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Disaster Risk Reduction Literacy Through Participatory Mapping of Tsunami Disaster in Bobanehena

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Abstract: *Halmahera Island in North Maluku consists of active faults that cause frequent tectonic earthquakes. In addition to earthquakes, tsunamis can also occur. Bobanehena village is one of the villages located on the coast of Jailolo sub-district and could be at great risk of a tsunami if an earthquake strikes Halmahera Island. The problems addressed are first, the limited capacity of individuals, households and communities in facing and dealing with tsunami disasters. Second, there is no tsunami evacuation route in Bobanehena Village based on participatory mapping. The method in this service is the Community Based Disaster Risk Reduction (CBDRR) approach which involves the community to be actively involved in disaster management. Participatory mapping of evacuation routes was carried out by Forum Group Discussion (FGD) and assessment of disaster capacity was carried out by submitting pre-test and post-test questionnaires conducted during the activity. The results of the service were a participatory map of the tsunami evacuation route plan and increased community capacity regarding tsunami disasters in Bobanehena Village.*

Keywords: CBDDR, Mapping, Participatory, Tsunami

Introduction

West Halmahera is an area prone to high disaster risk, especially earthquakes, because it is influenced by very complex tectonic activity. The region is affected by the meeting of 3 major plates namely the Eurasian, Indo-Australian and Pacific plates and

several other small plates namely the Philippine plate and the Maluku Sea.[1,2,3,4,5] Large earthquakes trigger tsunami hazards, which are natural events that can cause disasters. Based on data from the North Maluku disaster risk assessment by BNPB, 2015, the vulnerability assessment for tsunami disaster aims to determine the potential population exposure and the amount of loss (both in rupiah and hectares of environment) caused by tsunami disaster.[6] The potential for tsunami disaster for Jailolo is high although the results of the losses caused by the tsunami are moderate.

Bobanehena Village is a village located on the coast of Jailolo Sub-district, West Halmahera, which has a high level of vulnerability (Figure 1) and the impact of a tsunami in the event of an earthquake. An earthquake accompanied by a tsunami will cause losses to villages located on the coast. These losses are not only material losses but also loss of life. However, the potential threat of tsunami disaster has not been fully realized because the local community is still unfamiliar with it. Based on this, the role of academics is required to educate the community, so that the community has the ability, capacity and preparedness for tsunami disasters that are very potential around them.[7]

[1] Warren Bell Hamilton, *Tectonics of the Indonesian Region (4th edn.)* (Washington: United States Government Printing Office, 1979), 44

[2] John A. Katili, "Past and Present Geotectonic Position of Sulawesi, Indonesia," *Tectonophysics* 45, no. 4 (1978), 289-322 https://doi.org/10.1016/0040-1951(78)90166-X

[3] Richard K. Cardwell and Bryan L. Isacks, "Geometry of the Subducted Lithosphere Beneath the Banda Sea in Eastern Indonesia From Seismicity and Fault Plane Solutions," *Journal of Geophysical Research* 83, no. 83 (1978), 2825-2838

[4] Robert Mccaffrey, Eli A. Silver, and Russell W. Raitt, "Crustal structure of the Molucca Sea collision zone, Indonesia," *The tectonic and geologic evolution of Southeast Asian seas and islands* 23, (1 January 1980), https://doi.org/10.1029/GM023p0161

[5] R. Sukamoto, T. Apandi, S. Supriatna, A. Yasin, *The Geology and Tectonic of Halmahera Island and Surrounding Areas* (Bandung, Indonesia, Special Publication, 2, 1981)

[6] Badan Nasional Penanggulangan Bencana (BNPB), *Kajian Risiko Bencana Maluku Utara 2016-2020. Deputi Bidang Pencegahan dan Kesiapsiagaan* (Jakarta: BNPB, 2015).

