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Natural Disaster Risk Mapping in Realizing Sustainable Environmental Management in the East Rembang Region, Indonesia

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ABSTRACT

East Rembang is an area in the Rembang district prone to disasters. Various disaster management efforts have been carried out, but disaster risk measurement at the village level has yet to be done. Therefore, this research was carried out to know hazards, vulnerability, and coping capacity so that disaster risk in East Rembang can be analyzed. This research was carried out to know hazards, vulnerability, and coping capacity so that disaster risk in East Rembang can be analyzed. The research was conducted in East Rembang, consisting of three sub-districts, namely Kragan, Sarang, and Sluke, with 27, 23, and 14 villages, respectively. This research uses mixed methods, including literature study, interviews, and observation techniques. The research results show that the disaster threat and vulnerability of villages in East Rembang based on 2020-2022 data is, on average, low, although several villages have high threat and vulnerability. This is due to the relatively high capacity of the community, which supports low disaster risks. In general, it can be seen that the average level of disaster risk in East Rembang is "Very High". Even so, the community's capacity to face disasters could be higher.

1. INTRODUCTION

Coastal areas in Indonesia are synonymous with various natural disasters [1], including Rembang Regency Central Java [2]. In 2021, Rembang Regency was at risk of seven types of disasters, with four kinds of disasters at a high-risk level, two at a medium-risk level, and one at a low-risk group. This number decreased in 2020 when six types of disasters were in the high-risk class, and one other was moderate [3]. In 2022, the number will decrease again compared to 2021, where in 2022, there were only two disasters in the high category and one disaster in the low class, while the others were in the medium type [4]. Overall, the multi-threat index in 2020 is higher than in 2021 and 2022.

The multi-threat risk score gradually decreased, with the risk class initially in the "high" category in 2020 decreasing to the "medium" type over the following two years. This decline is possible due to supporting natural factors and the result of successful mitigation efforts. However, it does not rule out the possibility of natural disasters in the following years.

It will occur in Rembang Regency. Suppose the threat of disaster is seen from the history of disasters. In that case, Rembang Regency has experienced natural disasters and incredible abrasion since 2003, and this will continue until 2023, except from 2005 to 2009. This history shows that Rembang Regency still has a high threat of disasters, especially abrasion disasters [2]. Apart from abrasion, various natural disasters occur in Rembang Regency, with the total number of incidents constantly fluctuating yearly, as shown in Figure 1, which informs disaster events in 2015-2019, with the most disaster events occurring in 2015. This number decreased in 2016, increased again in 2017, and fluctuated in subsequent years. However, from this data and the previously mentioned abrasion data, it is known that Rembang experiences natural disasters yearly. This data also shows that if we look at the history of disasters in Rembang in the past few years, it can be seen that the Regency has a significant threat of disaster.

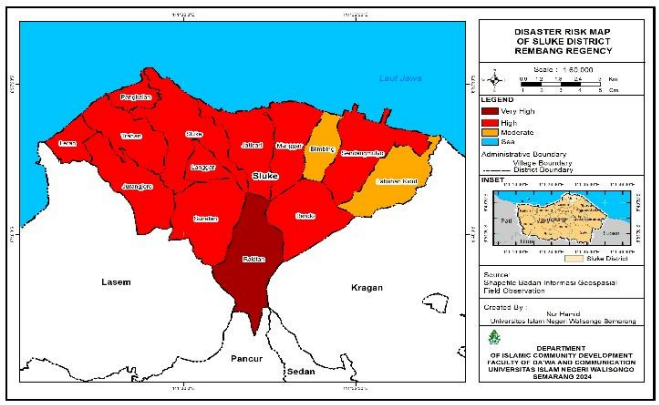

Figure 1. Disaster risk map of Sluke district

Data on disaster events for five years shows that the most disaster events occurred in 2015. This number decreased in 2016 and increased again in 2017. This number rose again in 2018 but declined again in 2019. Assessment of vulnerability to disaster risks must look at the history of disasters that have occurred in the area over a long period, not just the last few

years [5].

Disaster risk calculations must consider the threat of significant disasters. Disaster risk is a calculation of the estimated losses that may result from an area at a specific time due to a natural disaster [6]. Disaster risk calculations by Badan Nasional Penanggulangan Bencana (BNPB) and Badan Pusat Statistik (BPS) are limited to information about the number of disaster events and fatalities. However, disaster risk calculations, especially at the village level, have yet to be carried out. It is essential to know disaster risk down to the village level so that each village can carry out mitigation efforts that are appropriate to its level of disaster risk. Due to the importance of measuring disaster risk down to the village level, several studies such as those conducted by Rizki Novitasari [7], Widyantoro and Usman [8], and Raharjo [9] have researched disaster risk from various specific areas down to the village level, so that the disaster risk of the village is known. Disaster risk assessment or analysis becomes a reference in formulating priority actions for disaster risk reduction (Mitigation) [10].

Disaster risk calculations must be carried out as part of disaster management. Sustainable disaster management will depend heavily on ongoing disaster risk assessment [2, 11]. If the disaster risk is known, and the threats, vulnerabilities, and capacities are known, appropriate disaster management strategies can be implemented. However, if these three still need to be discovered, it will also be challenging to determine appropriate disaster management strategies in the long, medium, and long term [12]. Apart from that, research results related to disaster vulnerability must also be disseminated to the public, as Farhi [13] has socialized the results of research related to the preparedness index and the level of vulnerability of the Brebes Regency community so that the community has an awareness of the vulnerability of disasters in their surroundings so that the community will try to increase preparedness in facing disasters.

Given the existing limitations, this research was only conducted in East Rembang, the area in Rembang Regency most prone to natural disasters. East Rembang consists of three sub-districts, namely Sarang, Sluke, and Kragan sub-districts, which are vulnerable to four disasters at once: floods, landslides, abrasion, and drought [14, 15]. Various studies have been carried out to deal with natural disasters in East Rembang. The first is research entitled “Evaluation and Mapping of Disaster Resilient and Resilient Village Readiness in East Rembang” conducted by Montesinos-Pedro et al. [16]. The second is a study entitled “Participatory WebGIS-based Disaster Anticipation Information System (SIAB) to Improve Disaster Preparedness and Economic Development for East Rembang Coastal Communities” conducted by Juhadi et al. [11]. Third, research specifically conducted in the Kragan District by Hamid [17] with the title “Study of Community Capacity in Facing the Threat of Coastal Erosion in Kragan District, Rembang Regency” and Setyowati et al. [18] with the title “The Role of the Disaster Preparedness Group in adapting abrasion to communities affected by abrasion on the North Coast of Rembang, Central Java.”

