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Prioritizing flood mitigation in villages affected by the Palasari dam break using TOPSIS

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ABSTRACT

Dam collapse is a disaster that has the potential to have a significant impact on communities in downstream areas. This study aims to determine priorities for handling villages affected by flooding due to the collapse of the Palasari Dam in Jembrana Regency, Bali, using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. The data used was obtained from the results of hazard classification analysis based on InaSAFE software which includes four main parameters, namely the area of inundation, length of affected roads, number of affected buildings and number of affected populations. Each parameter is grouped by village and given a weight based on the principle of disaster vulnerability by placing life safety as the main priority. The results of the analysis show that the villages of Nusasari, Candikusuma, and Tuwed are the villages with the highest treatment priority, each with a preference value of 0.760; 0.605; and 0.524. The TOPSIS method has proven effective in combining spatially based quantitative data to support objective and systematic disaster mitigation decision making. This research also provides a basis for preparing a more adaptive Emergency Action Plan (EAP).

Keywords: dams; floods; TOPSIS; priority management; disaster mitigation

1 Introduction

In Indonesia as a country with many large dams, has various vital infrastructure that supports food security and water resource management. One of the large dams in Indonesia is the Palasari Dam which is located in Bali and functions to supply irrigation water for 800 ha of rice fields. As a strategic dam, Palasari has a capacity of 10.37 million m^3 and have an important role in supporting the agricultural sector in Bali. However, like other large infrastructure the Palasari Dam is not free from potential disaster risks especially collapses which can cause major flooding in downstream areas, damage infrastructure and endanger life safety [1].

The risk of dam collapse is increasing due to climate change, which causes extreme fluctuations in rainfall, both in the form of long droughts and sudden high rainfall. Sudden excess water volume can put great pressure on the dam structure, increasing the possibility of collapse and triggering flood disasters [2], [3], [4]. Several dam failure events have occurred in Indonesia, such as the Situ Gintung tragedy in 2009. This incident resulted in large losses both in terms of casualties and infrastructure damage [5], [6], [7]. Therefore, disaster risk analysis due to dam collapse is an important part in preparing emergency action plan documents and disaster mitigation strategies. The Emergency Action Plan (EAP) is a document needed to deal with the risk of this dam collapsing. Evacuation plans and flood inundation mapping are the main elements in the development of EAP, which aims to reduce losses and minimize the impact of disasters on residents and infrastructure [8].

Determining priorities for handling villages affected by flooding due to dam collapses requires a systematic approach to ensure appropriate resource allocation and response. One method that can be used for this is TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). In this kind of multi-criteria decision making, the TOPSIS method was chosen because of its ability to process quantitative data objectively without intervention from subjective judgment [9], [10]. TOPSIS can determine the villages that need the most attention and prioritize disaster management according to the level of urgency. The advantage of this method in its ability to calculate the

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distance between positive and negative ideal solutions, thereby assisting in making more efficient and targeted decisions [11].

Previous studies have utilized multi-criteria decision-making methods, such as TOPSIS, in handling flood and landslide disasters. Such as combining the TOPSIS method with machine learning to map flood vulnerability in urban areas, applying CV-TOPSIS to evaluate flood risk on strategic transportation routes, emphasizing the importance of infrastructure factors, developing geospatial-based flood risk maps and multi-criteria analysis to identify vulnerable zones in India, and applying TOPSIS in the context of landslides to assess social vulnerability and spatial-based risk dynamics [12], [13], [14], [15], [16].

Although these approaches demonstrate the effectiveness of TOPSIS in risk assessment, there are still several general limitations identified, such as the lack of integration with spatial data from real simulation results, the use of weights that do not refer to national policy principles, and the dominance of assessments of physical aspects without considering social aspects as a whole. This research was designed to complement the approach taken in previous studies by utilizing the results of the InaSAFE-based hazard classification analysis combined with the TOPSIS method to determine priorities for handling affected villages. Criteria weighting is determined proportionally based on the urgency of treatment, prioritizing life safety as the main priority [17], [18]. This approach is not only quantitative and objective, but also in line with data-based disaster principles and national policies.

This research aims to apply the TOPSIS method in determining priorities for handling villages affected by flooding due to the collapse of the Palasari Dam based on spatial data from the results of hazard classification analysis with a focus on disaster impact analysis and determining priority weights based on criteria such as infrastructure damage and number of fatalities. It is hoped that the results of this research can support the development of a more effective and efficient Emergency Action Plan (EAP), as well as increase preparedness in facing potential dam collapses in the future [19], [20].