[7] Rahmat Catur Wibowo et al, "Peningkatan Partisipasi Masyarakat pada Studi Pemetaan partisipatif dalam pembuatan Jalur Evakuasi Bencana Tsunami di Desa Wisata Pagar Jaya," *Jurnal Pengabdian Kepada Masyarakat Sakai Sambayan* 4, no. 1 (2020), 43 – 48 http://dx.doi.org/10.23960/jss.v4i1.172

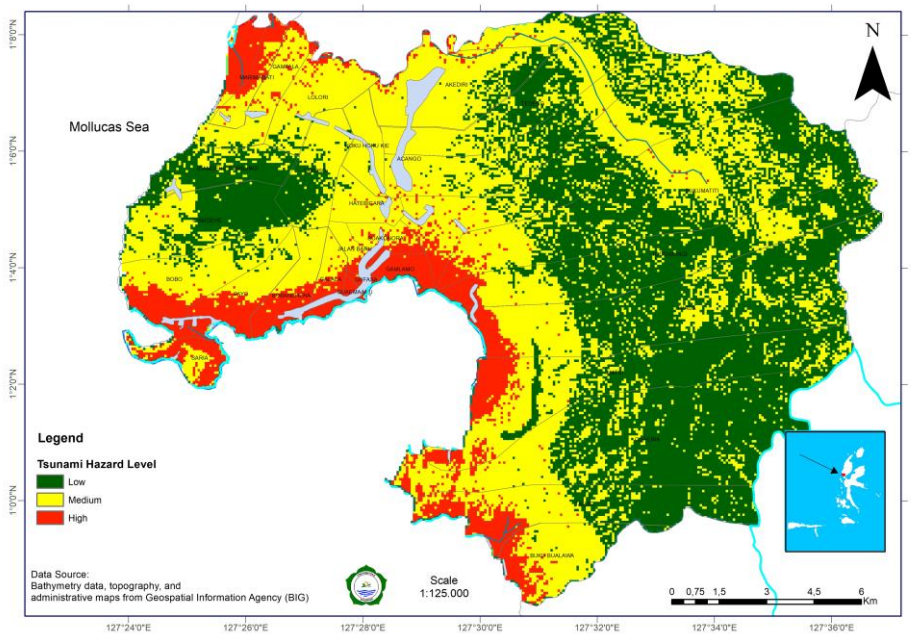

Figure 1. Tsunami Vulnerability Map of Jailolo Sub-district

One of the weaknesses in applying disaster risk reduction methods is that solutions are only oriented towards saving disaster victims, not at the level of prevention. Disaster victims are generally described as marginalized communities that have not been able to deal with potentially harmful disasters. After conducting observations in the field, it was found that in Bobanehena Village, there is a lack of information about early warning systems, a lack of community knowledge in disaster management and there is no infrastructure available that becomes a protection location during a disaster, in the form of evacuation routes, shelters and others.

Not all types of threats can be prevented or reduced in intensity such as tsunamis. To minimize disaster risk in these types of threats can be done by improving existing weaknesses and increasing capabilities. Forming a village disaster preparedness team, designing tsunami evacuation routes, determining danger signs, are forms of activities to minimize disaster risk by improving weaknesses while increasing capabilities. Further disaster risk assessments related to emergency assessment and planning begin to integrate the roles of local government, public elements and local communities.

Participatory mapping has been initiated and developed since 1980. The mapping method started from simple and traditional techniques using open land such as a large field as the basis of the drawing. Maps are still in the form of sketches which then develop into three-dimensional models to the realm of online systems. The benefits of participatory mapping, especially in the field of disaster management, have been felt by local communities and used as guidelines in various scientific literature.[8]

[8] Antonella Piccolella. "Participatory Mapping for Adaptation to Climate change: The Case of Boe

Participatory mapping is a mapping process that involves communities to collect local information for tsunami disaster planning and decision-making. The purpose of participatory mapping is to improve understanding of tsunami risks, identify vulnerable areas and develop more effective mitigation strategies. The potential of community knowledge in the field of disaster can be integrated with participatory mapping methods to generate spatial information that supports local capacity.[9]

The problem in Bobanehena Village is the limited capacity of individuals, households and communities in facing and dealing with disasters, especially tsunamis. In Bobanehena Village there are no tsunami evacuation routes and no information boards explaining temporary evacuation locations. Therefore, this activity was very useful as participatory mapping is a powerful tool in dealing with tsunami disaster risks. Involving the local community in this process not only improves preparedness, but also strengthens social bonds and togetherness in the face of such disaster threats.