Based on the description above, it is known that East Rembang is an area in the Rembang district that is prone to disasters. Various disaster management efforts have been carried out, but disaster risk measurement at the village level has yet to be done. Therefore, this research was carried out to know hazards, vulnerability, and coping capacity so that disaster risk in East Rembang can be analyzed. The formulation of the problem in this study includes; What are the results of the disaster threat (hazard) analysis in East Rembang? What are the results of the community vulnerability analysis to disasters in East Rembang? What are the results of the community capacity analysis (coping capacity) in dealing with disasters in East Rembang? What are the results of the disaster risk analysis in East Rembang?

2. METHODS

2.1 Research design

This research is a type of mixed methods research. The primary technique used in this research is literature study, which examines facts and data from scientific sources. These include statistical reports from Badan Pusat Statistik (BPS), the Disaster Risk Index published by the National.

BNPB, and scientific journals from previous research. After collecting and processing library data, the data is then validated for its correctness using other data collection techniques. These techniques are interview and observation techniques, carried out as triangulation techniques to test the validity of the data. The data that will be the focus of this research is data that shows disaster risk [19]. The interview technique was carried out by interviewing key informants in the form of the Head or members of the Regional Disaster Management Agency (BPBD) of Rembang Regency, sub-district heads from the three sub-districts studied, and village heads if necessary. The selection of informants was snow-ball in nature, where the longer the research was carried out, the number of samples would widen according to the research needs.

2.2 Research location and time

This research was conducted in East Rembang, one of the areas in Rembang Regency. The research locations are three sub-districts in East Rembang, namely Kragan, Sarang, and Sluke, each with 27, 23, and 14 villages (as shown in Figures 2 and 3). However, considering that this research was conducted in literature and the field, it was conducted in two places. Field research was conducted randomly in several purposive areas in three sub-districts in East Rembang. The location selection was based on the suitability of the location criteria with the research objectives.

According to Sugiyono [20], the simple random sampling technique is a technique for taking samples from members of the population that is carried out randomly without considering the strata in the population. Requirements for using the simple random sampling technique: 1) If the population elements are homogeneous, any element selected as a sample can represent the population. 2) It is carried out if the research analysis tends to be descriptive and general.

The sample characteristics expected to be identical to the population are most likely to be obtained through truly random sample determination. This means that no interests can influence the determination of the sample, including the researcher's interests.

This research was conducted over three months. The first two months were used to collect, study, analyze, process, present, and conclude data obtained through library research. Furthermore, the analysis results were confirmed to be correct through field research for approximately one month.

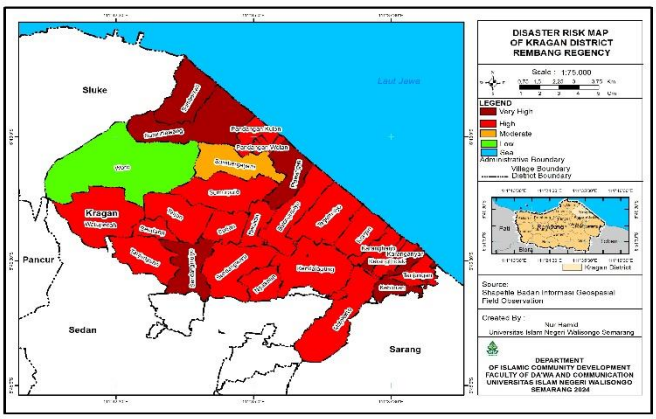

Figure 2. Disaster risk map of Kragan district

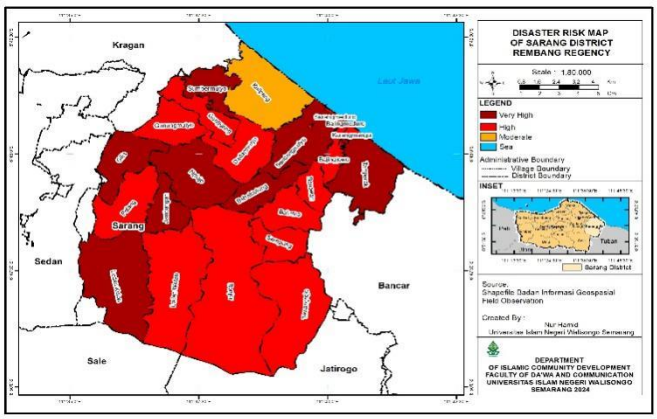

Figure 3. Disaster risk map of Sarang district

2.3 Research techniques and instruments

This research uses three research techniques. The first is the literature study technique, which is carried out by examining reference sources that are relevant to the research topic. The research instrument is a literature study sheet that contains a grid related to natural disaster risks. The literature study sheet instrument was developed based on the theory of natural disaster risk according to the Head of BNPB Regulation Number 2 of 2012 concerning the Preparation of Disaster Risk Studies. The grid contains aspects and indicators that measure natural disaster risk, namely, managing aspects of threat, vulnerability, and capacity. The research instrument was developed by referring to several previous studies that examined disaster risk, namely Widyantoro and Usman [8], Raharjo [9], and Aminatun [21].

The second and third techniques used are interview and observation techniques. These two techniques confirm the correctness of data obtained from the literature review. A more valid and accurate document related to the discussed topic will be requested if a discrepancy is found. The interview technique was carried out by interviewing key sources from disaster experts and the community in Rembang Regency. The selection of sources is a snowball in nature, where the more extended the research is carried out, the wider the sample size will be according to research needs. The observation technique is carried out by reviewing the primary measurement points' locations. For example, if the literature states that there is school data, it will be confirmed again whether the numbers listed are appropriate or not. The instruments used for these two techniques are semi-structured interviews and observation sheets [22, 23].

2.4 Data analysis

On the odd (right) pages, the author's name of your paper will be inserted. This research data analysis was carried out descriptively qualitative-quantitatively. The qualitative data in the measurement indicators is converted into quantitative data in z-scores. The z-score calculation is carried out on each aspect that is measured and then processed to find the level of disaster risk using descriptive statistics. Processing is carried out in all villages in East Rembang utilizing the help of Microsoft Excel number processing tools so that the disaster risk of each town will be known. The z-score is formulated as follows.

$$z - score = \frac{Criterium\ score - mean\ score}{standard\ deviation}$$

The z-score for each village is then used to determine its disaster risk category or level. Class intervals and types are determined by calculating the number of classes and class lengths, formulated as follows. Based on these calculations, the class length and number of classes will be known to obtain a disaster risk categorization based on the z-score value.

$$\text{Number of Classes} = 1 + (3{,}3)\log n$$

$$\text{Class Length} = \frac{Biggest\ Data - Smallest\ Data}{\text{Many Classes}}$$

3. RESULTS

3.1 Hazard in East Rembang Region

The threat of disaster in this study is measured through two indicators, namely disaster events as an indicator of the possibility of a disaster occurring in the future and the number of disaster victims as an indicator of the magnitude of the recorded impact. Data was obtained from quantitative data collection by the Rembang Regency Central Statistics Agency for 2020-2022. The data is then converted into a z-score to add the two data. However, of the three sub-districts measured, during the three years from 2020-2022, disaster events in the three sub-districts did not have a significant impact, especially regarding fatalities, so this indicator has the same value in all sub-districts.

