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Spatial Decision Support System to Determine the Feasibility of Evacuation Posts in Natural Disasters

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Abstract

This study aimed to improve the accuracy of determining the feasibility of evacuation posts after natural disasters using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) within a Spatial Decision Support System (SDSS). A dataset of 50 evacuation posts from the 2021 Mount Semeru eruption was analyzed. The Rank Order Centroid (ROC) method was applied for criteria weighting, and TOPSIS was used to process the data. Results showed 72% accuracy, confirming that TOPSIS is a passable method for assessing post-feasibility based on accessibility, sanitation, and refugee facilities. Although the focus is on evaluating post-disaster evacuation posts, the system can be adapted for use in various other types of disasters. However, it is still dependent on historical data and lacks real-time adaptability. Future research can integrate Artificial Intelligence (AI) and Machine Learning (ML) with real-time data to improve decision-making in disaster management.

Keywords: After Natural Disasters, Evacuation Posts, Management Disasters, Spatial Decision Support System, Technique For Order Preference By Similarity to Ideal Solution (TOPSIS)

Abstrak

Penelitian ini bertujuan meningkatkan akurasi penentuan lokasi pos pengungsian bencana alam menggunakan metode Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) dalam Sistem Pendukung Keputusan Spasial (SDSS). Dataset yang digunakan terdiri dari 50 pos pengungsian erupsi Gunung Semeru tahun 2021. Metode Rank Order Centroid (ROC) digunakan untuk memberikan bobot pada kriteria, dan TOPSIS untuk pemrosesan data. Hasil penelitian menunjukkan akurasi 72%, membuktikan bahwa TOPSIS cukup baik dalam mengevaluasi kelayakan pos berdasarkan aksesibilitas, sanitasi, dan fasilitas pengungsi. Meskipun berfokus pada evaluasi pos pengungsian pasca bencana alam, sistem ini dapat beradaptasi ke berbagai jenis bencana lainnya, seperti gempa bumi, banjir, badai, dan kebakaran hutan. Namun, sistem ini masih bergantung pada data historis dan belum dapat menganalisis secara real-time, yang membatasi respons cepat dalam situasi darurat. Penelitian di masa depan dapat mengintegrasikan Kecerdasan Buatan (AI) dan Machine Learning (ML) dengan data real-time untuk meningkatkan akurasi dan pengambilan keputusan dalam manajemen bencana.

Kata Kunci: Pasca Bencana Alam, Pos Pengungsian, Manajemen Bencana, Sistem Pendukung Keputusan Berbasis Spasial, Technique For Order Preference By Similarity to Ideal Solution (TOPSIS)

1. INTRODUCTION

Natural disasters are events that occur as a result of natural phenomena, such as earthquakes, tsunamis, floods, landslides, volcanic eruptions, and extreme weather events like storms and forest fires (Meilano et al., 2020). Natural disasters, as defined by Law No. 24 of 2007, are events resulting from natural phenomena. These disasters cause significant damage and losses across various sectors (Fathiyaturahma, 2023). Indonesia experienced 2.594 natural disasters from January to August 2023, including floods, extreme weather, landslides, forest fires, tidal waves, earthquakes, droughts, and volcanic eruptions (Badan Nasional Penanggulangan Bencana, 2023). This highlights Indonesia's high vulnerability to natural disasters (Ozbay et al., 2019). Different regions in Indonesia face different types of natural disasters due to their diverse geographical conditions (Setiawan & Fitriani, 2024). Lumajang Regency in East Java is particularly prone to disasters, with Mount Semeru, the highest mountain in Java, located there. In 2021, a volcanic eruption in Lumajang caused significant damage, disrupting access to bridges, village roads, and homes (Perwita et al., 2023).