Method

This service was carried out in Bobanehena Village, Jailolo, West Halmahera, namely at the Bobanehena Village Office. There were 30 participants consisting of community groups, stakeholders, and youth organizations. Participatory mapping is carried out using the Community-Based Disaster Risk Reduction (CBDRR) approach, a process that involves the community in identifying, analyzing, and reducing disaster risks in their area. It also aims to strengthen community preparedness for disaster risks and minimize their impacts. Involving local people in this entire process can strengthen the community's capacity to deal with disasters and build better resilience.Here are the steps in conducting participatory mapping with a CBDRR approach:

Improving Community Capacity

Through education and awareness activities to the community, emphasizing: (a) introduction to the basic concepts of disaster risk reduction, (b) community-based disaster risk reduction, (c) steps for making tsunami evacuation maps and other basic materials deemed relevant. This was done to strengthen the community's capacity to deal with tsunami disasters (Figures 2a and 2b). To assess the community's capacity to understand and mitigate tsunami disasters, a questionnaire was administered before the activity (pretest) and after the activity (postest) (Figure 3).

Boe Solomon Islands," *Knowledge Management for Development Journal* 9, no. 1 (2013), 24-36.

[9] Muhammad Zid et al., "Pengurangan Risiko Bencana Melalui Pemetaan Partisipatif Di Desa Wisata Cisaat Kecamatan Ciater Kabupaten subang," *Prosiding Seminar nasional Pengabdian Kepada Masyarakat 3*, no. 1 (2022), 119-127 https://journal.unj.ac.id/unj/index.php/snppm/article/view/33389

(a) (b)

Figure 2. Community Capacity Building in Bobanehena Village, Sub-district

Figure 3. Community Capacity Assessment by administering pretest and postest.

Risk Analysis with the Community in Mapping Evacuation Routes

Improving understanding with historical memories of previous tsunami disasters in Bobanehena Village. So that the community can understand the various vulnerabilities that exist now that contribute to the potential risks that exist or may arise in the future.

This activity was also intended to analyze preliminary data such as geological, geographical, topographical and socio-economic data that had been collected by identifying the existing risks in Bobanehena Village, and the causes and potential impacts of these tsunami disaster risks. Then conduct community participatory mapping through Forum Group Discussions (FGD) with the help of remote sensing image data interpretation. The mapping technique used in this service is the Scaled 2D Mapping Technique, which is a participatory mapping technique where the resource persons describe the known information (using stationery and drawings) into a printed base map. (Figure 4). This FGD involves local communities in mapping their areas using their local knowledge and using tools such as participatory maps or community-based technology to assist communities in mapping vulnerable areas.

Figure 4. Participatory Mapping to Determine Tsunami Disaster Risk Areas in Bobanehena Village

Analysis of Tsunami Participatory Mapping Results

The results obtained in participatory mapping were then combined with risk data that had identified areas most vulnerable to tsunami disaster risk. After that, identifying and creating safe evacuation routes for the community when evacuating and mitigation planning together with the community. The results of participatory mapping are in the form of a participatory map of the tsunami evacuation route plan in Bobanehena Village which is then socialized to the community level again to be known and responded to. The map can be used as a document to develop further plans such as village contingency plans, developing emergency aid standards, developing hazard warning systems, developing simulation plans and so on.

Disaster Risk Analysis Document

All the results of the assessment with the community are collected and made into a community document that is very useful for the community to develop a community-level Disaster Risk Reduction Action Plan. It is very useful for the community to develop a community-level Disaster Risk Reduction Action Plan. The document can be used as advocacy material that has the legitimacy of grassroots knowledge to encourage change at the community level.

Periodic Evaluation & Promoting Community Action Plans.

Conduct periodic monitoring of the implementation of mitigation measures and their impacts, and evaluate the effectiveness of the participatory mapping program through the CBDRR approach. It is important to socialize and disseminate information to share the results of the mapping and information on mitigation measures with local

communities and other stakeholders. This is done in order to increase public awareness about mitigation plans and how to act when a disaster occurs. Furthermore, it is necessary to revise and sustain the resulting mapping and mitigation plan based on lessons learned and changing conditions in the field.

The stages of participatory mapping of tsunami evacuation route plans are shown in the flowchart in Figure 5 below.