The disaster threat values from the three sub-districts are then grouped based on class intervals. Seven class intervals indicate the threat of disaster in East Rembang, with each having a score, as shown in Table 1.

Table 1. Disaster threat value in East Rembang

Disaster Threat Value	Category
6.8 - 8.1	Very Very High
5.4 - 6.7	Very High
4.0 - 5.3	High
2.6 - 3.9	Quite High
1.2 - 2.5	Not High Enough
(-0.2) - (1.1)	Low
(-1.6) - (-0.3)	Very Low

In general, it is known that the highest threat is in

Karangmangu Village, while the lowest threat is in fourteen villages in Kragan District, which have a vulnerability value of -1.6. Apart from Karangmangu Village, there is also a village in the "Very High" category, namely Sumurtawang Village. In general, seven types of disaster threats.

The threat percentage can be shown in Figure 4. The highest rate is in the "Very Not High" category. The lowest percentages are in three categories, namely the "Very Very High", "High," and "Quite High" categories. These results indicate that, in general, the threat of disasters in East Rembang is low.

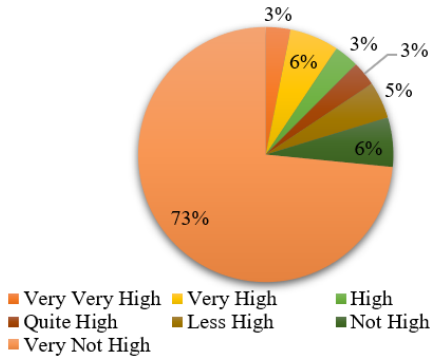

Figure 4. Hazard percentage in East Rembang

This study's research on disaster threats is carried out in previous research. Aminatun [21] used almost the same method, namely, Findayani et al. [24], reviewing central data but only carried out landslide disasters and divided the threat class into three classes. In line with that, Rahmad et al. [25] concluded the results of their research by grouping the threat level into three categories, while in this study, it was broken down into seven categories.

The disaster hazard value in three sub-districts in East Rembang is summarized as intended: the highest threat is in Karangmangu Village, while the lowest threat is in fourteen villages in Kragan Sub-district with a vulnerability value of -1.6. In addition to Karangmangu Village, there is a village with the category "Very High," namely Sumurtawang Village. In addition, in general, there are four villages with the category "Very High", two villages with the category "High", two villages with the category "Quite High", three villages with the category "Less High", four villages with the category "Not High", and forty-seven other villages with the category "Very Not High".

3.2 Vulnerability in East Rembang Region

Vulnerability is the second variable that determines disaster risk in an area. Head of BNPB Regulation Number 2 of 2012 concerning Preparation of Disaster Risk Studies states that the vulnerability aspect can be measured from two indicators: the loss index, which consists of physical, economic, and environmental components, and the exposed population index, which consists of socio-cultural components. According to Ramadhan and Chamid [26], the loss index in environmental aspects can be subdivided into the social and ecological environments so that vulnerability in this study is measured based on the aspects shown in Figure 5.

East Rembang's disaster vulnerability is calculated by adding the z-score of all measured aspects. All aspects were estimated using data from 2020 to 2022. Based on the z-score obtained from all villages, class intervals were calculated to bring vulnerability categories based on the value of vulnerability to disasters.

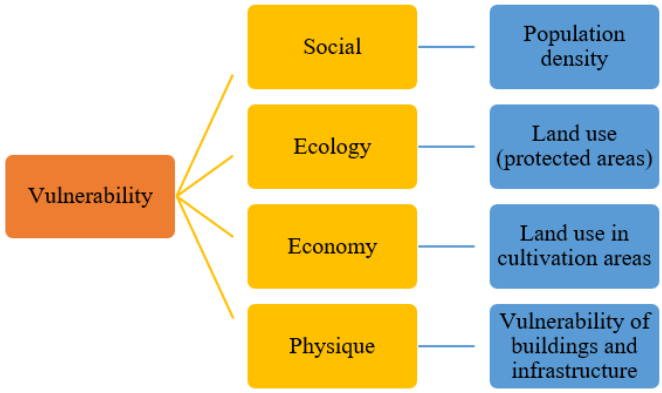

Figure 5. Measured aspects of disaster vulnerability

The three villages with the highest vulnerability are Kalipang, Woro, and Lodan Wetan Villages. In contrast, the village with the lowest exposure in the "Very Not High" category is Blimbing Village. Based on overall vulnerability data, there are seven categories of village vulnerability.

Next, the percentage of disaster vulnerability in East Rembang was developed, as shown in Figure 6. The category with the highest rate was the "Not High" category, while the lowest was the "Very Not High" category. These results indicate that, in general, disaster vulnerability in East Rembang is in the low category.

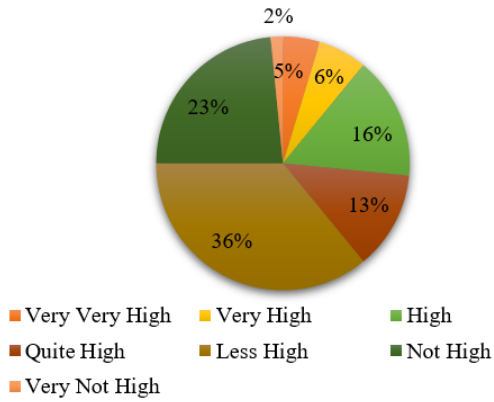

Figure 6. Disaster vulnerability percentage in East Rembang

The measurement of vulnerability in this research was carried out by Mantika et al. [27]. The study in Gunungkidul, DIY, also used secondary or library data as a data source, with the same aspects being measured, namely economic, physical, environmental, and social vulnerability. The difference is that that research used GIS as a mapping tool, while this research only used simple mapping. This research also summarized the vulnerability results into three levels of vulnerability, while this study classified it into seven interval classes.

This vulnerability mapping can then be used to increase community capacity, considering that if a vulnerability is not accompanied by high power, it will increase losses due to disasters [28]. Like hazard assessment, DFID [29] states that vulnerability assessments can also be carried out using existing data, such as poverty data, household surveys, etc.

The vulnerability of villages in East Rembang is summarized by the vulnerability value between Sarang, Kragan, and Sluke Sub-districts; it is known that the three

villages with the highest vulnerability in succession are Kalipang, Woro, and Lodan Wetan Villages, while the village with the lowest vulnerability in the category "Very Not High" is Blimbing Village. In general, there are four villages with the category "Very High", ten villages with the category "High", eight villages with the category "Quite High," twenty-three villages with the category "Less High," and fifteen villages with the category "Not High".

