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District Clustering in Malang City Based on Natural Disaster Vulnerability: Basic Polity Formulation in Disaster Management

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Abstract

The primary objective of this study is to assess the vulnerability to natural disasters in various sub-districts within Malang City, utilizing secondary data from the Central Statistics Agency (BPS). Additionally, it seeks to recognize and analyze distinct vulnerability patterns within each sub-district and establish a more effective disaster management policy framework tailored to the specific vulnerability characteristics of each sub-district cluster. The research employed cluster analysis to categorize sub-districts with comparable vulnerability characteristics. As a result, two distinct clusters emerged: Cluster 1 comprising the Sukun and Blimbing sub-districts, characterized by a higher vulnerability rate, and Cluster 2 encompassing the Kedungkandang, Klojen, and Lowokwaru sub-districts, which exhibit a lower vulnerability rate. This shows a significant difference in vulnerability to natural disasters between sub-districts in Malang City. This research approach is expected to provide a deeper understanding of disaster vulnerability in each sub-district to help formulate more effective disaster management policies on the characteristics of vulnerability in each sub-district cluster.

Keyword: *Clustering; Disaster Management*; *Vulnerability*

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1. Introduction

Indonesia is a country prone to natural disasters such as floods, landslides, earthquakes, tsunamis, and volcanic eruptions. Some of the biggest natural disasters in Indonesia have even killed most of the earth's population. Parts of Indonesia, including Malang City, are prone to wet hydrometeorological disasters such as floods due to heavy rainfall. Natural disasters have a huge impact on humans and the natural environment.

According to Law No. 24 of 2007 concerning Disaster Management, natural disasters are disasters caused by events or series of events caused by nature, including earthquakes, tsunamis, erupting mountains, floods, droughts, typhoons, and landslides, droughts, forest/land fires due to natural factors, pests of plant diseases, epidemics, plagues, extraordinary events, and space events/celestial bodies.

To reduce the risk of natural disasters in Malang City, it is necessary to map sub-districts based on the level of vulnerability to natural disasters. The research involved several factors, including land area, number of disasters, disaster mitigation facilities, and education and health facilities. The study employed data analysis techniques, such as descriptive statistics and cluster analysis, to categorize sub-districts with comparable traits. These cluster analysis findings serve as a foundation to formulate more efficient disaster management policies tailored to the specific vulnerabilities within each sub-district cluster.

Comparable research has been undertaken in various regions of Indonesia, such as Lampung, Bengkulu, and Makassar (Riani et al., 2020; Sahib et al., 2018; Nessa et al., 2016). These studies employed similar methodologies to map and pinpoint regions at risk of natural disasters. Identifying these vulnerable areas enables authorities to give priority to disaster relief efforts and allocate resources with greater efficiency. Furthermore, cluster analysis can assist in recognizing common vulnerability patterns among sub-districts, serving as a foundation for the formulation of more comprehensive disaster management policies.

Nojavan et al. (2018) emphasized the necessity for enhanced monitoring and evaluation systems in disaster risk management programs. ng and Kamarudin Chong & Kamarudin (2018) highlighted the significance of well-coordinated efforts among agencies and stakeholders to improve disaster risk reduction, preparedness, and response. Cho (2024) identified several challenges in disaster risk management systems at national and local government levels, including issues with laws, budgets, coordination, and response measures.

Furthermore, Bosher et al. (2021) discussed the evolution of disaster management phases and outlined the key actions required during disasters. Kunguma et al. (2021) focused on the role of risk communication in disaster risk management, particularly in the context of the COVID-19 pandemic. Raillani et al. (2020) provided a comprehensive definition of disaster risk management, emphasizing its holistic approach before, during, and after disasters. Rijal et al. (2020) outlined priority actions for disaster risk reduction and management, including enhancing disaster preparedness and resilience.