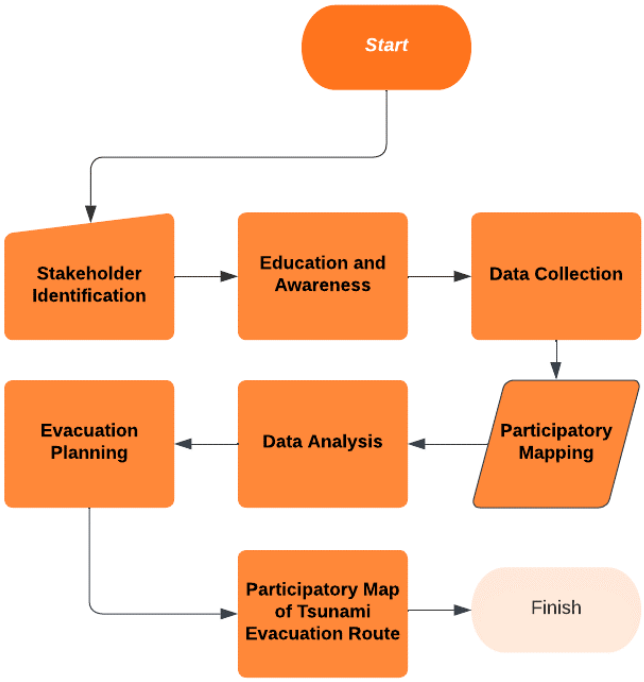

Figure 5. Flowchart of Activity Implementation Stages

Result

Activity Location Overview

The location of the service activities was carried out in Bobanehena Village which is located on the coast of Jailolo District, West Halmahera. Bobanehena Village has an area of 0.10 km2, with a geographical location in the North bordering Taboso Village, the East bordering Galala Village, the South bordering the Maluku Sea, and the West bordering Payo Village. If an earthquake occurs in the Maluku Sea with a large intensity, it can be accompanied by a tsunami. An earthquake accompanied by a tsunami will cause losses in Bobanehena Village because it is located in a coastal area.

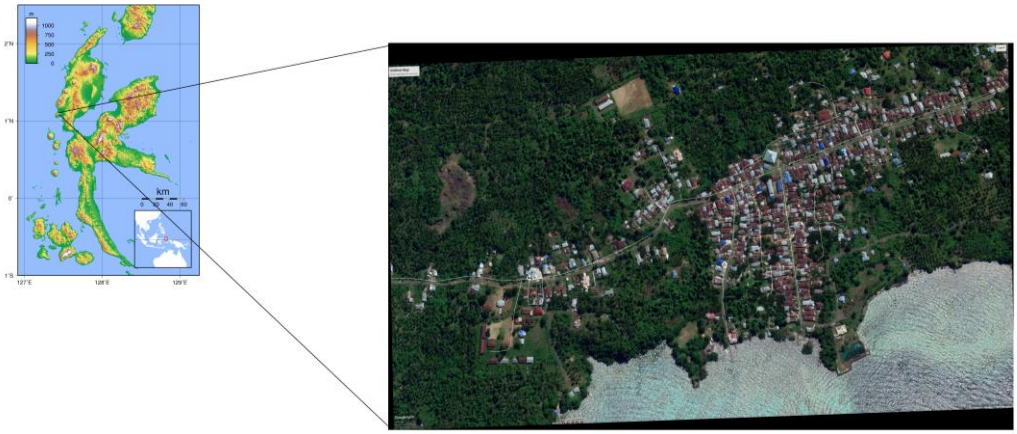

Figure 6. Partner Location Map Based on Image Map

Community Capacity Building

The activities carried out to increase the community's capacity to deal with tsunami disasters included the presentation of materials containing (a) an introduction to the basic concepts of disaster risk reduction, (b) community-based disaster risk reduction, (c) steps for making tsunami evacuation maps and various basic materials deemed relevant. Before the material was presented, a pretest was given to the participants. After the presentation of the material, the activity continued with mentoring the community of Bobanehena Village, totaling 30 people, to map the potential for tsunami disasters in the surrounding community.

Participatory Mapping of Tsunami Evacuation Routes

Participatory mapping activities are carried out by integrating knowledge from local communities and science in a top-down and bottom-up manner in disaster risk management.[10] Disaster risk reduction by conducting participatory mapping is very significant with the involvement of the community. Participatory mapping of evacuation routes was carried out by Forum Group Discussion (FGD) with the help of remote sensing image data interpretation. Objects are identified through image maps that have been laid out then delineated and finally a thematic map of the distribution of identified objects is produced. The participatory mapping technique used in this activity is the Scaled 2D Mapping technique. The Scaled 2D Mapping technique was chosen over other participatory mapping methods because the resource persons involved were village officials who were already quite familiar with maps and photos to minimize distortion of the mapped information. The base map used in this activity is a low-resolution satellite image map.