3.3 Coping capacity in East Rembang Region

The final indicator to measure disaster risk in an area is the community's capacity to face disasters. Head of BNPB Regulation Number 2 of 2012 concerning Preparation of Disaster Risk Studies states that ability can be measured from institutional components, early warning, mitigation education, and preparedness. These aspects are then adjusted to the availability of BPS data regarding villages in East Rembang. Therefore, in this study, community capacity was measured from the disaster early warning system, tsunami warning system, safety equipment, evacuation signs, community participation, and the number of village reservoirs.

The data used are BPS data from 2020 to 2022. Data was taken from all villages in East Rembang, which was then converted into a z-score. Data from various aspects converted into z-scores can then be added to obtain the final disaster capacity value. The total worth from the sum of the z-scores becomes the value of the community's capacity to face disasters. The ability of the East Rembang community is classified into seven class intervals.

Based on the demonstrated capacity of the community to deal with disasters, the ability was then mapped from the three sub-districts that were measured. The results show that East Rembang has seven categories of community capacity in dealing with disasters.

Furthermore, the percentage of community capacity in dealing with disasters in East Rembang is also known, as shown in Figure 7. The highest rate is in the "Not High" category, while the lowest is in the "Very High" sort. The results in Figure 7 show that some villages have high capacity, but several other towns also have low ability.

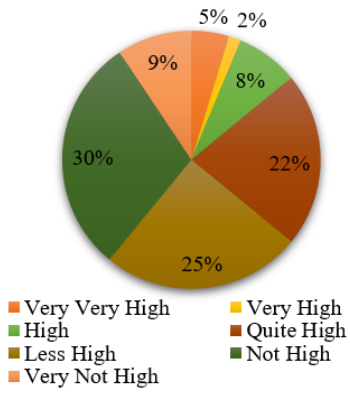

Figure 7. Disaster capacity percentage in East Rembang

Community capacity, which is generally still low, must continue to be increased. One of the efforts is to increase community participation in natural disasters. Community participation shows a strong awareness within the community of the vulnerability of their area so that the community voluntarily moves together to overcome existing disaster problems [30]. The community's capacity (coping capacity) in dealing with disasters in East Rembang is generally also low because cumulatively 64% are in the categories of "Less High", "Not High", and "Very Not High". While the other 36% cumulatively are in the categories of "Very Very High", "Very High", "High", and "Quite High". Existing community participation should also continue to be supported by the local government. Moreover, the government and other bodies with authority over disasters and the private sector must continue working together to overcome disaster problems [31-33]. This aligns with what Shiwaku and Fernandez [34] stated connectivity between society and the government, private sector, and university experts can increase coping capacity.

Coping capacity can be increased with several efforts. Among them are empowerment, education, and training [35-38]. This is what Borgo Village in Minahasa Regency has done, which has increased capacity through outreach and training as well as supporting it by completing all evacuation needs such as hazard maps, evacuation signs, and routes to various equipment such as loudspeakers and headlamps [39]. Another effort, as mentioned by Tiernan et al. [40], is increasing mental health support.

3.4 Disaster risk in East Rembang Region

After obtaining data in the form of threats, vulnerabilities, and capacity, disaster risk is then measured. Disaster risk is obtained from hazard and exposure and then divided by ability. When the product of the threat and vulnerability is the same between two villages, the village with higher capacity will have a more negligible risk, and vice versa. For example, this can be seen in Plawangan and Sumbergayam Villages, which have the same numerator value, namely -9. However, Plawangan Village has a lower capacity, so the risk level is higher.

The percentage can be shown in Figure 8. In general, there are only four categories. The disaster risk category with the highest rate is in the "Very High" category. The lowest category is in the "Very Not High" category.

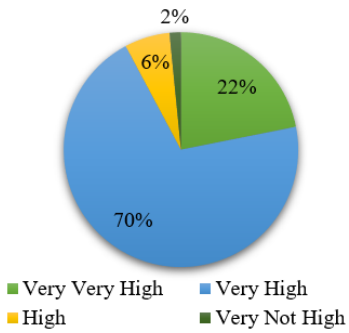

Figure 8. Disaster risk percentage in East Rembang based on category

In general, it can be seen that the average level of disaster risk in East Rembang is "Very High". All villages in East Rembang have a risk level in the category "Very Very High" to "High," and there is only one village that has a vulnerability of "Very Not High," namely Woro Village. If explained from the components of disaster risk, the villages in East Rembang have a generally low threat of disaster and low disaster vulnerability. However, it is also known that the capacity of the community to deal with disasters is also low so the risk of disaster is high. To reduce the risk of disaster, villages in East Rembang must increase their capacity and reduce the hazard

and vulnerability.

Based on the analysis and mapping results, validation was then carried out on all sources involved in this research. Seven sources stated that the results obtained followed the actual situation. In general, the seven sources can be summarized in the words,

"In general, the disaster risks resulting from the analysis and mapping of this research are appropriate. However, several villages need to be more suitable. I tried checking randomly, for example, Woro Village. This village is prone to landslides; there is no early warning system. However, the results of this research have a low risk of disaster. However, in general, the results are as they should be."

After obtaining the interview data and stating that the results of the analysis and mapping are based on actual conditions, observations were made in villages in East Rembang. These include towns with a very high disaster risk and those with a shallow risk. However, considering the limitations of the research, observations were only carried out in several random villages as representatives to determine the condition of East Rembang as a whole. This library research study uses data sources in the form of village statistical data published by BPS of Rembang Regency. The data used is relevant to the research objectives, limited to the research location, and only in 2020-2022.

In general, it can be seen that the average level of disaster risk in East Rembang is "Very High." All villages in East Rembang have a risk level in the "Very Very High" to "High" category, and there is only one village that has a "Very Not High" vulnerability, namely Woro Village. If analyzed from the components of disaster risk, towns in East Rembang generally have low disaster threats and vulnerability. However, it is also known that the community's capacity to deal with disasters is also standard, so the risk of catastrophe is high. As Annisa and Setyowati [41] and Yashiro & Hayashin [42] mentioned, community capacity plays a significant role in disaster control and must continue to be improved. Considering the importance of community capacity, Mei et al. [43] and Abas et al. [44] strive to increase it through schools and education.