In response to disasters, the government, with various stakeholders, establishes evacuation and protection posts to provide critical assistance (Ismeti et al., 2023). These posts are essential in disaster management and are divided into eight sub-clusters, including shelter, water and sanitation, coordination and management, security, child protection, and psychosocial support (Kementerian Sosial Republik Indonesia, 2019). Evacuation posts must meet specific criteria to minimize disaster risks, including adequate land, water supply, sanitation facilities, and access to public services. The Regional Disaster Management Agency (BPBD) determines evacuation posts by referring to the contingency plan (Renkon). Renkon is a joint agreement in disaster management. However, not all evacuees are in the evacuation posts established by BPBD, so some evacuees occupy places that are not in the designated Renkon area. A proper evacuation post is in accordance with the agreed-upon Renkon; therefore, the locations of evacuation posts not included in the Renkon have subjective feasibility. In an emergency, people tend to make decisions under emotional pressure, which can make decision-making ineffective. Determining the feasibility of an evacuation can utilize information technology. In decision-making, surveyors require technology to make structured and objective decisions. One of the information technologies that can be used to determine the feasibility of evacuation posts is the Decision Support System (DSS).

A DSS is a system that can be used for objective decision-making in the face of information uncertainty (Ojo et al., 2024). A DSS uses a Computer-Based Information System (CBIS) developed to support flexible and interactive decision-making systems (Trieu et al., 2024). A DSS will help make decisions based on appropriate criteria to get an existing alternative (Xie et al., 2024). One type of DSS that can be used to make decisions is the Spatial Decision Support System (SDSS). An SDSS is a decision support system that uses a spatial or geographic approach. Spatial is an approach that utilizes geographical location (Keenan & Jankowski, 2019). Web-based SDSS are designed to support all types of data, from vector to raster. The location approach in this decision support system can use latitude and longitude coordinates. The spatial approach in the research to be carried out is in the form of coordinates for the locations of established evacuation posts. Surveyors will input data related to the location of the evacuation post, and the system will analyze and process the information to determine the suitability of the input data against predetermined criteria. After the data is processed, the system selects the best alternative, considering it the most suitable based on the input data.

A DSS in decision-making employs a specialized method known as Multiple Criteria Decision Making (MCDM). MCDM is an approach to decision-making that involves many criteria or decision support factors (Shao et al., 2024). MCDM employs several approaches, one of which is the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). TOPSIS is one of the multi-criteria decision support system methods used to solve the problem of selecting the best alternative (Dewi et al., 2021). Decision support systems can be developed using the TOPSIS approach in decision-making. The TOPSIS approach is carried out by determining the alternative that is closest to the positive and negative ideal solution values based on existing criteria. This approach can help overcome the multiple criteria that exist within the system. The TOPSIS approach helps overcome the complexity of criteria and provides priority rankings on alternatives, enabling the system to make decisions quickly.

The TOPSIS approach was selected as the main decision-making instrument in this study to assess the viability of evacuation posts following Mount Semeru's 2021 eruption. Because it can handle multiple criteria simultaneously and rank options according to how closely they approach an ideal solution, the TOPSIS technique was chosen. The approach is especially helpful for complex decision-making situations that involve multiple variables, such as safety, accessibility, and available facilities. The study aims to provide a methodical and impartial approach for determining the best evacuation points using TOPSIS.

The main reference for this research is the research conducted by Hadiguna et al., titled "Implementing a Web-Based Decision Support System for Disaster Logistics: A Case Study of an Evacuation Location Assessment for Indonesia." The research developed a web-based decision support system used to evaluate the feasibility of public facilities as post-disaster evacuation sites (Hadiguna et al., 2014). Unlike previous research that employed the TOPSIS method to assess the level of building damage following a natural disaster, this research focuses on the subject of evacuation post-eligibility. The calculation of the weight of each criterion uses the Rank Order Centroid (ROC) method. This research also applies the SDSS by obtaining latitude and longitude points on Google Maps. This research uses seven criteria and three alternatives. The alternatives used are categorized as feasible, somewhat feasible, and not feasible. At the same time, the criteria considered include health facilities, drinking and cooking water, bathing, washing, and toilet facilities, closed bathrooms and toilets, waste disposal, and refugee privacy areas.