2 Data and Methods

2.1 Study Area

Based on the results of the assessment of the performance of Palasari dam operations and services, there were four main components evaluated, namely operation and maintenance (OP) guidelines, dam operations, dam services, and EAP. Of these four aspects, the EAP component received a score of 68, which indicates the need for improvement in disaster risk mitigation planning in the event of dam failure. This value reflects that the aspect of preparedness for possible disasters due to structural damage or failure still requires further attention, especially in the preparation of EAP documents [1]. Based on the results of the hazzard classification analysis, it is known that there are 8 villages that will be affected if the Palasari Dam collapses as shown in Figure 1.

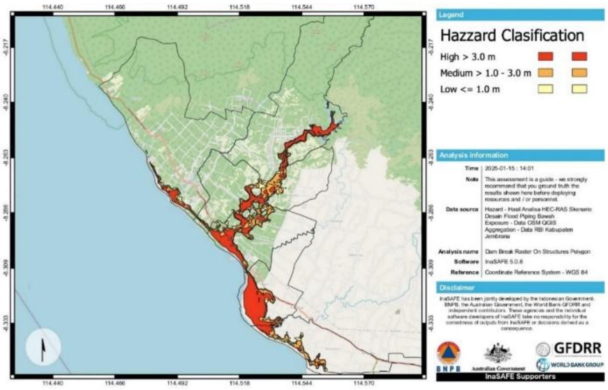

Figure 1. Flood inundation map based on hazzard classification

2.2 Data

The data used in this research is the result of a hazard classification analysis due to the collapse of the Palasari Dam, which was carried out with InaSAFE software as a plugin in the Geographic Information System (GIS) QGIS [21]. The flood inundation data used in this study was generated from a dam break simulation conducted using HEC-RAS software. The hydrological data forming the basis of the simulation was obtained from previous research conducted by the authors [22]. The simulation results were then used as the foundation for hazard classification in InaSAFE. Meanwhile, population, building, and road network data were extracted from OpenStreetMap (OSM), accessed in 2024, and processed through InaSAFE to produce spatial impact data at the village level [23].

Hazard classification is an important step in disaster risk management, which aims to identify the level of danger based on flood inundation height parameters. This hazard level classification refers to BNPB Regulation no. 02 of 2012, which categorizes threats based on flood height, namely Low Threat with a flood height of less than 1 meter, Medium Threat with a height of between 1 to 3 meters and High Threat with a height of more than 3 meters [24].

This analysis produces disaster impact parameters in spatial form, namely a map of the area of inundation, the length of affected roads, the number of affected buildings, and an estimate of the population that needs to be evacuated. All these parameters are then grouped based on village administration using spatial overlay techniques and zonal statistics, thereby producing quantitative data for each affected village. The four flood impact parameters used for priority analysis of affected villages are the total area of inundation, the length of affected roads, the number of affected buildings, and the number of affected populations. The parameters used in the TOPSIS analysis to determine priorities for handling affected villages are presented in Table 1.

Table 1. Data and parameters

Village	Total Inundation Area (km^2)	Road (km)	Building (unit)	Population (people)
Baluk	0,05	0	0	20
Banyubiru	1,05	1700	0	800
Tuwed	2,17	8500	20	1900
Candikusuma	2,13	13200	609	500
Nusasari	1,45	7100	427	1800
Warnasari	0,41	1100	28	20
Malaya	0,65	2300	162	360
Ekasari	1,39	5700	131	170

2.3 TOPSIS Method

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method has an important role in determining priorities for mitigation actions, including in flood disasters due to dam collapses (Adi, 2014; Akbar et al., 2017). TOPSIS is a multi-criteria decision making method (Multi-Criteria Decision Making/MCDM) which compares a number of alternatives based on their distance to a positive ideal solution (best) and a negative ideal solution (worst) [11].

This method is very suitable to be applied in determining priorities for handling villages affected by flooding due to the collapse of the Palasari Dam. This is because TOPSIS is able to accommodate various indicators with different weights of importance, resulting in a systematic, objective and data-based decision making process [25], [26]. One of the main advantages of TOPSIS is its methodological structure which is clear and easy to apply [27], [28]. This method provides better results compared to other methods such as Simple Additive Weighting (SAW) and Weighted Product (WP) [29]. The calculation steps for the TOPSIS method are creating a decision matrix, creating a normalized decision matrix, creating a weighted normalized decision matrix, determining positive ideal solutions and negative ideal solutions, separate means, calculating the preference value for each alternative and ranking alternatives based on scores [11].