For disaster risks to decrease, villages in East Rembang must increase capacity and reduce threats and vulnerabilities. This is what has been done by several villages. The first is Buluh Cina Village, Siak Hulu, Kampar, Riau, which has formed a Disaster Risk Reduction Forum and has succeeded in increasing community capacity through disaster outreach carried out directly through community forums and leaflets posted in strategic places [45]. The second is Ngargomulyo Village, which is in the Mount Merapi area. The community has been involved in a participatory manner to determine the evacuation route so that the community understands the evacuation route that must be taken, starting from evacuation at the hamlet, village level, to the refugee camp in Temanggung Regency, Central Java, which is the final point. This increased participation is hoped to increase community capacity in dealing with disasters to reduce disaster risk [46]. Third, Gunung Geulis Village in Bogor is committed to becoming a Disaster Resilient Village and developing a Pengurangan Risiko Bencana Forum (PRB). Various structural disaster mitigation activities, such as planting trees and building retaining embankments, and non-structural mitigation, such as disaster education, have been carried out [47].

On average, the disaster threat and vulnerability of villages in East Rembang based on 2020-2022 data is low, although several villages have high threats and vulnerabilities. Even so, the community's capacity to face disasters is also typical. Therefore, the risk of disaster is high, with a percentage of 22% in the "Very Very High" category, 70% in the "Very High" sort, 6% in the "High" category, and only 2% in the "Very Not High" category.

4. DISCUSSION

In this research, measuring the threat of disasters uses two indicators, including disaster events as an indicator of the possibility of a disaster occurring in the future and the number of disaster victims as an indicator of the magnitude of the recorded impact. Viewed from the perspective of the concept of disaster risk reduction, the threat of disasters can result in significant disasters in residential areas when the level of vulnerability (vulnerability) is high, and capacity (capacity) is low [48]. Data was obtained from quantitative data collection by the Rembang Regency Central Statistics Agency for 2020-2022. The threat and vulnerability of village disasters in East Rembang based on 2020-2022 data is low on average, although several villages have high threats and vulnerabilities. Even so, the community's ability to deal with disasters is also low. Therefore, disaster risk is considered high, with a percentage of 22% in the "Very Very High" category, 70% in the "Very High" sort, 6% in the "High" category, and only 2% in the "Very Not High" category. Aminatun [21] and Findayani et al. [24] also used almost the same method by reviewing data from the Rembang Regency Central Statistics Agency. Still, they only carried out landslide disasters and divided the threat class into three classes. In line with that, Rahmad et al. [25] concluded the results of their research by grouping threat levels into three categories [31].

The categorization can vary and be divided into three categories: high, medium, and low [8]. The classification of the level of vulnerability of the East Rembang coastal area to the threat of coastal abrasion disasters has the same level of exposure, namely being in the medium category [49]. However, history shows that the Rembang Regency still has a high threat of disasters, including abrasion [11]. The geomorphology of Rembang Regency is dominated by alluvial plains, which makes the area quite vulnerable to the threat of abrasion and coastal erosion [50].

There are development policies and strategies in Presidential Regulation Number 2 of 2015 concerning the 2015-2019 National Medium Term Development Plan (RPJMN), one of which contains directions for sustainable management of coastal areas by combining non-structural and structural approaches in a balanced manner through the development of safeguards. Beaches, especially beaches directly affected by rising sea levels due to climate change, including the frontier islands, protect the territorial integrity of the Republic of Indonesia. It is also through optimizing existing beach safety functions, preparing zoning for built-up and public beach areas, developing and restoring beaches for ecosystem preservation and tourism purposes, improving monitoring and maintenance systems for coastal areas, and developing and revitalizing beaches [51].

This research also measures disaster vulnerability, as mentioned by Antofie et al. [52], and includes multi-dimensional aspects because it consists of various physical, social, economic, environmental, institutional, and human

factors that directly or indirectly determine vulnerability itself. Parameters that can measure social exposure are population density, number of people of vulnerable age, population growth rate, and population education [8]. According to reference [26], the loss index due to disasters in the environmental aspect can be subdivided into the social and ecological environments. The environmental vulnerability is the area of productive and protected land, the percentage of forest area, the production forest area, and the conservation forest area [8]. The research results show that, in general, disaster vulnerability in East Rembang is in the low category; this is based on the results of all aspects measured using data from 2020 to 2022. The measurement of vulnerability in this research was carried out by Mantika et al. [27]. The study was conducted using secondary or library data as a data source, with the same aspects being measured, namely economic, physical, environmental, and social vulnerability. Apart from that, research results related to disaster vulnerability must also be disseminated to the public, as Farhi [13] has socialized the results of research related to the preparedness index and the level of community vulnerability so that the community has an awareness of the vulnerability of disasters in their surroundings so that the community will try to increase preparedness in facing disasters.

The results indicate that East Rembang possesses seven distinct categories of community capacity for disaster management, showcasing significant variations across different villages. Some villages demonstrate robust capabilities, while others exhibit relatively low capacity. This variability in capability is assessed based on several criteria, including comprehensive disaster management plans (before, during, and after a disaster), the availability of logistics, security measures, educational environment comfort, infrastructure robustness, and emergency systems. These elements are bolstered by the community's knowledge, preparedness, standard operating procedures (SOPs), and early warning systems [53].

In coastal regions, the disaster risk index incorporates components such as disaster threats, vulnerability, and the capacity of the community area [49]. The Community-Based Disaster Preparedness (CBDP) program adopts a participatory and cross-sectoral approach to reduce physical, environmental, health, and socio-economic vulnerabilities to unforeseen events through various mitigation measures [54].

The KBBM program focuses on diminishing the exposure of individuals, families, and communities to the impacts of disasters. It emphasizes providing essential information on disaster management, focusing on disaster preparedness, risk reduction efforts, and emergency response strategies. This initiative strives to lessen the vulnerability of community members to disaster impacts by enhancing their knowledge and preparedness in these critical areas.

Referring to the Head of BNPB Regulation Number 2 of 2012 concerning Preparation of Disaster Risk Studies and the Hyogo Framework for Action agreement, aspects of threat, vulnerability, and capacity greatly influence disaster risk in an area [55]. Disaster risk calculations are urgent and must be carried out as part of disaster management. Sustainable disaster management will depend heavily on ongoing disaster risk assessment. The research results show that the average level of disaster risk in East Rembang is “Very High.” All villages in East Rembang have a risk level in the “Very Very High” to “High” category, and there is only one village that has a vulnerability of “Very Not High.” It is essential to map disaster threats in an area. As per Findayani et al. [24], who mapped flood hazards in Semarang, this mapping helps local communities reduce the impact of disasters that may occur in the future more effectively. Disaster risk mapping is one of the disaster mitigation efforts. For example, Basid et al. [56] have mapped the risk of earthquake disasters in Lombok and Sulawesi. This assessment develops action plans for risk management and reduction strategies [52]. If the disaster risk is known, and the threats, vulnerabilities, and capacities are known, appropriate disaster management strategies can be implemented [12].