The results of this research can serve as a foundation for crafting improved disaster management strategies that are customized to suit the unique features of specific district clusters. By pinpointing the regions most susceptible to natural calamities, decision-makers can give higher importance to disaster relief initiatives and distribute resources more efficiently. Additionally, the analysis of groupings can reveal shared vulnerability trends among districts, offering valuable insights for creating more all-encompassing disaster management policies.

The primary goal of this research is to assess the susceptibility of various districts within Malang City to natural disasters. This study aims to uncover distinct vulnerability patterns in each district and develop a basis for more effective disaster management policies tailored to the characteristics of each district cluster. Comparable research has been conducted in other regions of Indonesia, offering valuable insight into the methods employed and the discoveries made in this study. Ultimately, the outcomes of this research can be harnessed to formulate more efficient disaster management policies that are customized to the specific characteristics of each district cluster.

2. Literature Review

Definition and Concept of Disaster Vulnerability

Disaster vulnerability is the measure of how susceptible a population or area is to negative impacts caused by natural or human-made disasters (Surjan et al., 2016). It encompasses a range of elements, including physical, social, economic, and environmental factors, all of which contribute to the overall risk and resilience of a particular region. Effective disaster management policies play a crucial role in reducing the consequences of disasters and enhancing the resilience of communities (Alshehri et al., 2015). These policies encompass comprehensive planning, preparedness, response, and recovery strategies, aiming to mitigate the consequences of disasters and promote sustainable development.

Understanding vulnerability is crucial for disaster risk reduction and climate change adaptation efforts as it sheds light on the causes and triggers of disasters (Malakar & Bhandari, 2012). Acknowledging and comprehending organizational vulnerability is a fundamental step toward enhancing risk management effectiveness, fostering resilience, and ensuring sustainable success in an evolving disaster landscape (Chipangura, 2024). The concept of vulnerability also plays a significant role in shaping market and policy responses to disasters, highlighting the importance of addressing human vulnerability to mitigate and recover from natural hazards effectively (Baker, 2009).

Moreover, vulnerability is intertwined with resilience, with both concepts being essential in disaster risk reduction and climate change adaptation research (Jamshed et al., 2020). Resilience and vulnerability are key components in understanding and minimizing disaster risks, emphasizing the need to consider long-term social processes that contribute to vulnerability before, during, and after disasters (Yamori & Goltz, 2021). The concept of vulnerability provides a comprehensive framework for assessing the differences in damage incurred from natural hazards at various levels, from individuals to entire regions (Fekete et al., 2014).

The process of evaluating disaster vulnerability offers a structured approach to identifying and comprehending the elements that contribute to a region's or population's vulnerability (Lizarralde et al., 2015). This approach empowers policymakers and practitioners to prioritize resource allocation, design targeted interventions, and create evidence-based policies tailored to address specific vulnerabilities.

Key Variables in Disaster Vulnerability Evaluation

1. Land
   The size of the land plays a crucial role in determining how susceptible a region is to natural disasters (Chen et al., 2013). Regions with restricted land resources are generally at a higher risk of experiencing disasters, particularly when they have a dense population and significant human activities occurring within their boundaries. The constraints of limited land can lead to environmental challenges, including heightened urbanization, alterations in land use, and a shortage of green open spaces.
2. Number of Disasters
   The history of disasters in a particular area, including how often they occur and how severe they have been, serves as a crucial gauge for assessing that region's susceptibility to future occurrences (Cutter et al., 2003). This factor assists in pinpointing areas that have previously endured numerous disasters and are at a heightened risk of encountering comparable challenges in the times ahead.
3. Disaster Mitigation Facility
   Disaster mitigation facilities, including disaster early warning systems, safety equipment, evacuation signage, and routes, as well as the construction and upkeep of infrastructure, constitute crucial elements influencing the susceptibility to natural

disasters within a given area (BPS, 2023). An efficient disaster early warning system can swiftly alert the community to take necessary preventive and evacuation actions. Sufficient safety equipment can diminish the likelihood of injuries and loss of life. Clear and well-marked evacuation signs and routes facilitate easy access and guide individuals during evacuation procedures. Furthermore, the establishment and maintenance of robust facilities play a pivotal role in minimizing the impact of disasters such as floods and landslides. The presence of adequate disaster mitigation facilities can notably decrease the region's vulnerability to natural disasters.