3 Results and Discussion

Determining the weight of criteria in this research is based on a conceptual approach that considers aspects of danger and vulnerability. Danger refers to the frequency and severity of flood events. Meanwhile, vulnerability is related to the extent to which assets and human populations are affected by disasters. In this research, direct material losses such as damage to roads, buildings and inundated areas are considered to have a lower level of urgency compared to indirect losses involving life safety [18].

Referring to the principle that human safety is the main priority in disaster management [17], the criteria for the number of affected populations is given the highest weight. The weight of each parameter is determined proportionally and is shown in Table 2.

Table 2. Weight of each parameter

No	Parameter	Weight
1	Population (people)	4
2	Building (unit)	3
3	Road (km)	2
4	Inundation area (km^2)	1

This weighting is intended to represent the relative level of urgency of each criterion in the context of flood risk mitigation due to dam collapse in accordance with the view that prioritizes the safety of human lives as the most critical factor in disaster management [30], [31]. This is also supported by the concept of vulnerability assessment which assesses the impact of damage based on direct losses that can be measured in real terms while indirect losses, although important, are difficult to calculate in a clear form [32]. Thus, it is hoped that determining this weight can produce a more realistic and priority-based ranking of life safety aspects in flood disasters. The results of the priority determination analysis using the TOPSIS method are presented in the following Table 3 until Table 9.

Table 3. Creating a parameter matrix

Village	Total Inundation Area	Road	Building	Population
weight (w)	1	2	3	4
Baluk	0,05	0	0	20
Banyubiru	1,05	1700	0	800
Tuwed	2,17	8500	20	1900
Candikusuma	2,13	13200	609	500
Nusasari	1,45	7100	427	1800
Warnasari	0,41	1100	28	20
Malaya	0,65	2300	162	360
Ekasari	1,39	5700	131	170

Table 4. Creating a normalized decision matrix

Village	Total Inundation Area	Road	Building	Population
weight (w)	1	2	3	4
Baluk	0,005	0,000	0,000	0,004
Banyubiru	0,113	0,043	0,000	0,144
Tuwed	0,233	0,215	0,015	0,341
Candikusuma	0,229	0,333	0,442	0,090
Nusasari	0,156	0,179	0,310	0,323
Warnasari	0,044	0,028	0,020	0,004
Malaya	0,070	0,058	0,118	0,065
Ekasari	0,150	0,144	0,095	0,031

Table 5. Creating a weighted normalized decision matrix

Village	Total Inundation Area	Road	Building	Population
weight (w)	1	2	3	4
Baluk	0.005	0.000	0.000	0.014
Banyubiru	0.113	0.086	0.000	0.575
Tuwed	0.233	0.429	0.044	1.364
Candikusuma	0.229	0.667	1.327	0.359
Nusasari	0.156	0.359	0.930	1.292
Warnasari	0.044	0.056	0.061	0.014
Malaya	0.070	0.116	0.353	0.259
Ekasari	0.150	0.288	0.285	0.122
Max	0.233	0.667	1.327	1.364
Min	0.005	0.000	0.000	0.014

Table 6. Determining positive ideal solutions and negative ideal solutions

	Total Inundation Area	Road	Building	Population
A+	max	max	max	max
A-	min	min	min	min
A+	0.233	0.667	1.327	1.364
A-	0.005	0.000	0.000	0.0144

Table 7. Separate meansures

Village	S+	S-
Baluk	2.020	0.000
Banyubiru	1.654	0.577
Tuwed	1.305	1.436
Candikusuma	1.005	1.541
Nusasari	0.513	1.628
Warnasari	1.958	0.091
Malaya	1.581	0.449
Ekasari	1.667	0.444

Table 8. Calculating the preference value for each alternative

Village	Preference value
Baluk	0.000
Banyubiru	0.259
Tuwed	0.524
Candikusuma	0.605
Nusasari	0.760
Warnasari	0.045
Malaya	0.221
Ekasari	0.210

Table 9. Ranking alternatives based on scores

Village	Preference value	*Ranking*
Nusasari	0.760	1
Candikusuma	0.605	2
Tuwed	0.524	3
Banyubiru	0.259	4
Malaya	0.221	5
Ekasari	0.210	6
Warnasari	0.045	7
Baluk	0.000	8

The ranking results obtained from the TOPSIS method show that Nusasari Village ranks first in priority for handling flood disasters due to the collapse of the Palasari Dam. This decision was supported by a combination of high values for the number of affected population (1,800 people) and the number of affected buildings (427 units), as well as the length of the affected road (7,100 m). With the highest weighting given to population (4), followed by buildings (3), roads (2), and inundation area (1), these results emphasize that life safety indicators are the dominant factor in the decision-making process.