2. METHODS

The system programming in this study was carried out using the PHP (Hypertext Preprocessor) programming language. The method implementation utilized the Laragon database to display views from the queries of each stage. Figure 1 shows that the developed system includes input, process, and output stages. There are three stages in the research data processing cycle: input, process, and output. The input stage is the stage for entering data into the Spatial Decision Support System (SDSS). The data that needs to be input into the system consists of location, criteria, alternatives, weights, and a decision matrix. The process of inputting the longitude and latitude points into the SDSS uses the coordinate points on Google Maps. The process stage is the stage of data processing to achieve the desired results. This stage involves processes such as determining the divider value, data normalization, weighted normalization, identifying the maximum and minimum values, determining the positive and negative ideal solution values, determining the size of the separator, and assigning alternative preference values. The output stage is the result of the data processing that has been performed. The output in question is an alternative result that matches the input data. In the system for determining the feasibility of natural disaster refugee posts, the alternatives that emerge as output are categorized as feasible, quite feasible, and not feasible. The system design based on these three stages is structured as follows.

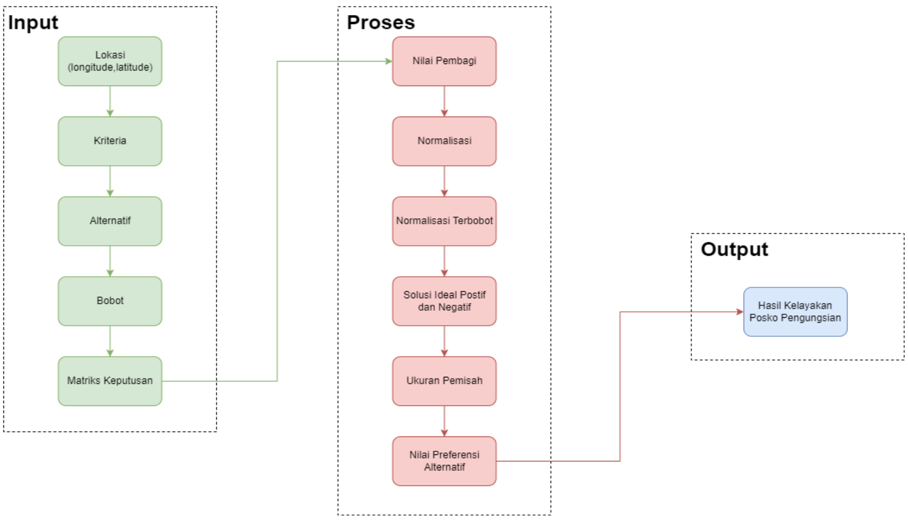

Figure 1 System Design

This research utilizes data collected and compiled by other parties or sources, known as secondary data. The secondary data for this study were obtained from data released by the National Disaster Management Agency (BNPB) and the Regional Disaster Management Agency (BPBD) of Lumajang District. The dataset consisted of 50 records on evacuation posts for the 2021 eruption of Mount Semeru. Several criteria were obtained from this previously collected data. Table 1 presents the criteria that will be used as supporting factors for determining suitable alternatives. These criteria are useful to assist surveyors in determining the feasibility of post-natural disaster refugee camps in Lumajang Regency.

Table 1 Research Criteria

Criteria Code	Criteria Name
K1	Drinking and cooking water
K2	Bathing, washing, and toilet water
K3	Closed Bathroom
K4	Toilet
K5	Waste Disposal
K6	Refugee Privacy Temp
K7	Drinking and cooking water

The original data obtained from BNPB and BPBD will be processed by providing a rating scale on predetermined criteria. Table 2 presents the criteria assessment provisions used in the research. The assessment scale for each criterion uses a statistical scale, namely an ordinal scale. An ordinal scale provides ranked data or sequential values, where each value is assigned a rank. Values on an ordinal scale have a lower or smaller value than other values. The ordinal scale also lacks a definite distance between each category. The value on the ordinal scale does not represent an exact value, but rather indicates a value that is considered higher or lower than the comparison value. Based on a research journal entitled "Application of the ROC-TOPSIS Method in the Decision on Recipients of the Family Hope Program," sequential category data values can be provided from the range of 1-3 for each data rank according to the sub-criteria used. In addition to the criteria obtained from the description above, there are alternatives, which are the conclusions drawn from comparing the criteria. Three alternatives will be used in this study as described in Table 3.