4. Education Infrastructure
   Assessing a sub-district's susceptibility to natural disasters hinges significantly on its educational infrastructure (Siagian et al., 2014). This factor encompasses various elements such as the presence and standard of educational facilities, ease of school access, and the education system's ability to handle emergencies (Islam et al., 2018). Having robust educational infrastructure plays a pivotal role in diminishing community vulnerability to natural disasters. It achieves this by raising risk awareness and preparedness levels, thereby contributing to enhanced disaster resilience.
5. Health Infrastructure
   The assessment of vulnerability to disasters also takes into account the state of healthcare infrastructure (Huq et al., 2020). This aspect encompasses various factors such as the presence of healthcare facilities, the availability of medical professionals and medications, and the ease of accessing healthcare services within the sub-district (Redwood-Campbell et al., 2018). Having a robust healthcare infrastructure and convenient access can play a crucial role in mitigating health-related risks during disasters and expediting the recovery process that follows.

Cluster Analysis (Grouping)

Cluster analysis is a multiple-variable technique that has the main purpose of grouping objects based on their similar characteristics (Hair et al., 2014). The characteristics of objects in a group have a high level of similarity, while the characteristics of objects in a group with other groups have a low level of similarity (Mattjik and Sumertajaya, 2011). According to Hardle and Simar (2007), cluster analysis can be divided into two fundamental steps, namely as follows.

1. Choice of proximity size
   The measure of proximity is checked from each observation pair (object) for the similarity of values. A measure of similarity is defined as to measure of the proximity of objects. The closer the objects are to each other, the more homogeneous they are.
2. The choice of group-building algorithm
   Based on proximity measure objects are assigned to groups so that differences between groups become large and observations within groups become as close as possible.

The cluster formation procedure is divided into 2, namely hierarchical and non-hierarchical. The formation of hierarchical clusters has the nature of developing a hierarchy or branching tree-like structure. Hierarchical methods can be agglomerative or divisive. Agglomerative methods consist of linkage methods, variance methods, and centroid methods. The linkage method consists of single linkage, complete linkage, and average linkage (Supranto, 2004).

3. Research Methods

This research was conducted with a quantitative approach using secondary data from BPS as a data source. The data was obtained from a BPS publication entitled "Malang City in 2023 Figures". The data used in this study include land area, number of disasters, disaster mitigation facilities, and education and health facilities as variables to be analyzed. The methods used in this study are descriptive methods and cluster analysis.

At the data analysis stage, the identification of variable characteristics and sub-districts in Malang City was carried out using descriptive statistics. Then, cluster analysis was carried out to group sub-districts that have similar characteristics. The grouping of sub-districts is carried out based on predetermined variables. The results of cluster analysis are used as a basis for formulating disaster management policies that are more effective and by the characteristics of vulnerability in each sub-district cluster.

Similar research has been conducted in several regions of Indonesia, such as Lampung, Bengkulu, and Makassar. The study used similar methods to map and identify areas vulnerable to natural disasters. In Rozi Wahyudi's (2016) research on disaster mitigation in Bengkulu Province, researchers used qualitative methods to collect secondary data on the location and impact of disasters. Meanwhile, in Maria Dewi Sulistyawati's (2018) research on disaster vulnerability mapping in Lampung Province, researchers used cluster analysis methods to group areas that have similar characteristics.

4. Results and Discussion

1. Cluster Validation

Before conducting a Cluster analysis it is necessary to calculate the distance. The calculation of distance in this study uses the Euclidian distance formula. Distance calculations are used to determine groupings, where the results of distances that are close to each other will form a certain group. To determine the optimal number of clusters, the silhouette method is used.