The second and third places are occupied by Candikusuma Village and Tuwed Village respectively. Although Candikusuma Village has a lower number of affected residents (500 people) compared to Tuwed (1,900 people), it ranks higher in the TOPSIS results due to significantly higher values in the number of affected buildings (609 units) and the length of affected roads (13,200 m). While the highest weight was assigned to population to emphasize life-safety priorities, the TOPSIS method calculates preference scores based on the weighted distance from ideal solutions. In this case, very high absolute values in infrastructure-related parameters can influence the final score significantly, even with lower population figures. This does not contradict the prioritization of life safety, but rather reflects the complexity of disaster risk, where infrastructure damage can amplify vulnerabilities. For instance, extensive road and building damage may hinder evacuation, delay emergency response, and increase casualties, thereby indirectly compromising life safety [33], [34]. This interpretation aligns with the broader understanding of disaster impact, where both direct (population) and indirect (infrastructure) risks interact to influence the severity of outcomes. Therefore, the ranking outcome remains consistent with the life-safety principle, while also acknowledging that effective disaster response requires a holistic view of vulnerability. Meanwhile, Baluk Village ranks last with a preference value of 0.000, followed by Warnasari with a value of 0.045. This is due to the extremely low exposure in all four parameters—minimal inundation area, no significant road or building infrastructure affected, and a very small number of residents at risk. The placement of these villages at the bottom of the priority ranking reflects the TOPSIS method's ability to filter out low-impact areas and prevent misallocation of limited mitigation resources.

Comparison with previous studies shows that the TOPSIS method provides a more objective decision-making approach compared to using only qualitative assessments [17], [25]. This research also shows that using spatial data resulting from hazard classification with InaSAFE can be converted into a strong numerical database in an MCDM-based decision-making system. The results of this research support the importance of integration between spatial impact data, quantitative decision-making methods, and disaster emergency policies. The integration of GIS-based hazard analysis in evaluating risk supports this research in assessing the impact of flood risk through spatial and quantitative parameters [35].

The weighting criteria in this research have been prepared based on the principles of vulnerability and life safety, in accordance with the national policy approach and previous references. However, to increase local relevance and ensure accuracy in the context of implementation in the field, further research can integrate a participatory approach through Focus Group Discussions (FGD) with local stakeholders such as BPBD, village officials and affected communities. This approach is expected to strengthen the local context validation of the weight structure that has been used

With this priority, disaster mitigation strategies can be prepared more efficiently and on target. Resources can be allocated optimally, both in the form of evacuating residents, distributing logistical aid, and repairing affected infrastructure and can assist related parties in designing more effective emergency response action plans to reduce the impact of disasters on affected communities. To make visualization easier, the flood management priority map is presented in Figure 2.

