BORNEO JOURNAL OF SCIENCES AND TECHNOLOGY (BJoST)
VOL. : 6, ISSUE: 1 , 67-81
DOI: http://doi.org/10.35370/bjost.2024.6.1-08
e-ISSN: 2672-7439 © 2018, UTS Publisher.

University of Technology Sarawak

ORIGINAL ARTICLE

Decision Support System for Determining Priority Areas for Flood Evacuation

*[1]Azriel Christian Nurcahyo and [2]Kurniadin Abd Latief

[1]Information Technology Department, Shanti Bhuana Institute, Bengkayang 79211, West Borneo, Indonesia
[2]Department of Software Engineering, Bumigora University, Mataram 83127, West Nusa Tenggara, Indonesia

ABSTRACT - Flood is a natural disaster that can cause damage to the environment, economy and social aspects. Bengkayang Regency is one of the regencies in West Kalimantan that often experiences floods. Several natural factors that can cause flooding are high rainfall, soil clearance lower than sea level, embankments or river flows that cannot withstand rainwater discharge, and others. Because floods often occur, efforts are needed to be related to flooding management. One of the flood management efforts is preparedness efforts. Preparedness is a response or a way to deal with disasters. This study aims to determine priority areas for flood evacuation using AHP and TOPSIS methods. The AHP method is used to determine the weight value of the criteria automatically. The criteria used refer to the BPBD guidelines, which have 14 criteria. Determining the weight value is done automatically to avoid subjectively determining the weight value. At the same time, the TOPSIS method is used to rank priority areas for evacuation. The result of this study is an application of a decision support system by combining the AHP and TOPSIS methods, which can recommend priority areas for flood evacuation. The priority area for flood evacuation is Alternative A13, the Sungai Raya sub-district, with a preference value of 0.630218215.

ARTICLE HISTORY
Received: 21 July 2023
Revised: 20 Nov 2023
Accepted: 3 Jan 2024

KEYWORDS
Bengkayang Regency, Evacuation, Flood, AHP, Topsis.

INTRODUCTION

The ecology, the economy, and society are all significantly impacted by floods, which are substantial natural disasters. Most of the time, they are brought on by natural elements such as heavy rainfall, soil removal below sea level, and inadequate river embankments to manage precipitation discharge. In addition, changes in land use and climate change contribute to floods, which can destroy property, disrupt community activities, and even the presence of victims. Floods are one of the natural disasters that can cause damage to the environment, economy, and society [1]. Floods are usually caused by natural factors such as high rainfall, soil clearance lower than sea level, embankments or river flows that cannot withstand rainwater discharge and others [2; 3]. In addition, changes in land use and climate change can be one of the causes of flooding [4]. Floods can cause damage and loss of property, disrupt various community activities, and cause casualties [5]. Bengkayang Regency is one of the regencies in West Kalimantan through the expansion determined by the Regional Government, which consists of 17 sub-districts, 122 villages, and two definitive sub-districts [6]. Bengkayang Regency has three watersheds (DAS), namely: the Sambas, Selakau, and Mempawah [7]. Almost every year, Bengkayang Regency experiences flooding [8]. Based on data from BPS Singkawang City, for the last five years, Bengkayang Regency has experienced regular floods and flash floods. In 2018, Bengkayang Regency 4 flash floods submerged several sub-districts [9].

*Corresponding Author: Azriel Christian Nurcahyo. Shanti Bhuana Institute (SBI), email: azriel@shantibhuana.ac.id

Preparedness is a response or a way to deal with disasters. Preparedness is something that needs to be instilled in the community. One form of disaster preparedness is determining priority areas for flood evacuation. Evacuation is one of the crucial things in dealing with disasters [10]. Evacuation aims to move people to a safer place from disaster.

Regarding the problems above, there are several studies related to preparedness efforts that have been carried out, such as those carried out by Fernando and friends [11], namely planning for flood disaster evacuation sites based on Geographic Information Systems (GIS) Case Study Pekanbaru City, Rumbai District. The researcher used the Dijkstra method to determine evacuation sites in his research. Then, he utilized a geographic information system to display or present information on flood evacuation sites in the Rumbai sub-district, Pekanbaru City. From the research carried out by the analysis, it was found that 7 (seven) locations could be used as potential evacuation sites.