Based on the research results, several things can be recommended to the Government, including: 1) Reducing the level of disaster threat in East Rembang by carrying out various activities that can prevent disasters. Among them are structural disaster mitigation, such as development in disaster-prone areas, and non-structural mitigation, such as disaster education for the community through training and socialization, to the development of disaster-resilient villages [57-59]. 2) Reducing vulnerability to disasters, both in social, ecological, economic, and physical vulnerabilities. Among them are improving the community's quality of life through education and training, improving the community's economy through community empowerment, especially women, intensifying Village-Owned Enterprises (BUMD), and increasing the strength of buildings to avoid disasters [60-63]. 3) Increasing community capacity in dealing with disasters. Community capacity in dealing with disasters can be increased, including by empowering the community to increase community preparedness in dealing with disasters, improving the environment such as installing evacuation signs to early warning systems for disasters to be more prepared when disasters occur or forming Disaster Resilient Villages (Destana) [16, 64, 65].

5. CONCLUSION

The disaster threat and vulnerability of villages in East Rembang based on 2020-2022 data on average is low, although several villages have high threat and vulnerability. Even so, the community's capacity to face disasters could be higher. In general, it can be seen that the average level of disaster risk in East Rembang is “Very High”. All villages in East Rembang have a risk level in the “Very Very High” to “High” category, and there is only one village that has a “Very Not High” vulnerability, namely Woro Village.

Several villages have undertaken community efforts to deal with disasters. The first is establishing a Disaster Risk Reduction Forum, which has succeeded in increasing community capacity through disaster outreach through community forums and leaflets posted strategically. Second, the community has been involved in a participatory manner to determine evacuation routes. Third, commit to becoming a Disaster Resilient Village and developing a Disaster PRB. Various structural disaster mitigation activities, such as planting trees and building retaining embankments, and non-structural mitigation, such as disaster education, have been carried out.

This research is useful for the development of disaster science, especially those that occur in coastal areas such as East Rembang. The results of this study will complement various disaster studies in coastal areas that have been conducted previously. Some of the benefits felt by the

community include: 1) Knowing the threats of natural disasters in East Rembang and their vulnerabilities so that they can carry out appropriate disaster mitigation. 2) Knowing the condition of the community, especially related to the capacity and resilience of the community in dealing with disasters. 3) Comparing the level of disaster risk between one village and another in East Rembang. 4) Conducting evaluations so that the capacity of the community in dealing with disasters can be increased. In contrast, the threat and vulnerability of disasters can be minimized as much as possible to gradually decrease the risk of disasters. The local government also feels the benefits: 1) Knowing the disaster risk level from East Rembang villages. 2) Facilitating the decision-making of policies that will be taken related to disaster management efforts that will be carried out in the present and the future. 3) Regional Disaster Management Agency.

REFERENCES

[1] Mardiatno, D., Malawani, M.N., Annisa, D.N., Wacano, D. (2017). Review on tsunami risk reduction in Indonesia based on coastal and settlement typology. The Indonesian Journal of Geography, 49(2): 186-197. https://doi.org/10.22146/ijg.28406

[2] Hamid, N., Setyowati, D.L., Juhadi, J., Priyanto, A.S., Suswanti, S., Royyani, M.A., Aroyandini, E.N. (2021). Sustainable development of the coastal environment through participatory mapping of abrasion-prone areas. Journal of Environmental Management and Tourism, 12(5): 1997-2009. https://doi.org/10.14505/jemt.v12.7(55).24

[3] Bencana, B.N.P. (2021). Indeks risiko bencana Indonesia (IRBI) tahun 2020. Badan Nasional Penanggulangan Bencana.

[4] Bencana, B.N.P. (2023). Indeks risiko bencana Indonesia (IRBI) tahun 2022. Jakarta.

[5] Barandiarán, M., Esquivel, M., Ayuso, S.L., Suarez, G., Zuloaga, D. (2019). Disaster and climate change risk assessment methodology for IDB projects: A technical reference document for IDB project teams. Inter-American Development Bank. https://doi.org/10.18235/0002041

[6] Amarnath, G., Amarasinghe, U.A., Alahacoon, N. (2021). Disaster risk mapping: A desk review of global best practices and evidence for South Asia. Sustainability, 13(22): 12779. https://doi.org/10.3390/su132212779

[7] Rizki Novitasari, A. (2015). Analisis risiko bencana tanah longsor di wilayah pt. perkebunan nusantara XII kebun teh kertowono lumajang (The analysis of landslide disaster risk in area PT. perkebunan nusantara XII tea plantation kertowono lumajang). Repository Universitas Jember.

[8] Widyantoro, I.A., Usman, F. (2021). Perhitungan risiko bencana banjir di Kecamatan Kanor. Planning for Urban Region and Environment Journal, 10(3): 13-22.

[9] Raharjo, A.P. (2019). Disaster risk analysis of forest and land fires in Serang Regency. Jurnal Sains dan Teknologi Mitigasi Bencana, 13(1): 1.

[10] Niode, D.F., Rindengan, Y.D., Karouw, S.D. (2016). Geographical information system (GIS) untuk mitigasi bencana alam banjir di Kota Manado. Jurnal Teknik Elektro dan Komputer, 5(2): 14-20. https://doi.org/10.35793/jtek.v5i2.11646

[11] Hamid, N., Setyowati, D.L., Priyanto, A.S., Hardati, P., Soleh, M., Wijayanti, N.R., Aroyandini, E.N. (2021). The effect of human activities towards coastal dynamics and sustainable coastal management. International Journal of Sustainable Development & Planning, 16(8): 1479-1493. https://doi.org/10.18280/ijsdp.160809

[12] Inan, D.I., Beydoun, G., Othman, S.H. (2023). Risk Assessment and Sustainable Disaster Management. Sustainability, 15(6): 5254. https://doi.org/10.3390/su15065254

[13] Farhi, Z. (2012). Tingkat kerentanan dan indeks kesiapsiagaan masyarakat terhadap bencana tanah longsor di kecamatan bantarkawung kabupaten brebes. Majalah Geografi Indonesia, 26(1): 80-97.

[14] Rembang, B. (2021). Kabupaten Rembang dalam Angka 2021. Kabupaten Rembang.

[15] Juwana, I., Lazuardi, S.V., Herdiansyah, H. (2024). Investigating the factor of water consumption regarding the impact and implementation of water governance in urban areas. International Journal of Environmental Impacts, 7(1): 55-64. https://doi.org/10.18280/ijei.070107

[16] Montesinos-Pedro, E., Domínguez-Ramírez, N., Montejano-Castillo, M. (2022). Flood risk in times of COVID-19, Peñón de los Baños, Venustiano Carranza, Mexico City, Mexico. International Journal of Environmental Impacts, 5(3): 216-226. https://doi.org/10.2495/EI-V5-N3-216-226

[17] Hamid, N. (2015). Kajian kapasitas masyarakat dalam menghadapi ancaman erosi pantai di kecamatan kragan kabupaten rembang. Universitas Gadjah Mada.