Table 2 Criteria Value Conditions

Criteria	Sub- Criteria	Value
Health Facilities	None	1
	> 1.6 km	2
	<= 1.6 km	3
Drinking and cooking water	Not available	1
	Existing and insufficient	2
	Existing and sufficient	3
Bathing, washing, and toilet water	None	1
	Existent and insufficient	2
	Present and sufficient	3
Closed Bathroom	None	1
	Present and insufficient	2
	Present and sufficient	3
Toilet	None	1
	Present and insufficient	2
	Present and sufficient	3
Waste Disposal	None	1
	Present and insufficient	2
Refugee Privacy Temp	None	1
	Existing and insufficient	2

Table 3 Research Alternative

Alternative Code	Alternative Name
A1	Not Feasible
A2	Decent Enough
A3	Feasible

2.1 Rank Order Centroid (ROC)

The determination of criteria weights is performed using the ROC method. Before determining the weight, the criteria will be sorted based on priority. Criteria will also be determined, including the type of benefit or cost associated with each option. The type of criteria is obtained after the rating scale for each criterion is determined. Criteria that have an assessment scale where the lower the assessment provision, the better the criterion will be, are a type of cost criterion. If, on the contrary, the type of criteria is a benefit. The determination of the type of criteria is described in Table 4.

Table 4 Research Criteria

Criteria Code	Criteria Name	Type
K1	Drinking and cooking water	Cost
K2	Bathing, washing, and toilet water	Benefit
K3	Closed Bathroom	Benefit
K4	Toilet	Benefit
K5	Waste Disposal	Benefit
K6	Refugee Privacy Temp	Benefit
K7	Drinking and cooking water	Benefit

In determining weights, the ROC (Rank Order Centroid) method prioritizes the most important criteria. This prioritization is expressed by ordering the criteria as shown in Eq. (1), with the corresponding ROC weights following the same order, as presented in Eq. (2). The ROC method calculates the weight of each criterion to reflect its relative importance in a decision support system (DSS), as illustrated in Eq. (3) (Damanik & Utomo, 2020). Using an average approximation, the weights for each criterion can be determined as shown in Eq. (4)–(7) (Simanjuntak et al., 2022), ensuring that higher-priority criteria receive greater weights.

$$K_1 \geq K_2 \geq K_3 \geq \cdots \geq K_n \tag{1}$$

$$W_1 \geq W_2 \geq W_3 \geq \cdots \geq W_n \tag{2}$$

$$W_k = \frac{1}{k}\, \Sigma_{i=k}^{k} (1 + \frac{1}{k}) \tag{3}$$

$$W_1 = \frac{1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{k}}{k} \tag{4}$$

$$W_2 = \frac{0 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{k}}{k} \tag{5}$$

$$W_3 = \frac{0 + 0 + \frac{1}{3} + \cdots + \frac{1}{k}}{k} \tag{6}$$

$$W_k = \frac{0 + \cdots + 0 + \frac{1}{k}}{k} \tag{7}$$

2.2 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS, or Technique for Order Preference by Similarity to Ideal Solution, is a multi-criteria decision-making (MCDM) method used to identify the best alternative based on its proximity to the positive ideal solution (PIS) and distance from the negative ideal solution (NIS). This approach is fundamental in MCDM, where decision-making involves multiple criteria that influence the selection process (Baydaş et al., 2024). TOPSIS calculates how far each alternative deviates from the PIS, which represents the highest value for each criterion, and the NIS, which represents the lowest value for each criterion. The distances between alternatives and ideal solutions are computed using the Euclidean method (Divayana & Suyasa, 2021). The TOPSIS procedure begins with constructing the decision matrix as shown in Eq. (8), followed by calculating the divider value (Eq. 9) to normalize the data (Eq. 10). Each criterion is then weighted to obtain the weighted normalized values (Eq. 11). Positive and negative ideal solutions are determined for benefit and cost criteria as illustrated in Eq. (12) and Eq. (13). Subsequently, the separation distances from the PIS and NIS are calculated using Eq. (14) and Eq. (15). Finally, the preference value for each alternative is derived as presented in Eq. (16), which enables ranking the alternatives according to their closeness to the ideal solution (Dewi et al., 2021).

