents will be distributed proportionally to each village according to their respective number of residents, obtained using a non-probability sampling technique with purposive sampling. The non-probability sampling technique is a sampling technique that does not provide equal opportunities or opportunities for each element or member of the population to be selected as a sample [25]. The purposive sampling technique is a sampling technique based on specific goals with the criteria set by the researcher [26]. The criteria in determining the respondents are residents in the nine villages with a tsunami threat in Watulimo District.

2.2. Research Variable

The research variable attributes an object with a specific variation and is determined by the researcher to study and draw conclusions [31]. Table 1 are the variables, sub-variables, and research parameters.

| Variable         | Sub Variable                          | Parameter                                      |
|------------------|---------------------------------------|-----------------------------------------------|
| Natural Capital  | - Land Ownership Area                  | [21,27,29]                                    |
| Financial Capital| - Income                               | [21,27,29]                                    |
|                  | - Savings Ownership                    |                                               |
| Physical Capital | - House Construction                   | [21,27,29]                                    |
|                  | - Road Quality                         |                                               |
| Human Capital    | - Community Knowledge about Tsunami Disaster | [21,27,29]                               |
|                  | - Participation in Tsunami Disaster Training | [21,27,29]                               |
|                  | - Participation in Tsunami Disaster Socialization | [21,27,29]                               |
| Social Capital   | - Trust in Community Leaders           | [21,27,28,29]                                 |
|                  | - Trust in Fellow Community            |                                               |
|                  | - Trust in the COVID-19 Task Force      |                                               |

2.3. Analysis Method

2.3.1. Scoring Technique

Calculation of classification in the analysis of the community capacity of each village used a scoring technique with the Sturgess Method. Equation (1) is the class width calculation method [30]:

\[
\text{length of class} = \frac{\text{Maximum value} - \text{Minimum value}}{3}
\]  

(1)

2.3.2. Pentagon Assets Technique

The results of the scoring analysis of each capital per village are depicted in a pentagon diagram. The pentagon area of the village is calculated by the Equations (2) and (3) [31].

\[
\text{Area of Pentagon} = \sum_5 \text{Area of Irregular Triangle}
\]  

(2)

\[
\text{Area of Irregular Triangle} = \frac{1}{2} a \cdot b \cdot \sin \gamma
\]  

(3)

Where: \( \gamma \) = the angle of each irregular triangle

The wider the pentagon area of a village, the higher the capacity. The pentagon also represents the balance of capital ownership; the more symmetrical the pentagon, the more balanced the capital ownership of a village [21].
3. Result and Discussion

3.1. Natural Capital
Natural capital scoring shows that all villages/sub-villages on the coast of Watulimo District are classified as having a low average area of land ownership. Land ownership is dominated by the possession of land with an area of 0–0.5 ha. Although the coastal village area of Watulimo District is vast, it is dominated by the use of permanent production forest land, thus the community’s land ownership is low.

3.2. Financial Capital
Financial capital scoring shows that Tirt, Gendingan, Sumber, and Karanggongso Sub-villages are classified as low in financial capital. On the other hand, the classification of a medium level of financial capital can be seen in Gading, Gandu, and Gares Sub-villages. Meanwhile, the classification of a high level of financial capital is visible in Prigi Village and Ketawang Sub-village because they have high average savings ownership. In addition, the average savings ownership is high in the two villages because they are located on a national road, resulting in good access to banking facilities, such as Bank Rakyat Indonesia (BRI) in Prigi Village, Bank Jatim in Ketawang Village, and Savings and Loan Cooperatives (KSP) for saving purposes that are closer than the other villages/sub-villages.

3.3. Physical Capital
Physical capital scoring shows that all villages on the coast of Watulimo District are classified as high in physical capital because, on average, they have permanent house construction with good conditions. In addition, this finding is also supported by intermediate and excellent road quality with concrete/cement/concrete pavement in Karanggandu Village and asphalt pavement in Prigi Village. Meanwhile, Karanggongso Sub-village is classified as having moderate physical capital because it has an average of inferior road quality with soil pavement. Karanggongso Sub-village is located on the Southern Cross Line, which is currently under construction.