[18] Setyowati, D.L., Hardati, P., Benardi, A.I., Hamid, N., Anugrahanto, Y.D. (2021). The role of the disaster preparedness group in adapting abrasion to communities affected by abrasion on the North Coast of Rembang, Central Java. In 6th International Conference on Education & Social Sciences (ICESS 2021), pp. 61-66. https://doi.org/10.2991/assehr.k.210918.012

[19] Creswell, J.W. (2015). Penelitian Kualitatif & Desain Riset. Yogyakarta: Pustaka Pelajar.

[20] Sugiyono, D. (2013). Metode penelitian pendidikan pendekatan kuantitatif, kualitatif dan R&D. Perpustakaan Universitas Gresik

[21] Aminatun, S. (2017). Kajian analisis risiko bencana tanah longsor sebagai dasar dalam pembangunan infrastruktur di desa sriharjo kecamatan imogiri kabupaten bantul. Teknisia, 22(2): 372-382.

[22] Creswell, J.W., Creswell, J.D. (2017). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications.

[23] Yin, R.K. (2015). Qualitative Research from Start to Finish. Guilford Publications.

[24] Findayani, A., Aji, A., Juhadi, M., Indrayati, A. (2019). Semarang city food risk disaster mapping based on geographic information system. In International Conference on Rural Studies in Asia (ICoRSIA 2018), pp. 311-313. https://doi.org/10.2991/icorsia-18.2019.74

[25] Rahmad, R., Suib, S., Nurman, A. (2018). Aplikasi SIG untuk pemetaan tingkat ancaman longsor di kecamatan sibolangit, kabupaten deli serdang, sumatera utara. Majalah Geografi Indonesia, 32(1): 1-13. https://doi.org/10.22146/mgi.31882

[26] Ramadhan, E.C., Chamid, C. (2022). Analisis kerentanan

bencana tsunami di wilayah pesisir Kecamatan Labuan. Jurnal Riset Perencanaan Wilayah dan Kota, 2(1): 59-66. https://doi.org/10.29313/jrpwk.v2i1.929
[27] Mantika, N.J., Hidayati, S.R., Fathurrohmah, S. (2020). Identifikasi Tingkat Kerentanan Bencana di Kabupaten Gunungkidul. Matra, 1: 59-70.
[28] Haryani, H., Aditya, E. (2020). Assessment of beach abration vulnerability levels and directions for space utilization in Central Pariaman District Pariaman City. Sumatra Journal of Disaster, Geography and Geography Education, 4(2): 225-233.
[29] Department for International Development. (2012). Multi-Hazard Disaster Risk Assessment (v2). Department for International Development, London, pp. 1-6.
[30] Edyanto, C.H. (2014). Partisipasi masyarakat sebagai upaya untuk mengurangi risiko bencana tsunami di daerah pantai. Jurnal Sains dan Teknologi Indonesia, 16(3): 26-32.
[31] Ledoh, L., Satria, A., Hidayat, R. (2019). Kerentanan penghidupan masyarakat pesisir perkotaan terhadap variabilitas iklim (studi kasus di Kota Kupang). Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan, 9(3): 758-770. https://doi.org/10.29244/jpsl.9.3.758-770.
[32] Hamid, N. (2020). Kesiapsiagaan masyarakat dalam menghadapi gempa bumi (Mengenang 14 tahun silam gempa bumi bantul, Yogyakarta). Journal of Community Services, 1(2): 81-89. https://doi.org/10.22219/altruis.v1i2.12184
[33] Taslim, I., Akbar, M.F. (2019). Koordinasi publik untuk pengurangan risiko bencana (PRB) banjir pada pelaksanaan pembangunan berkelanjutan gorontalo. Jurnal Wilayah Dan Lingkungan, 7(2): 63-78. https://doi.org/10.14710/jwl.7.2.63-78
[34] Shiwaku, K., Fernandez, G. (2011). Chapter 6 Innovative approaches in disaster education. In: Disaster Education, pp. 115-136. https://doi.org/10.1108/S2040-7262(2011)0000007012
[35] Dufty, N. (2018). A new approach to disaster education. In The International Emergency Management Society (TIEMS) Annual Conference, Manila, Philippines, pp. 13-16.
[36] Lee, J., Lee, E. (2020). The effects of disaster training education on the attitudes, preparedness, and competencies in disaster nursing of hospital nurses. Journal of Korean Academy of Community Health Nursing, 31(4): 491-502. https://doi.org/10.12799/jkachn.2020.31.4.491
[37] Shaw, R., Takeuchi, Y., Ru Gwee, Q., Shiwaku, K. (2011). Chapter 1 Disaster education: An introduction. In: Disaster Education, pp. 1-22. https://doi.org/10.1108/S2040-7262(2011)0000007007
[38] Paschalia, Y.P.M., Doondori, A.K., Sekunda, M.S., Budiana, I. (2022). Revitalization of disaster mitigation management and community empowerment through community-based disaster risk reduction (CBDRR). Jurnal Penelitian Pendidikan IPA, 8(5): 2563-2574. https://doi.org/10.29303/jppipa.v8i5.2368
[39] Tamuntuan, G., Pasau, G., Takumansang, E. (2019). Peningkatan Kapasitas Masyarakat Untuk Kesiap-siagaan dan Mitigasi Bencana Tsunami di Desa Borgo Kabupaten Minahasa. VIVABIO: Jurnal Pengabdian Multidisiplin, 1(3): 1-7. https://doi.org/10.35799/vivabio.1.3.2019.25442
[40] Tiernan, A., Drennan, L., Nalau, J., Onyango, E., Morrissey, L., Mackey, B. (2019). A review of themes in disaster resilience literature and international practice since 2012. Policy Design and Practice, 2(1): 53-74. https://doi.org/10.1080/25741292.2018.1507240
[41] Annisa, A., Setyowati, D.L. (2019). Community capacity in landslide disaster risk reduction. Edu Geography, 7(1): 83-94. https://journal.unnes.ac.id/sju/index.php/edugeo/article/view/30138/13293.
[42] Yashiro, H., Hayashin, T. (2021). Analysis on impact of compact city progress on seismic risk fluctuation. International Journal of Environmental Impacts, 4(1): 25-35. https://doi.org/10.2495/EI-V4-N1-25-35
[43] Mei, E.T.W., Putri, R.F., Sadali, M.I., et al. (2020). Building volcanic disaster resilience community through school and education. IOP Conference Series: Earth and Environmental Science, 451(1): 012014. https://doi.org/10.1088/1755-1315/451/1/012014
[44] Abas, M.A., Ibrahim, N.E., Wee, S.T., Sibly, S., Mohamed, S. (2020). Disaster resilience education (DRE) programmes in schools: A case study in Kelantan, Malaysia. IOP Conference Series: Earth and Environmental Science, 549(1): 012078. https://doi.org/10.1088/1755-1315/549/1/012078
[45] Najib, A., Rahmat, H.K. (2021). Analisis pelaksanaan program desa tangguh bencana di Desa Buluh Cina, Siak Hulu, Kampar, Riau. Jurnal Ilmiah Muqoddimah: Jurnal Ilmu Sosial, Politik, dan Humaniora, 5(1): 14-23. https://doi.org/10.31604/jim.v5i1.2021.14-23
[46] Mei, E.T.W., Rachmawati, R. (2016). Participatory planning for evacuation routes and meeting points in ngargomulyo village as a disaster risk reduction effort of mount merapi. Journal of Regional and City Planning, 27(1): 34-48. https://doi.org/10.5614/jrcp.2016.27.1.4
[47] Julius, A.M., Widyaningrum, N., Najib, A., et al. (2020). Implementasi Program Desa Tangguh Bencana di Desa Gunung Geulis, Sukaraja, Bogor. Jurnal Swabumi, 8(1): 1-10.
[48] Sarwidi, Wantoro, D., Suharjo, D. (2013). Evaluasi sekolah siaga bencana (Studi kasus: smkn berbah kabupaten sleman, Yogyakarta). Prosiding Seminar Nasional 2013 Menuju Masyarakat Madani Dan Lestari Universitas Islam Indonesia, Yogyakarta.
[49] Firdaus, F., Chaerul, M., Gusty, S. (2022). Analisis pengurangan risiko bencana abrasi pantai di kecamatan galesong utara kabupaten takalar. Syntax Literate; Jurnal Ilmiah Indonesia, 7(4): 3965-3977. https://doi.org/10.36418/syntax-literate.v7i4.6726
[50] Huda, A.C., Pratikto, I., Pribadi, R. (2019). Karakteristik lahan terhadap kerentanan pesisir pantai Kabupaten Rembang, Jawa Tengah. Journal of Marine Research, 8(3): 253-261. https://doi.org/10.14710/jmr.v8i3.25268
[51] Indonesia, Pemerintah Pusat. (2015). Peraturan Presiden (Perpres) Nomor 2 Tahun 2015 tentang Rencana Pembangunan Jangka Menengah Nasional Tahun 2015 - 2019.
[52] Antofie, T.E., Doherty, B., Marin-Ferrer, M. (2018). Mapping of risk web-platforms and risk data: Collection of good practices. Publications Office of the European Union.
[53] Zahro, Z.R., Andriningrum, H., Sari, E.P., Gunawan, I. (2017). Sekolah siaga bencana: Kajian evaluatif kesiapsiagaan sekolah menghadapi bencana. In Seminar