$$D = (x_{ij})_{m\,x\,n} \tag{8}$$

$$N = \sqrt{\sum_{i=1}^{m} x_{ij}^2} \tag{9}$$

$$r_{ij} = (\frac{x_{ij}}{N})_{m\,x\,n} \tag{10}$$

$$y_{ij} = (w_j \,.\, r_{ij})_{m\,x\,n} \tag{11}$$

$$A^+ = \{(^{max}_{\;i} y_{ij} | j \in J_b), (^{min}_{\;i} y_{ij} | j \in J_c)\} \tag{12}$$

$$A^- = \{(^{min}_{\;i} y_{ij} | j \in J_b), (^{max}_{\;i} y_{ij} | j \in J_c)\} \tag{13}$$

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (y_{ij} - A^+)^2} \tag{14}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij} - A^-)^2} \tag{15}$$

$$v_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{16}$$

3. RESULTS AND DISCUSSION

The TOPSIS method is implemented using PHP and MYSQL programming. The stages of the TOPSIS method calculation process are carried out by querying the views contained in the database. The TOPSIS calculation process at each stage is carried out with interconnected views. The PHP programming language is used to implement the TOPSIS method in the form of a website. The following are the results of implementing the TOPSIS method.

3.1 Data Processing

The data processed is information on the evacuation post for the 2021 eruption of Mount Semeru. The total dataset used consists of 50 data points on evacuation posts for the 2021 eruption of Mount Semeru. The data obtained are data on the name of the refugee post, refugee address, latitude point, longitude point, distance to health facilities, availability and adequacy of bathing, washing and toilet water, availability and adequacy of bathing and drinking water, availability and adequacy of bathrooms, availability, adequacy and number of toilets, amount of drinking water, amount of clean water, availability of waste disposal, and availability of refugee privacy places. The data obtained is in the form of category data on each criterion. The data will be converted into quantitative data so that it can be processed in the calculation of the TOPSIS method. Table 5 presents the data preprocessing that can be used in research.

Table 5 Preprocessing Data Result

No.	Pos Name	Pos Address	Latitude	Longitude	K1	K2	K3	K4	K5	K6	K7
1	Balai Desa Gesang	Dusun Krajan I, Gesang, Tempeh	-8,17882052032194	113,147427494563	3	3	3	3	3	2	2
2	Balai desa Jambe Arum	Pakem, Jambearum, Pasrujambe, Lumajang	-8,1683721537445	113,078814435035	3	3	3	3	3	2	2
3	Balai desa Karang Anom	Jl. Raya Semeru, Tambakrejo Wetan, Karang Anom, Pasrujambe	-8,3824920798675	113,145563024991	3	3	3	3	3	2	2
4	Balai desa Klopo Sawit	Krajan, Kloposawit, Kec. Candipuro, Lumajang	-8,14873467600424	113,081888178848	2	3	3	3	3	2	2
5	Balai desa Pasrujambe	Jl. Raya Semeru, Pasrujambe, Pasrujambe	-8,113237391364702	113,044102294561	2	3	3	3	3	2	2

3.2 System Interface Implementation

The decision support system in determining the feasibility of post-disaster refugee camps is implemented using a website-based user interface. The website features several pages tailored to the user’s needs. Figure 2 shows the SDSS website for the feasibility of post-disaster refugee camps. The website display consists of a login page, dashboard, evacuation post input, user, criteria, alternatives, criteria weights, rating scale, assessment input, TOPSIS method process results page, and user profile page.

The SDSS implementation on the web comprises several pages that facilitate ease of system interaction with users. The website features maps that display the locations of evacuation posts, along with information related to each post, such as its eligibility as an evacuation site. The input page also provides a map display, allowing users to directly select the location point of the evacuation post without manually entering the longitude and latitude points. The result display of evacuation posts that have been checked with SDSS will display the stages of the calculation process until the results of the TOPSIS calculation are obtained.