The Silhouette Index measures how closely similar objects in a cluster are, which also indicates how precisely objects have been grouped, so the greater the Silhouette Index value, the more similar the objects in a cluster. The Silhouette Index value ranges from -1 to 1 so the closer to 1, the number of clusters is the most optimal. Based on the graph above, cluster validation using the Silhouette Index is known that the optimal number of clusters in this study is as many as 2 clusters because it has the largest Silhouette Index value.

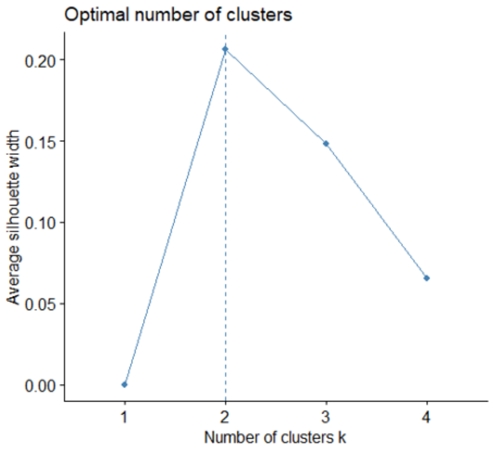

Figure 1. Optimized Clusters

2. Dendrogram

The next stage is to conduct a Cluster analysis using the Ward linkage method. Here is the output of the dendrogram. Dendogram clusters are projected using R software as shown below. Dendrograms are used to see the clusters formed and the members within each cluster.

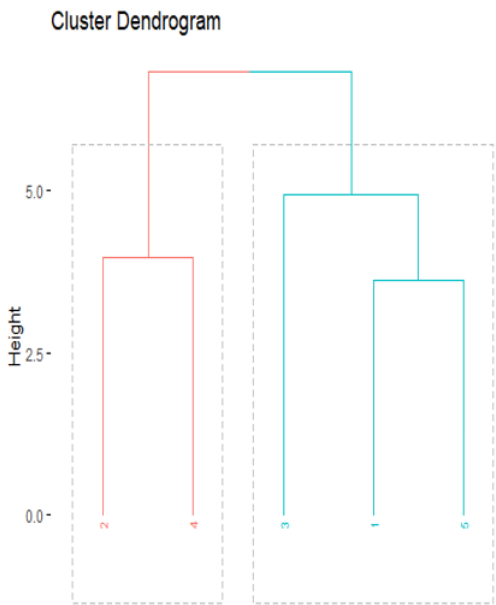

Figure 2. Dendrogram

From the dendrogram, 2 clusters with significantly different groupings were obtained. The results of grouping potential areas and socio-economic supporting infrastructure in Malang City by sub-district using the ward method cluster analysis that has been carried out in 2 clusters with each cluster consisting of sub-districts as shown in Table 1 below.

Table 1. Cluster Table

Cluster	**Member**
1	Sukun, Blimbing
2	Kedungkandang, Klojen, Lowokwaru

Based on Table 2, it can be seen that cluster 1 consists of 2 members, namely Sukun and Blimbing sub-districts. As for cluster 2, there are 3 districts, namely Kedungkandang, Klojen, and Lowokwaru. The cluster profile table below explains which clusters provide the best results, both for each variable and as a whole.

Table 2. Cluster Profile

X	Information	Cluster 1	Cluster 2
X1	Broad	19.37	23.77
X2	Landslide	29	10.33
X3	Extreme Weather	7.5	9.33
X4	Flood	22.5	17.67
X5	Earthquake	1	1
X6	Disaster Early Warning System	0.5	2.67
X7	Fitting Salvation	1	2.67
X8	Evacuation Signs & Routes	2	5.67
X9	Facility Creation & Maintenance	8	7
X10	SD	66.67	6
X11	SMP	23.5	32.67
X12	SMA	19	29
X13	Health	22	23

Table 3 is obtained from the results of calculating the average of each variable for the two clusters. Based on the calculation results, it was found that cluster 1 had a greater number of natural disasters except for extreme weather. Then the disaster mitigation system in Cluster 1 is slightly less when compared to Cluster 2. Cluster 1 also has fewer education and health facilities. In Cluster 2, it was found that there were fewer natural disasters than in Cluster 1, as well as facilities in disaster mitigation, Disaster Early Warning Systems, Safety Equipment, Signs & Evacuation Routes, Facility Manufacture & Maintenance, which were more adequate than in Cluster 1. For education and health facilities, better results were also obtained than cluster 1.