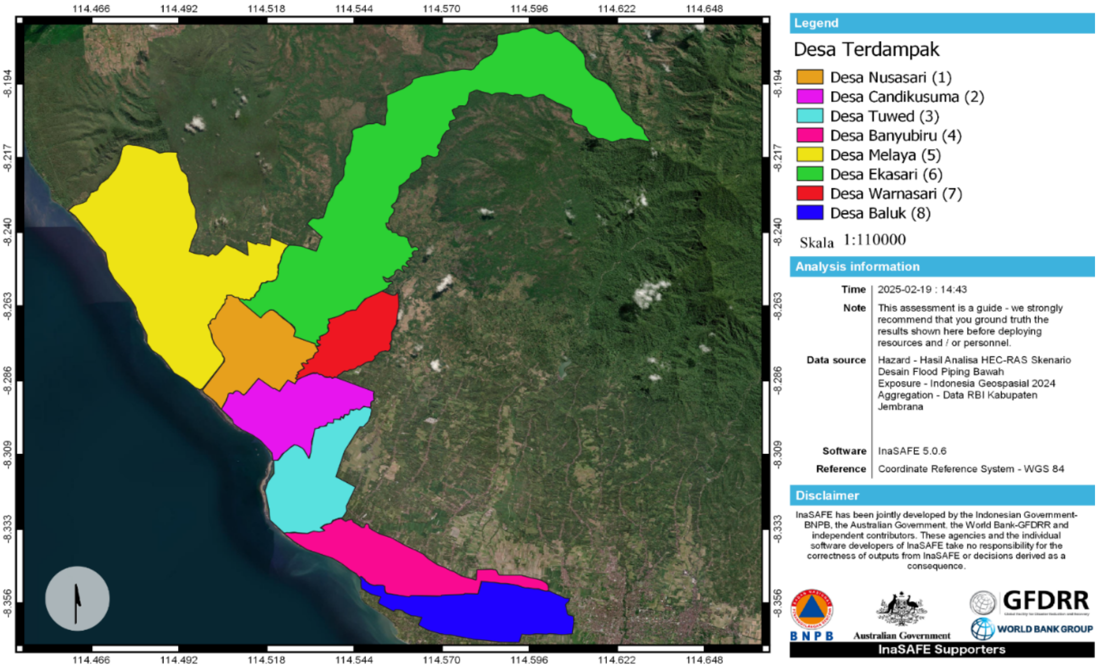

Figure 2 Priority map for handling affected villages

4 Conclusion

This research has applied the (TOPSIS) method in determining priorities for handling villages affected by flooding due to the collapse of the Palasari Dam. By considering the four main parameters of inundation area, length of affected roads, number of affected buildings, and affected population as well as weighting based on the principles of vulnerability and life safety, objective and measurable ranking results for affected villages were obtained.

The results of the analysis show that the villages of Nusasari, Candikusuma, and Tuwed are the three villages with the highest treatment priority, with a preference value of 0.760 respectively; 0.605; and 0.524. The results of this research demonstrate that the TOPSIS method is effective in developing a priority scale based on multi-interrelated criteria in the context of disasters.

This research recommends that a similar approach be used in preparing Emergency Action Plan (EAP) documents, especially at the stage of determining priority villages for treatment. In addition, the integration of spatial analysis results using InaSAFE with quantitative methods such as TOPSIS has proven to be a strong strategy in supporting more responsive and data-based disaster mitigation planning.

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References

[1] BWS Bali-Penida, “Laporan Akhir Updating AKNOP Bendungan Palasari tahun 2023,” Denpasar, 2023.

[2] M. A. F. Khairi, H. Suprijanto, and A. P. Hendrawan, “Analisis Keruntuhan Bendungan Rukoh Kabupaten Pidie Menggunakan Aplikasi HEC-RAS Dan Berbasis InaSAFE,” *J. Teknol. Dan Rekayasa Sumber Daya Air*, vol. 2, no. 1, pp. 1–

66, 2022, doi: 10.21776/ub.jtresda.2022.002.01.05.

[3] D. C. Siregar, “Analisis Variabilitas Curah Hujan Dan Suhu Udara Di Tanjungpinang,” *J. Mater. Dan Energi Indones.*, vol. 9, no. 02, p. 45, 2020, doi: 10.24198/jmei.v9i2.23834.

[4] B. Suhada, H. Nugroho, S. Suprapto, and H. Herawati, “Analisis Keruntuhan Bendungan Akibat Piping Dan Pemetaan Genangan Banjir (Studi Kasus : Bendungan Saguling),” *J. Saintis*, vol. 22, no. 01, pp. 1–10, 2022, doi: 10.25299/saintis.2022.vol22(01).8081.

[5] B. Harsoyo, “Analisis Faktor Penyebab Jebolnya Tanggul Situ Gintung,” *J. Air Indones.*, vol. 6, no. 1, 2018, doi: 10.29122/jai.v6i1.2453.

[6] R. A. Nabilah, D. Sutjiningsih, E. Anggraheni, and S. Murniningsih, “Dam Break Analysis of Situ Gintung Dam Collapse Reconstruction,” *Iop Conf. Ser. Earth Environ. Sci.*, vol. 599, no. 1, p. 12064, 2020, doi: 10.1088/1755-1315/599/1/012064.

[7] J. Sujono, “Hydrological Analysis of the Situ Gintung Dam Failure,” *J. Disaster Res.*, vol. 7, no. 5, pp. 590–594, 2012, doi: 10.20965/jdr.2012.p0590.