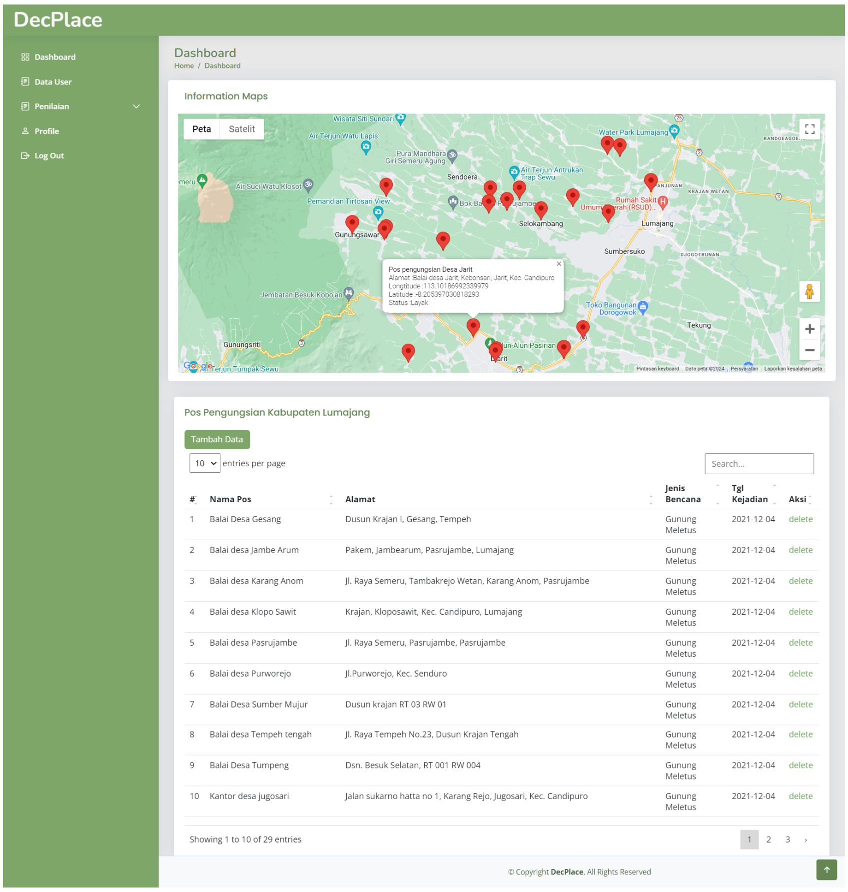

Figure 2 Dashboard Page

3.3 Accuracy Calculation

The accuracy of the TOPSIS method is calculated by comparing the corresponding data between the original data and the system data. Table 6 presents the calculation results obtained using the TOPSIS method and actual data. From the system calculations above, it is evident that 14 data points yield different results from the TOPSIS calculation data. To determine the accuracy of the TOPSIS method, the steps in Eq. (17) can be taken.

Table 6 Comparison Table of Original Data with TOPSIS Data

No.	Evacuation Name	K1	K2	K3	K4	K5	K6	K7	Original Data	TOPSIS Result	Description
1	Balai Desa Gesang	3	3	3	3	3	2	2	Feasible	Feasible	Suitable
2	Balai desa Jambe Arum	3	3	3	3	3	2	2	Feasible	Feasible	Suitable
3	Balai desa Karang Anom	3	3	3	3	3	2	2	Feasible	Feasible	Suitable
…	…	…	…	…	…	…	…	…	…	…	…
50	PPKM MIKRO	2	3	3	3	3	2	2	Feasible	Feasible	Suitable

$$Accuracy = \frac{suitable\ data}{total\ number\ of\ data} \times 100\% = \frac{36}{50} \times 100\% = 0{,}72 \times 100\% = 72\% \qquad (17)$$

3.4 Discussion

The test data consist of records from refugee camps following the eruption of Mount Semeru in Lumajang Regency in 2021. The data used is in the form of data on the name of the refugee post, the address of the refugee post, the supply of facilities located at the refugee post, such as health facilities, bathing, washing, and toilet water supplies, drinking and cooking water supplies, bathrooms, toilets, waste disposal, and refugee privacy areas. Each evacuation post's data includes a description of its eligibility, which is based on the analysis by BPBD Lumajang District. The refugee post eligibility data obtained will be compared with the data generated by the system to assess the accuracy of the method. The data obtained is qualitative, so that it will be processed into quantitative data for further analysis. The qualitative data will be given a rating scale in accordance with Table 2.