[10] Jake Rom D Cadag and J.C. Gaillard, "Integrating Knowledge and Actions in Disaster Risk Reduction: The Contribution of Participatory Mapping," R*oyal Geographical Society* 44, no.1 (2012), 100-109 https://doi.org/10.1111/j.1475-4762.2011.01065.x

Figure 7. Results of the Participatory Mapping of Tsunami Disaster Evacuation Routes Activity

The result of the participatory mapping activity is to determine the paths that are easily traveled during disaster evacuation and temporary gathering points (Figure 7). The results were then scanned from printed maps drawn by resource persons, and then georeferenced using QGIS software with digitization to obtain spatial data. The results of participatory mapping were then integrated with the results of land use mapping to complement the mapping information. The resulting mapping results were then submitted to the community as resource persons to be validated and corrected if some errors were found. The final product of this mapping activity is a participatory map of the tsunami evacuation route plan for Bobanehena Village, Jailolo, West Halmahera (Figure 8) in the form of a spatial database, and disseminated in the form of printed maps.

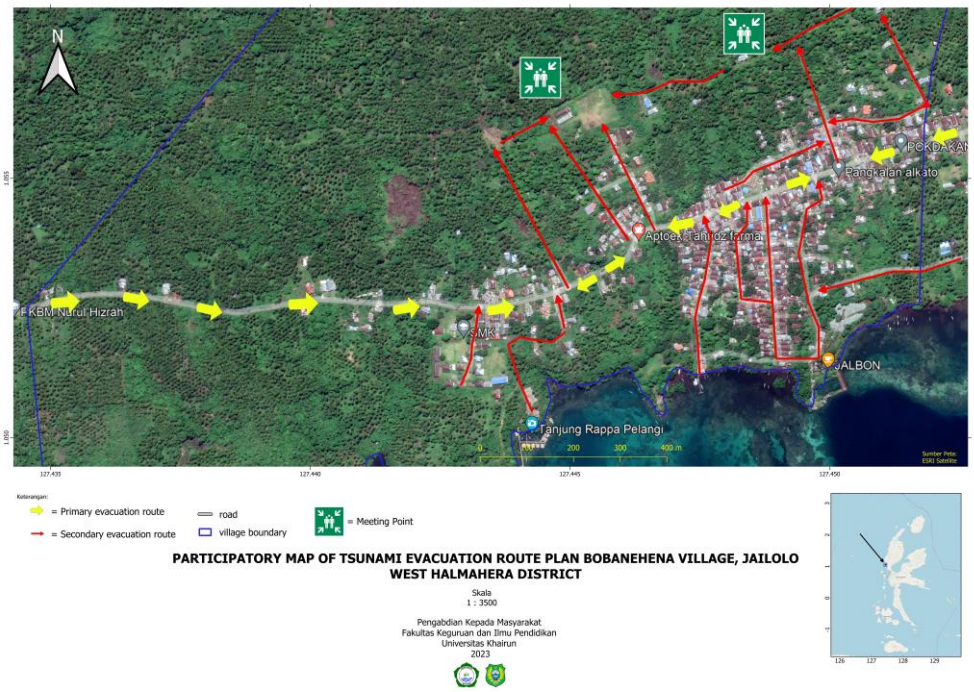

Figure 8. Results of the Bobanehena Village Tsunami Evacuation Route Plan Participatory Map

This activity is then evaluated based on the indicators of achievement that have been set by the program implementation team. The evaluation is in the form of a questionnaire, namely in the form of pretests and post-tests given before and after the activity is carried out. The criteria for the achievement of this activity is the increased capacity of the community in Bobanehena Village to deal with tsunami disasters and determine tsunami evacuation routes. The increase in knowledge can be seen from the increase in the average pretest and posttest scores. In the pretest the average value of community knowledge was 65, then the average value of the posttest was 83. An increase in community capacity of 18, which can be seen in Figure 7.