[8] Kementerian Pekerjaan Umum dan Perumahan Rakyat, *Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 7 Tahun 2023 tentang Perubahan Kedua Atas Peraturan Menteri Pekerjaan Umum Dan Perumahan Rakyat Nomor 27/PRT/M/2015 Tentang Bendungan*. 2023. [Online]. Available: https://jdih.pu.go.id/detail-dokumen/2721/1

[9] T. Kristina, “Sistem Pendukung Keputusan Dengan Menggunakan Metode TOPSIS Untuk Pemilihan Lokasi Pendirian Grosir Pulsa,” *Paradigma*, vol. 20, no. 1, pp. 8–12, 2018, [Online]. Available: https://ejournal.bsi.ac.id/ejurnal/index.php/paradigma/article/view/2908

[10] N. L. P. Prabandari, H. Siswoyo, and R. Haribowo, “Penentuan Skala Prioritas Pengembangan Potensi Mata Air untuk Irigasi Menggunakan Metode TOPSIS di Kecamatan Singosari Kabupaten Malang,” *J. Ilm. Univ. Batanghari Jambi*, vol. 21, no. 3, p. 996, 2021, doi: 10.33087/jiubj.v21i3.1580.

[11] C.-L. Hwang and K. Yoon, “Methods for Multiple Attribute Decision Making BT - Multiple Attribute Decision Making: Methods and Applications A State-of-the-Art Survey,” C.-L. Hwang and K. Yoon, Eds., Berlin, Heidelberg: Springer Berlin Heidelberg, 1981, pp. 58–191. doi: 10.1007/978-3-642-48318-9_3.

[12] L. Hu, X. Yang, Q. Li, and S. Li, “Numerical Simulation and Risk Assessment of Cascade Reservoir Dam-Break,” *Water*, vol. 12, no. 6, p. 1730, 2020, doi: 10.3390/w12061730.

[13] E. Javadian, “Urban flood vulnerability assessment using machine learning and TOPSIS,” *Sustain. Cities Soc.*, vol. 74, p. 103219, 2021, doi: 10.1016/j.scs.2021.103219.

[14] Y. Li, “Flood risk assessment using CV-TOPSIS in Belt and Road regions,” *Georisk*, vol. 14, pp. 166–179, 2020, doi: 10.1080/17499518.2020.1765703.

[15] A. I. Pathan *et al.*, “Flood risk mapping using geospatial and multi-criteria analysis: A case study of Navsari, India,” *EGU General Assembly*. Vienna, Austria, pp. EGU22-2418, 2022. doi: https://doi.org/10.5194/egusphere-egu22-2418.

[16] G. Rohmingthangi, F. C. Kypacharili, A. B. Mukherjee, and B. S. Mipun, “Landslide Risk Dynamics Modeling Using AHP-TOPSIS Model, Computational Intelligence Methods, and Geospatial Analytics: A Case Study of Aizawl City, Mizoram—India BT - Intelligent Data Engineering and Analytics,” S. C. Satapathy, P. Peer, J. Tang, V. Bhateja, and A. Ghosh, Eds., Singapore: Springer Nature Singapore, 2022, pp. 397–410. doi: https://doi.org/10.1007/978-981-16-6624-7_40.

[17] A. Miardini and H. Nugraha, “Penentuan Sub Das Prioritas Penanganan Banjir Di Das Bodri, Jawa Tengah,” *Maj. Ilm. Globe*, vol. 22, no. 2, p. 93, 2020, doi: 10.24895/mig.2020.22-2.992.

[18] G. Pariartha, A. Goonetilleke, P. Egodawatta, and H. Mirfenderesk, “The prediction of flood damage in coastal urban areas,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 419, no. 1, 2020, doi: 10.1088/1755-1315/419/1/012136.

[19] T. M. Aribawa, “Assessment of Flood Propagation Due to Several Dams Break in Banten Province,” *Int. J. Geomate*, vol. 20, no. 81, 2021, doi: 10.21660/2021.81.j2082.

[20] G. Juliastuti and O. Setyandito, “Dam Break Analysis and Flood Inundation Map of Krisak Dam for Emergency Action Plan,” 2017, doi: 10.1063/1.5011615.

[21] Australia-Indonesia Facility for Disaster Reduction, “InaSAFE User Manual,” 2014.