Criteria 1 is the top priority in the form of health facility distance. This type of criterion is a cost criterion because the smaller the distance to the health facility, the higher the value obtained. Meanwhile, the farther the distance of health facilities, the smaller the value obtained. The meaning of the unavailability of health facilities is the absence of health posts such as emergency health posts, village health posts (POSKESDES), or the nearest health center from the location of the evacuation post. Criteria 1 in the preprocessed data yields values of "3" for 22 data points, "2" for 28 data points, and "1" for 0 data points. From these results, it is evident that all evacuation posts meet the criteria for health facilities that must be located near the evacuation post and are therefore a priority for consideration.

In criterion 2, namely the supply of drinking and cooking water, which has a ranking of the 2nd level of importance among all criteria. This criterion is a benefit criterion because the more water supplies and the adequacy of drinking and cooking water, the higher the value obtained. In this criterion, refugee posts that have drinking and cooking water data considered "available and sufficient" will be assigned a value of 3, as it is deemed to have a sufficient water supply for all refugees in the refugee post. For data that has the availability of cooking and drinking water, but is insufficient for all refugees, it will be assigned a value of 2. Meanwhile, the refugee post does not have a supply of drinking and cooking water; it will be given a value of 1. From the data that has undergone the data preprocessing stage, it is observed that there are 50 refugee posts with a value of "3". From this amount of data, it can be seen that all refugee posts have sufficient water availability for all refugees.

In criterion 3, namely bathing, washing, and toilet water supply or bathing washing latrines, which have a ranking of the 3rd level of importance from the total of all criteria. This criterion is a benefit criterion because the more water supply and water adequacy, the higher the value obtained. Similar to the 2nd criterion, this criterion also considers the same sub-criteria in assigning value to the data. In this criterion, 46 data points were obtained for a value of "3", 3 data points for a value of "2", and 1 data point with a value of "1". From this data, it is evident that some refugee posts have sufficient water supplies for toilets, while others do not. This can be caused by many factors, one of which may be a small or nonexistent water source.

In criterion 4, namely a closed bathroom, which has a ranking of the 4th level of importance among all criteria. This criterion is a benefit criterion because the more bathroom supplies are available, the higher the value obtained. In this criterion, refugee posts that have "available and sufficient" data will be assigned a value of 3, as they are considered to have sufficient bathrooms for all refugees in the refugee post. For data that has a bathroom but is insufficient for all refugees, it will be assigned a value of 2. Meanwhile, if the refugee post does not have a bathroom, it will be given a value of 1. Criteria 4 in the preprocessed data yields values of "3" for 46 data points, "2" for 3 data points, and "1" for 1 data point. From this amount of data, it can be seen that most refugee camps have sufficient availability and adequacy of bathrooms for refugees.

In criterion 5, namely the number of toilets that have a ranking of the 5th level of importance of the total of all criteria. This criterion is a benefit criterion because the more the number of toilets, the higher the value obtained. In this criterion, refugee posts that have “there and enough” data will be given a value of 3. For data that has a bathroom but is insufficient for all refugees, a value of 2 will be assigned. If the refugee post does not have a toilet, a value of 1 will be given. Criteria 5 in the preprocessed data yields values of “3” for 44 data points, “2” for 5 data points, and “1” for 1 data point. From this amount of data, it can be seen that most refugee camps have toilets for refugees and a sufficient number of toilets for all refugees. Meanwhile, five refugee camps have toilets, but there are not enough for all refugees. This can happen if the number of toilets available is not proportional to the number of refugees at the refugee camp.

In criterion 6, namely waste disposal, which has a ranking of the 6th level of importance among all criteria. This criterion is a benefit criterion because if there is waste disposal, the value at the evacuation post will be higher, namely “2”. However, refugee camps that do not have waste disposal will receive a lower value, namely “1”. Criterion 6 in the preprocessed data yields a value of “2” for 49 data points and a value of “1” for 1 data point. From this amount of data, it can be seen that almost all refugee camps have proper waste disposal.