Discussion

In this study, the examination of variables can be categorized into three primary groups, namely the frequency of natural disasters, disaster prevention infrastructure, and educational and healthcare facilities.

1) Natural Disasters

   Table 3 demonstrates that Cluster 1 exhibits a greater occurrence of natural disasters in comparison to Cluster 2, except for extreme weather events. This suggests that regions falling under Cluster 1 encounter a more frequent occurrence of natural disasters than those falling under Cluster 2. Nonetheless, a more in-depth examination of the specific types of natural disasters in each cluster is required to enhance a deeper understanding.

2) Disaster Mitigation System

   The analysis of the calculations reveals that Cluster 2 boasts a superior disaster mitigation system in contrast to Cluster 1. This inference is drawn from the examination of the quantity of disaster mitigation facilities within both clusters. Specifically, Cluster 2 outperformed Cluster 1 in terms of safety equipment and early warning systems for disasters, suggesting that Cluster 2 possesses more robust facilities and infrastructure for managing natural disasters. To gain a deeper understanding of the elements influencing the efficacy of safety equipment and early warning systems within each cluster, additional research is imperative. Consequently, it becomes essential to delve into the determinants behind these disparities, such as resource allocation and the disaster mitigation policies adopted within each cluster.

3) Education and Health Facilities
Cluster 1 has a lower number of education and health facilities in comparison to Cluster 2. This indicates an evident disparity in the accessibility of education and health resources between these two clusters. Cluster 2 exhibits superior outcomes concerning education and health facilities when compared to Cluster 1. It is valuable to delve deeper into the factors contributing to these disparities, including budget allocation and the accessibility levels of these facilities in each cluster.

In summary, the analysis presented in Table 3 underscores significant distinctions between the two clusters concerning various factors, including the number of natural disasters, disaster mitigation systems, education and health facilities, safety equipment, and disaster early warning systems. These findings can form the basis for developing strategies and policies that are more effective in dealing with and reducing the impact of natural disasters in both clusters. More details are outlined in the discussion for each of the following clusters.

Cluster 1: Sukun and Blimbing sub-districts

Cluster 1 has a higher number of natural disasters except for extreme weather. This shows that areas included in cluster 1 tend to experience a high frequency of natural disasters. In addition, cluster 1 also has few facilities in disaster mitigation compared to Cluster 2. There is also a shortage of education and health facilities in Cluster 1.
Recommendations for Disaster Management:

1) Mitigation System Improvement: It is necessary to improve the disaster mitigation system in cluster 1. This can include capacity building for disaster management, training for disaster officials, and improving the accessibility and availability of disaster mitigation facilities.
2) Improvement of Education and Health Facilities: Improvement of education and health facilities within cluster 1 is required. The construction or recovery of education and health facilities damaged by disasters needs to be a priority. In addition, it is also important to ensure the accessibility of these facilities for communities in Cluster 1.
3) Early Warning System Development: It is necessary to develop a more effective and integrated early warning system in cluster 1. An adequate early warning system can help communities and disaster officials take quick and appropriate action in dealing with the threat of natural disasters.

Cluster 2: Kedungkandang District, Klojen, Lowokwaru

Cluster 2 has a smaller number of natural disasters compared to Cluster 1. The cluster also has better disaster mitigation facilities, including safety equipment, early warning systems, evacuation equipment, and facility maintenance. In addition, cluster 2 also has better education and health facilities compared to Cluster 1.
Recommendations for Disaster Management:

1) Facility Maintenance and Improvement: Although cluster 2 has good disaster mitigation facilities, it is still necessary to maintain and upgrade these facilities. This can include maintenance and updating of safety equipment, maintenance of early warning systems, improvement of evacuation infrastructure, and maintenance of disaster mitigation facilities.