Another research was conducted by Batu and Fibriani, 2017 [2], which was about the analysis of determining the location of flood evacuation using geographic information systems and the Simple Additive Weighting (SAW) method in the case study of Surakarta City. In his research, researchers used the Simple Additive Weighting method in determining flood evacuation locations and the use of Geographic Information Systems to present and display information on flood evacuation locations. This study uses five criteria sourced from interviews with the BPBD. His research found the best location to be used as a flood disaster evacuation point.

Another research was conducted by Fauzia and friends [12], namely on the Analysis of Determining Flood Evacuation Locations Using Geographic Information Systems and Simple Additive Weighting Methods Case studies in the Cileungsi sub-district. In his research, researchers used the Simple Additive Weighting (SAW) method to determine flood evacuation locations and use Geographic Information Systems to present and display information on flood evacuation locations. This study uses six criteria to help determine its decision: floods and similar disasters, road distance, settlement distance, watershed distance, land use, and rainfall. The results of his research obtained the seven best location points as evacuation locations in Cileungsi District with Vacant Land Types, Low-Moderate Threat levels, Distance from the River 0-100 m, Distance from settlements to Evacuation Locations on average 0-250 meters, and Rainfall 151- 300 mm (low-medium).

Some of the studies above use the concept of a decision support system in supporting decisions regarding the determination of evacuation. A decision support system (DSS) is a system that supports decision-making by choosing the best option by comparing several available alternatives to solve a problem [13; 14], Both of these studies were conducted in Indonesia. In addition, Fauzia and colleagues contributed to this subject with their study on the analysis of flood evacuation locations in the Cileungsi sub-district, which utilized comparable approaches. The findings of this research highlight the significance of decision support systems (DSS) in evacuation planning. These DSS include techniques such as AHP, TOPSIS, SAW, and others [15]. This system is used as a tool in decision-making [16], not to make decisions, only to support decisions that the decision-maker still makes [17]. The decision support system has several methods, such as the Analytical Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW) and so on. In addition to using one of the methods from the DSS, several studies use criteria as a benchmark in supporting their decision-making. The criteria used from several previous studies vary in the number, and sources used depending on the focus of the problem being solved. This study aims to evaluate the efficiency of the evacuation plans in Bengkayang Regency and provide a complete evacuation strategy that uses decision support systems. This will ultimately result in an increase in the region's level of preparedness for future examples of flooding.

MATERIALS AND METHODOLOGY

This section is variously called Methods or Materials and Methods. It should give essential details, including experimental design, calculation and statistical analysis. Subtopic for the main topic should be bold and after a single spacing from the text before. For example; in this study there are several stages, namely data collection, modeling using AHP and TOPSIS, coding and testing. The flow of the research can be seen in Figure 1.

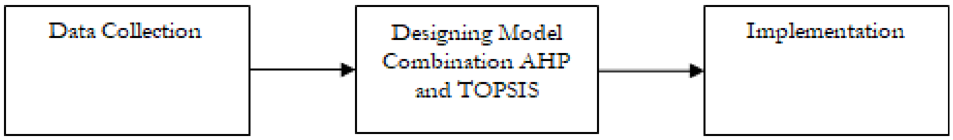

Figure 1. Research Flow

Data Collection – Step 1

The data utilized in this study comprises demographic data from Bengkayang Regency, acquired from the local government, and criterion data supplied from BNPB (Badan Nasional Penanggulangan Bencana) or the National Disaster Management Authority. The term 'Alternative' in Table 1 refers to the different sub-districts considered for flood evacuation planning. Within the framework of AHP and TOPSIS approaches, the term 'Alternatives' refers to distinct possibilities or choices that are accessible for decision-making. If a more precise designation is desired, 'Potential Evacuation Sites' could be an alternate nomenclature. Nevertheless, due to its established usage in AHP and TOPSIS methodologies, the word 'Alternative' will be maintained for consistency. Specifically, the study includes multiple phases: gathering data, applying AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) models, coding, and conducting tests. Figure 1 illustrates the sequence of steps involved in the research process.