In criterion 7, namely the place of refugee privacy, which has a ranking of the 7th level of importance out of all criteria. This criterion is a benefit criterion because having a place of privacy for refugees increases the value of the refugee camp, specifically to “2”. However, if the refugee camp does not have a place of privacy, the value obtained will be lower, namely “1”. A private space for refugees can be in the form of a plywood partition or a room for several family units (KK) who are still part of one family. This privacy space is useful for maintaining the privacy of each family or promoting peace among refugees. Criterion 7 in the preprocessed data contains values of “2” for 39 data points and “1” for 11 data points.

The results of testing the accuracy of the TOPSIS method obtained an accuracy of 72%. According to Pratiwi and Wibowo, the 72% accuracy result suggests that the TOPSIS method can accurately predict the correct data (Niu et al., 2024). The system testing showed an accuracy rate of 72%, with 36 matching results and 14 non-matching results when compared to actual data from BPBD Lumajang. While this accuracy indicates that TOPSIS can effectively assess evacuation posts based on historical data, the method has some limitations, particularly in distinguishing between the “Feasible” and “Decent Enough “ categories. This suggests that the weighting process used in TOPSIS may not fully capture the conditions of post-disaster situations, where external factors such as infrastructure damage and population density may affect the actual feasibility of evacuation sites.

Although this study focused on the 2021 Mount Semeru eruption, the proposed SDSS-based TOPSIS system has the potential for wide applications. Many disaster-prone regions worldwide, including earthquake zones (such as some areas in Indonesia), flood-prone areas, hurricane-prone regions, and wildfire-affected areas, could benefit from a structured decision-making tool to evaluate evacuation post-feasibility. By adjusting the criteria weights based on specific geographic and disaster conditions, this system can be customized to suit various disaster scenarios, ensuring more effective preparedness and response strategies.

The existing system’s dependence on historical data and lack of real-time adaptability. Decision-making in a rapidly changing crisis scenario requires dynamic analysis based on real-time data, rather than static records. To improve system performance, future research can combine machine learning (ML) with artificial intelligence (AI). Real-time evaluation of evacuation post-feasibility is made possible by AI-driven models that continually learn from previous evacuation results. Combining TOPSIS with AI/ML would enable the system not only to evaluate previously used evacuation sites but also to predict the best locations for future evacuation posts. This hybrid approach will increase decision-making speed, adaptability, and accuracy, making it more relevant for large-scale disaster management. Furthermore, real-time integration can help disaster response teams quickly identify the safest and most suitable locations for evacuation posts, ensuring disaster preparedness and response.

Overall, while TOPSIS has proven to be a reliable and well-structured method for evaluating evacuation posts, its effectiveness can be further enhanced by integrating AI and real-time data processing. Future research should explore hybrid decision-making models that incorporate machine learning and real-time geographic data analysis, allowing for more precise and adaptive disaster response planning. This research lays the foundation for further advancements in data-driven disaster management systems, helping decision-makers optimize the selection of evacuation posts on both local and global scales.

4. CONCLUSIONS

This research successfully implemented the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method in a web-based Spatial Decision Support System (SDSS) to determine the feasibility of evacuation posts after a natural disaster. The system was developed using PHP and MySQL, with the Rank Order Centroid (ROC) method applied for weighting the criteria. System testing showed an accuracy rate of 72%, with 36 matching results and 14 non-matching results compared to actual data from BPBD Lumajang. This system is designed to evaluate previously used evacuation posts, ensuring whether a location remains suitable for future disasters. By considering seven key criteria, including accessibility, sanitation, and refugee facilities, the system enables decision-makers to assess the effectiveness of evacuation posts based on historical data. Although this research focuses on the 2021 Mount Semeru eruption, the system has global potential and can be adapted for use in various disaster-prone areas. TOPSIS-based SDSS can be customized to accommodate different geographic conditions and disaster types, including earthquakes, floods, hurricanes, and wildfires. However, the system still relies on historical data and cannot yet determine evacuation post locations in real time. Future research can integrate artificial intelligence (AI) and machine learning (ML) to analyze data and dynamically predict the optimal evacuation post locations. This approach will enhance the system's accuracy and efficiency in making quick decisions during emergencies. In conclusion, this study contributes to the development of a data-driven decision support system for evaluating evacuation posts. It also serves as a foundation for future research in AI/ML-based systems that can determine evacuation post locations in real time, improving disaster response efforts worldwide.

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