Dissemination of Knowledge and Public Awareness: It is important to continue to increase public knowledge and awareness in cluster 2 regarding natural disasters and mitigation actions that can be taken. Counseling and training programs can help communities to recognize signs of disaster, take preventive action, and respond appropriately to disasters

5. Conclusion

Based on the results of the cluster analysis, it can be concluded that there are significant differences between the two clusters observed in terms of natural disaster characteristics, disaster mitigation systems, education, and health facilities, as well as safety equipment and disaster early warning systems. Cluster 1 has a higher number of natural disasters except for extreme weather, as well as inadequate disaster mitigation facilities, education, and health facilities compared to Cluster 2. Meanwhile, cluster 2 showed better results in all observed aspects.

Based on these findings, several suggestions are needed to improve disaster management in both clusters: 1) Improved Disaster Mitigation: Cluster 1 needs to improve disaster mitigation efforts by increasing disaster management capacity, adequate budget allocation, and updating mitigation facilities. Meanwhile, cluster 2 can maintain and improve existing mitigation infrastructure with regular maintenance and increased capacity of disaster workers; 2) Infrastructure Development: Cluster 1 needs to improve education and health facilities to ensure better access for communities. Cluster 2 can also examine the possibility of expanding existing education and health facilities to accommodate population growth and ensure adequate services. In addition, both clusters need to improve early warning systems and public awareness of the threat of natural disasters. Dissemination of knowledge about disasters and active participation of communities in disaster planning and preparation will be critical in reducing the impact of disasters and increasing overall community resilience.

6. References

Alshehri, S. A., Rezgui, Y., & Li, H. (2015). Delphi-based consensus study into a framework of community resilience to disaster. *Natural Hazards*, *75*, 2221-2245.

Bosher, L., Chmutina, K., & Niekerk, D. (2021). Stop going around in circles: towards a reconceptualization of disaster risk management phases. Disaster Prevention and Management an International Journal, 30(4/5), 525-537. https://doi.org/10.1108/dpm-03-2021-0071

Baker, S. (2009). Vulnerability and resilience in natural disasters: a marketing and public policy perspective. Journal of Public Policy & Marketing, 28(1), 114-123. https://doi.org/10.1509/jppm.28.1.114

Chen, W., Cutter, S. L., Emrich, C. T., & Shi, P. (2013). Measuring social vulnerability to natural hazards in the Yangtze River Delta region, China. *International Journal of Disaster Risk Science*, *4*, 169-181.

Chong, N. and Kamarudin, K. (2018). Disaster risk management in malaysia: issues and challenges from the persepctive of agencies. Planning Malaysia, 16(5). https://doi.org/10.21837/pmjournal.v16.i5.415

Cho, H. (2024). Analyzing vulnerabilities of disaster risk management systems of local governments in south korea: evidence from national audit office reports. Systems, 12(3), 76. https://doi.org/10.3390/systems12030076

Chipangura, P. (2024). Organisational vulnerability: exploring the pathways. Disaster Prevention and Management an International Journal, 33(6), 16-29. https://doi.org/10.1108/dpm-03-2024-0065

Fekete, A., Hufschmidt, G., & Kruse, S. (2014). Benefits and challenges of resilience and vulnerability for disaster risk management. International Journal of Disaster Risk Science, 5(1), 3-20. https://doi.org/10.1007/s13753-014-0008-3

Hair, J.F., Black, W.C., Babin, B.J., dan Anderson, R.E. 2014. *Multivariate Data Analysis.*Upper Saddle River, NJ: Prentice Hall.

Hardle, W. Dan Simar, L. 2007. *Applied Multivariate Statistical Analysis.* Berlin: Springer.