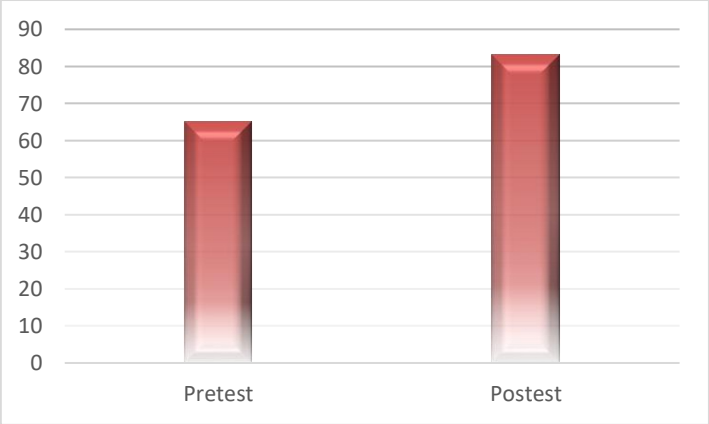

Figure 9. Diagram of the Average Value of Community Capacity on Tsunami Disasters in Bobanehena Village

Discussion

The evacuation route map provides information about the path that shows the direction to the public to get to a safe evacuation place, which can be an open field, or a building.[11] The essential elements of participatory mapping of tsunami evacuation routes are maps of evacuation routes and meeting points in Bobanehena village. The location of the chosen meeting point should be easily accessible in a short time, spacious, clearly marked and away from other hazards. The evacuation route map was created based on data on the distribution of the availability of public facilities (schools, markets and fields), tourist attractions, buildings from businesses, places of worship, government agencies, and main road access to the gathering point. The basis for determining the rallying point for temporary evacuation is a wide plain and at an altitude. The rallying point identified as a temporary or final evacuation site for Bobanehena Village is a vacant field which is a large area and located at an elevation. The FGD results for participatory mapping of tsunami evacuation routes are an application of Geographic Information System (GIS) technology in digital form integrated with low-resolution satellite imagery data.

[11] Badan Nasional Penanggulangan Bencana (BNPB), *Kajian Risiko Bencana Maluku Utara 2016-2020. Deputi Bidang Pencegahan dan Kesiapsiagaan*.

The gathering point used as a temporary evacuation site is an empty field with an altitude of 45-47 meters above sea level (masl), which is safe, spacious and far from other potential hazards. The evacuation route to the gathering point obtained from the results of the community's consideration during the FGD is the main access road and is easy to pass by the community on a daily basis. This makes it easier for the community to provide services for the basic needs of residents such as health services, food, accommodation and first aid.

From the FGD results, suggestions need to be made so that the community understands the evacuation routes and gathering points, namely a). improving mitigation management to be better at the village level in order to prevent the emergence of disturbances that slow down the evacuation process such as traffic congestion during a tsunami disaster, b). Strengthening community capacity through village governments and disaster activists to the general public, and c). More comprehensive publication of the village's fixed evacuation procedures is needed. In addition, there should be government assistance to address drainage and road improvements to the gathering point.

This increase in community capacity is due to the fact that the community in Bobanehena Village understands more about tsunami disasters and during the implementation of community service, the community was directly involved in making evacuation routes.[12] In addition, the level of active participation in the community also plays an important role.[13] Communities that have a strong culture of participation are more likely to be involved in mapping activities. This can be influenced by social and cultural factors.

Conclusion

Community service activities are aimed at the community in Bobanehena Village by actively involving the community directly by means of Community Based Disaster Risk Reduction (CBDRR). The activities carried out have run well and smoothly starting from the preparation stage, implementation stage, and evaluation stage. This activity helped increase the community's capacity about tsunami disasters and their mitigation. In addition, by making a participatory map of the tsunami evacuation route plan, the community knows the safe location for temporary evacuation in the event of a tsunami disaster. During the implementation of the activity, participants showed enthusiasm and hoped that this community service activity could be carried out in a sustainable manner

[12] Galuh Pramita, et al, "Pelatihan Sekolah Tangguh Bencana Di SMK Negeri 1 Bandar Lampung," *Journal of Sosial Sciences and Technology For Community Service (JSSTCS)* 3, no. 2 (2022), 264-271 https://doi.org/10.33365/jsstcs.v3i2.2177

[13] Dian Agustina, Etis Sunandi, and Sigit Nugroho, "Pendampingan Mitigasi Bencana Gempa Bumi dan Tsunami berbasis Pengetahuan Lokal pada Masyarakat Rentan Bencana di Kabupaten Mukomuko Bengkulu," *Jurnal Engagement* 4, no. 1 (2020), 087-099

by reviewing the implementation of community capacity building that is tailored to the characteristics and abilities of the local community because basically every community is unique.

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