Table 1. Alternative

Code	Alternative
A1	Bengkayang
A2	Capkala
A3	Jagoi Babang
A4	Ledo
A5	Lembah Bawang
A6	Lumar
A7	Monterado
A8	Samalantan
A9	Sanggau Ledo
A10	Seluas
A11	Siding
A12	Sungai Betung
A13	Sungai Raya
A14	Sungai Raya Kepulauan
A15	Suti Semarang
A16	Teriak
A17	Tujuh Belas

Table 2. Criteria

Code	Criteria
C1	Distance from river to settlement
C2	Flood Retaining Building
C3	Flood Detection Infrastructure
C4	Knowledge about flood
C5	Flood Disaster Preparedness
C6	Vulnerability Analysis
C7	Warning standard forecast
C8	Education
C9	Gender
C10	Age
C11	Sick person
C12	Work
C13	Riches
C14	Family members

Each of the above data is given a code. The initial data code C1 -C14 is criterion 1-14. While the codes A1-A17 are alternatives 1-17.

Designing Models with AHP and TOPSIS – Step 2

The study used a hybrid model that combines the Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) techniques. The Analytic Hierarchy Process (AHP) is employed to automatically assign weights and determine the priority of criteria, thereby reducing the reliance on subjective weighting. On the contrary, TOPSIS is used to prioritize and arrange locations that need to be evacuated during a flood by optimizing both positive and negative ideal solutions. Figure 2 depicts the sequential progression of the AHP and TOPSIS techniques. The flow of using the AHP and TOPSIS methods can be seen in the image below.

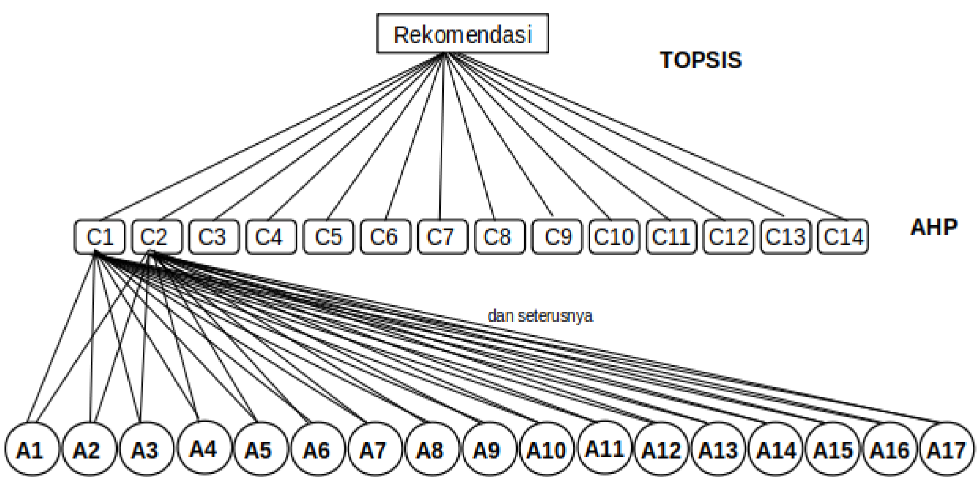

Figure 2. Combination AHP and TOPSIS

AHP

AHP is a decision support system method that uses multi-criteria analysis which uses a pairwise comparison process [18] to evaluate a complex decision by building a scoring matrix with an absolute scale of 1-9 [19; 20]. There are several stages in the weighting using AHP [21], namely :

1. Determine the level of importance between criteria using an absolute scale.
2. Create a pairwise comparison matrix for each criterion
3. Normalization
4. Calculate the average value of each criterion to be used as a weight
5. Calculating the Maximum Eigenvalue
6. Calculating Consistency Index (CI) and calculating Consistency Ratio (CR). To calculate CI can use Equation 1.

$$CI = \frac{(\lambda \max - n)}{(n - 1)} \quad (1)$$

Where λ max is the maximum Eigen value and n is the number of criteria. Meanwhile, to calculate CI can use Equation 2.

$$CR = \frac{CI}{RI} \quad (2)$$

7. Testing CR, if CR is more than 0.1 then this process should be repeated from level 1

For more details, the AHP flow in this study can be seen in Figure 3.