Nasional Pendidikan Sinergitas Keluarga, Sekolah, dan Masyarakat dalam Penguatan Pendidikan Karakter, Fakultas Ilmu Pendidikan Universitas Negeri Malang, Malang, Indonesia, pp. 511-519.
[54] Rozikin, M. (2018). Pembentukan perda penyelenggaraan penanggulangan bencana daerah berbasis partisipasi masyarakat (Studi proses pembentukan peraturan daerah tentang penyelenggaraan penanggulangan bencana pada DPRD kabaputen rembang, Jawa Tengah). Maksigama, 12(2): 129-144.
[55] BNPB. (2014). Berita Negara Republik Indonesia. https://www.bnpb.go.id/storage/app/media/uploads/24/peraturan-kepala/2012/perka-4-tahun-2012.pdf.
[56] Basid, A., Mahardika, I. K., Subchan, W., Astutik, S. (2021). Mapping risk levels of earthquake damage as disaster mitigation efforts: Case studies in West Java, Central Sulawesi and Lombok. AIP Conference Proceedings, 2320(1): 040007. https://doi.org/10.1063/5.0037540
[57] Hamid, N., Trihatmoko, E., Herlina, M., Aroyandini, E.N. (2021). Developing a model for disaster education to improve students' disaster mitigation literacy. Journal of disaster research, 16(8): 1243-1256. https://doi.org/10.20965/jdr.2021.p1243
[58] Ruslanjari, D., Dewi, T.P., Puspitasari, A.E. (2019). Non-structural mitigation through media literacy on cyclone disaster in west muna regency. The 10th International Graduate Students and Scholars' Conference (IGSSCI), Indonesia, pp.146-165. https://doi.org/10.18502/kss.v3i20.4933
[59] Wahyuningsih, D.S., Maulana, E., Wulan, T.R., Ambarwulan, W., Putra, M.D., Ibrahim, F., Setyaningsih, Z., Putra, A.S. (2012). Effectiveness of ecosystem-based abrasion mitigation efforts in Kulonprogo regency, special region of Yogyakarta (in Indonesian). In Proceedings of the National Marine Seminar, pp. 255-260.
[60] Endah, K. (2020). Pemberdayaan masyarakat: Menggali potensi lokal desa. Moderat: Jurnal Ilmiah Ilmu Pemerintahan, 6(1): 135-143. https://doi.org/10.25157/moderat.v6i1.3319
[61] Lestary, R.A., Hadi, K., Romadhan, A.A. (2022). Implementasi program desa berdaya melalui economic branding pada dinas pemberdayaan masyarakat dan desa kabupaten lamongan. Jurnal Ilmu Administrasi Negara ASIAN (Asosiasi Ilmuwan Administrasi Negara), 10(1): 340-352. https://doi.org/10.47828/jianaasian.v10i1.82
[62] Susilawati, S. (2019). Pemberdayaan perempuan di kampung damai: Studi pendampingan komunitas oleh wahid foundation di gemlegan klaten. Jurnal Pemberdayaan Masyarakat: Media Pemikiran dan Dakwah Pembangunan, 2(2): 425-446. https://doi.org/10.14421/jpm.2018.022-10
[63] Sakdiah, H., Muin, I., Ritonga, M.H. (2020). Peran Badan Usaha Mili Desa Dalam Memberdayakan Masyarakat Desa Liberia Kecamatan Teluk Mengkudu Kabupaten Serdang Bedagai. Jurnal Pemberdayaan Masyarakat, 6(2), 27. https://doi.org/10.37064/jpm.v6i2.6897
[64] Arini, D., Priyantini, D., Yuliastuti, C., Harfika, M., Farida, I. (2018). Mewujudkan Desa Tangguh Bencana diKelurahan Kedung Cowek Surabaya. Jurnal Pengabdian Kesehatan, 1(2): 109-121. https://doi.org/10.31596/jpk.v1i2.17
[65] Pancasilawan, R., Utami, S.B., Sumaryana, A., Ismanto, S.U., Rosmalasari, D. (2020). Mitigation of disaster risk reduction in Pangandaran Regency. Sosiohumaniora, 22(2): 214-222. https://doi.org/10.24198/sosiohumaniora.v22i2.25792