Huq, M. E., Shoeb, A. Z. M., Hossain, M. A., Fahad, S., Kamruzzaman, M. M., Javed, A.,... & Sarven, M. S. (2020). Measuring vulnerability to environmental hazards: qualitative to quantitative. *Environment, climate, plant and vegetation growth*, 421-452.

Jamshed, A., Birkmann, J., Feldmeyer, D., & Rana, I. (2020). A conceptual framework to understand the dynamics of rural–urban linkages for rural flood vulnerability. Sustainability, 12(7), 2894. https://doi.org/10.3390/su12072894

Kunguma, O., Mokhele, M., & Coetzee, M. (2021). Investigating the prevention and mitigatory role of risk communication in the covid-19 pandemic: a case study of bloemfontein, south africa. Jàmbá Journal of Disaster Risk Studies, 13(1). https://doi.org/10.4102/jamba.v13i1.1130

Lizarralde, G., Valladares, A., Olivera, A., Bornstein, L., Gould, K., & Barenstein, J. D. (2015). A systems approach to resilience in the built environment: the case of Cuba. *Disasters*, *39*(s1), s76-s95.

Mattjik, A.A. dan Sumertajaya, I.M. 2011. *Sidik Peubah Ganda dengan Menggunakan SAS*. Bogor: IPB Press

Malakar, Y. and Bhandari, D. (2012). Six steps to a quick hazards assessment at village level: a participatory assessment approach applied in nawalparasi district, nepal. Risk Hazards & Crisis in Public Policy, 3(1), 1-19. https://doi.org/10.1515/1944-4079.1099

Nessa, A., Usman, M., & Putra, R. (2016). Analisis Kerentanan Banjir di Kota Makassar dengan Pendekatan Multikriteria*. Jurnal Penelitian Sains, 19*(1), 21-28.

Nojavan, M., Salehi, E., & Omidvar, B. (2018). Conceptual change of disaster management models: a thematic analysis. Jàmbá Journal of Disaster Risk Studies, 10(1). https://doi.org/10.4102/jamba.v10i1.451

Riani, E., Oktari, R., & Yanti, M. (2020). Pemetaan Wilayah Rawan Bencana Longsor Menggunakan Metode Composite Index di Kabupaten Lampung Selatan. *Jurnal Rekayasa Sipil dan Desain, 8*(1), 1-8.

Raillani, H., Hammadi, L., Samed, M., Ballouti, A., & Barbu, V. (2020). Humanitarian logistics in the disaster relief supply chain: state of the art.. https://doi.org/10.2495/risk200161

Rijal, S., Adhikari, S., & Shrestha, A. (2020). Guiding documents for disaster risk reduction and management in health care system of nepal. Journal of Nepal Medical Association, 58(230). https://doi.org/10.31729/jnma.5041

Sahib, N. H., Putra, S. T., & Hatta, M. (2018). Pemetaan Tingkat Kerentanan Banjir di Kota Bengkulu. *Jurnal Pengembangan Kota, 6*(2), 94-102.

Siagian, T. H., Purhadi, P., Suhartono, S., & Ritonga, H. (2014). Social vulnerability to natural hazards in Indonesia: Driving factors and policy implications. *Natural hazards*, *70*, 1603-1617.

Supranto, J. 2004. Analisis Multivariat Arti dan Interpretasi. Jakarta: PT. Rineka Cipta.

Surjan, A., Kudo, S., & Uitto, J. I. (2016). Risk and vulnerability. *Sustainable development and disaster risk reduction*, 37-55.

Watson, R. (2015). Quantitative research. *Nursing Standard*, *29*(31), 44–48. https://doi.org/10.7748/ns.29.31.44.e8681

Yamori, K. and Goltz, J. (2021). Disasters without borders: the coronavirus pandemic, global climate change and the ascendancy of gradual onset disasters. International Journal of Environmental Research and Public Health, 18(6), 3299. https://doi.org/10.3390/ijerph18063299