[22] N. L. P. Prabandari, I. P. G. S. Pariartha, and S. G. Tonyes, “Analisa debit banjir rancangan Bendungan Palasari menggunakan,” *Padur. J. Tek. Sipil Univ. Warmadewa*. In press

[23] OpenStreetMap Contributors, “OpenStreetMap,” OpenStreetMap Foundation. Accessed: Dec. 15, 2024. [Online]. Available: https://www.openstreetmap.org

[24] Badan Nasional Penanggulangan Bencana (BNPB), “Peraturan Kepala BNPB No. 2 Tahun 2012 tentang Pedoman Umum Penyusunan Rencana Penanggulangan Bencana,” Jakarta, 2012. [Online]. Available: https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://bpbd.natunakab.go.id/wp-content/uploads/2024/03/Peraturan-Kepala-BNPB-No-02-Tahun-2012.pdf&ved=2ahUKEwjex_PIyLGMAxUIUWwGHSwrG1IQFnoECAkQAQ&usg=AOvVaw3ufyj1Oi7cMUjLQi_1rcCZ

[25] A. Hamid and D. M. Midyanti, “Penerapan Metode Topsis Dalam Penentuan Skala Prioritas Rehabilitasi Jaringan Irigasi Daerah Ketiat B Bengkayang,” *Simetris J. Tek. Mesin Elektro Dan Ilmu Komput.*, vol. 10, no. 1, pp. 295–302, 2019, doi: 10.24176/simet.v10i1.2979.

[26] Y. H. J.A, M. Musyirifah, and F. Wajidi, “Sistem Pendukung Keputusan Penerima Bantuan Bencana Alam Menggunakan Metode Topsis,” *J. Komput. Dan Inform.*, vol. 11, no. 2, pp. 185–194, 2023, doi: 10.35508/jicon.v11i2.11178.

[27] N. Sururi, K. Kusrini, and S. Sudarmawan, “Penentuan Wali Kelas Yang Ideal Menggunakan Metode TOPSIS,” *Creat. Inf. Technol. J.*, vol. 5, no. 2, p. 85, 2019, doi: 10.24076/citec.2018v5i2.163.

[28] A. Suryandini and I. Indriyati, “Sistem Pendukung Keputusan Untuk Penentuan Minat Peserta Didik Di SMA Menggunakan Metode TOPSIS,” *J. Masy. Inform.*, vol. 6, no. 12, pp. 30–37, 2015, doi: 10.14710/jmasif.6.12.11116.

[29] M. Y. Bahtiar, “Sistem Pendukung Keputusan Pengangkatan Karyawan Kontrak Menjadi Karyawan Tetap Dengan Menggunakan Metode Topsis (Studi Kasus : Pt. Sumber Mas Indah Plywood),” *Indexia Infomatic Comput. Intell. J.*, vol. 4, no. 2, p. 14, 2022, doi: 10.30587/indexia.v4i2.4329.

[30] K. Smith, C. J. Fearnley, D. Dixon, D. K. Bird, and I. Kelman, *Environmental Hazards: Assessing Risk and Reducing Disaster*, (7th ed.). Routledge, 2023. doi: https://doi.org/10.4324/9781351261647.

[31] B. Wisner, P. Blaikie, T. Cannon, and I. Davis, *At Risk: Natural Hazards, People's Vulnerability, and Disasters*. Routledge, 2012.

[32] S. L. Cutter, *The Vulnerability of Place: Marginality, Risk, and Disaster*. Routledge, 2003.

[33] K. Smith, C. J. Fearnley, D. Dixon, D. K. Bird, and I. Kelman, *Environmental Hazards Assessing Risk and Reducing Disaster*. London, 2023. doi: https://doi.org/10.4324/9781351261647.

[34] S. L. Cutter, B. J. Boruff, and W. L. Shirley, “Social Vulnerability to Environmental Hazards,” *Soc. Sci. Q.*, vol. 84, no. 2, pp. 242–261, 2003, doi: https://doi.org/10.1111/1540-6237.8402002.

[35] I. P. E. Sarassantika, G. Bagus, A. Wicaksana, K. Tania, and U. Putri, “Assessing the Impact of Environmental Hazards on Educational Facility Structures in Karangasem Regency : Implications for Risk Mitigation,” *J. Infrastruct. Plan. Eng.*, vol. 3, no. 2, pp. 41–49, 2025, doi: https://doi.org/10.22225/jipe.3.2.2024.41-49.