3.4. Human Capital
Human capital scoring shows that all coastal villages in Watulimo District are classified as having a medium level of human capital, except for Karanggongso Sub-village, which has a low level of human capital. The training/simulation for tsunami evacuation and the construction and testing of a tsunami early warning system were carried out by the Trenggalek District BPBD (Regional Disaster Management Agency) in collaboration with the BMKG (Meteorology, Climatology, and Geophysical Agency) in 2015. Meanwhile, in 2019, promotion of resilient villages and the installation of T-EWS (Tsunami Early Warning System) by the Trenggalek District BPBD in partnership with the National SAR Agency were carried out. This promotion was carried out with participants, consisting of three coastal villages, community representatives of three coastal villages, fishermen, traders around the coast, and related communities. However, not all levels of society have been involved in the training for and the promotional activities regarding tsunami, which is not routinely carried out. As a consequence, most people do not understand the mitigation efforts that must be carried out when a tsunami disaster occurs.

3.5. Social Capital
Social capital scoring shows that Gandu, Gendingan, and Karanggongso Sub-villages are classified as having a low level of social capital. Meanwhile, Sumber, Gares, and Ketawang Sub-village are classified with a medium level of social capital. Gading Sub-village and Prigi Village are classified as having a high level of social capital because they have high average trust in their community leaders and in the COVID-19 Task Force. Meanwhile, Tirto Sub-village is classified as having a high level of social capital because it has a high average trust in fellow community members and in the COVID-19 Task Force, seen from the discipline in implementing health protocols. The health protocol, expressed as 4M, consists of washing hands with soap/hand sanitizer, using masks correctly, maintaining a physical
distance of 1.5 m from other people, and avoiding crowds. These measures are good enough for the people of Karanggandu and Prigi Villages, judging from the low cumulative COVID-19 cases.

3.6. Community Capacity

After knowing the capital levels for each Village/Sub-village, the next step is to draw a pentagon diagram to calculate each respective pentagon area. **Table 2** shows that the sub-village/village with high capacity are Prigi Village, and Gading and Ketawang Sub-villages. Gading Sub-village’s high level of capacity derives from its high human and physical capital holdings. Prigi Village high level of capacity derives from its high human, financial, and physical capital holdings. Meanwhile, the high capacity level of Ketawang Sub-village comes from the high ownership of financial capital and physical capital. Therefore, high capacity levels derive from the vast and symmetrical pentagons of Prigi Village, and Gading and Ketawang Sub-villages.

On the other hand, sub-villages with medium capacity are Gandu, Tirto, Gendingan, Sumber, and Gares Sub-villages. Meanwhile, the sub-village with a low capacity is Karanggongso Sub-village. **Figure 2** is the distribution map of community capacity levels in the coastal Village/Sub-village of Watulimo Sub-district.

| Table 2. Classification of community capacity in Watulimo Sub-district |
| --- |
| **Karanggandu Village** |
| **Gading Sub-village** | **Gandu Sub-village** | **Tirto Sub-village** |
| ![Diagram](image1) | ![Diagram](image2) | ![Diagram](image3) |
| Pentagon Area: 11.22 units | Pentagon Area: 9.2 units | Pentagon Area: 10.24 units |
| Capacity Classification: High | Capacity Classification: Moderate | Capacity Classification: Moderate |
| **Prigi Village** |
| **Gendingan Sub-village** | **Prigi Sub-village** | **Sumber Sub-village** |
| ![Diagram](image4) | ![Diagram](image5) | ![Diagram](image6) |
| Pentagon Area: 8.26 units | Pentagon Area: 12.33 units | Pentagon Area: 9.28 units |
| Capacity Classification: Moderate | Capacity Classification: High | Capacity Classification: Moderate |
Tasikmadu Village

| Sub-village          | Pentagon Area | Capacity Classification |
|----------------------|---------------|-------------------------|
| Gares Sub-village    | 10.21 units   | Moderate                |
| Karanggongso Sub-village | 6.18 units   | Low                     |
| Ketawang Sub-village | 11.29 units   | High                    |

Figure 2. Community capacity map of Watulimo Sub-district

4. Conclusion
The capacity of the coastal communities in Watulimo District shows that the sub-villages showing high capacity are Gading, Prigi, and Ketawang Sub-villages. On the other hand, sub-villages with medium capacity are Gandu, Tirto, Gendingan, Sumber, and Gares Sub-villages. Meanwhile, the sub-village with a low capacity is Karanggongso Sub-village due to the low human capital and social capital. Therefore, in efforts to reduce disaster risk, the area that needs to be prioritized for handling is Karanggongso Sub-village through improvements in social conditions, for instance, by prioritizing education level, including training related to the threat of the tsunami disaster and the COVID-19 outbreak.

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