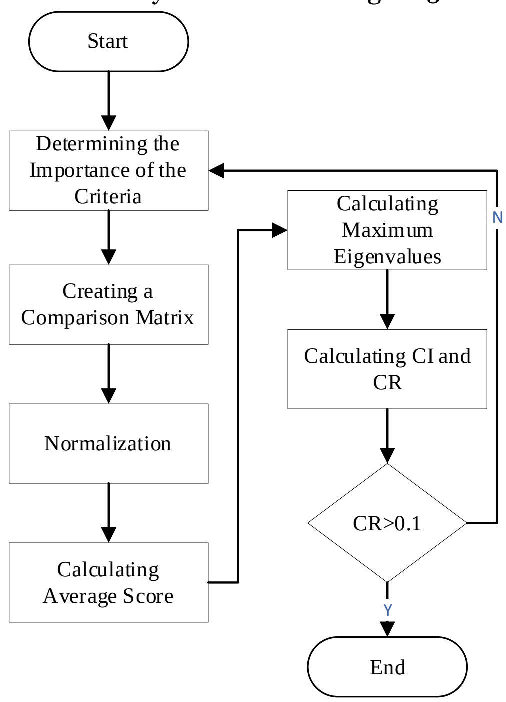

Figure 3. AHP Flow

TOPSIS

Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) is one of the decision support system methods which in getting a decision, this method not only chooses the alternative from the closest to the solution (Positive Ideal) but it will also choose the furthest of the (Negative Ideal) solution [22; 23]. In the TOPSIS method there are several stages, namely : [24]

1. Create a decision matrix
2. Automatic normalization of the decision by using Equation 3

$$R_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}^2}} \quad (3)$$

3. Weighting using the previous AHP results
4. Create a normalized weighted matrix using Equation 4.

$$Y_{ij} = W * r_{ij} \quad (4)$$

5. Determine the positive and negative ideal solutions based on the previous process using Equation 5

$$A^+ = (Y_1^+, Y_2^+, \dots \dots, Y_n^+) \quad (5)$$

$$A^- = (Y_1^-, Y_2^-, \dots \dots, Y_n^-) \quad (6)$$

6. Find the distance between the alternative and the positive and negative ideal solutions using Equations 7 and 8.

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (y_i^+ - y_{ij})^2} \quad (7)$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_i^-)^2} \quad (8)$$

7. Determine the preference value for each alternative using Equation 9.

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (9)$$

The TOPSIS flow in this study can be seen in Figure 4.

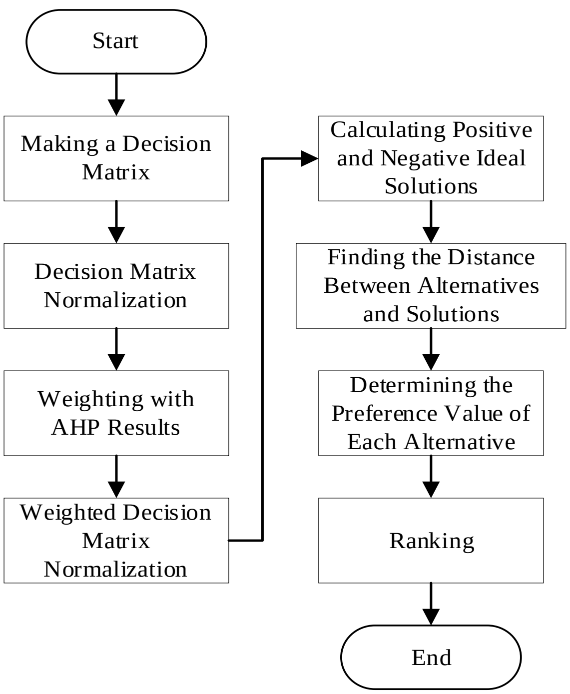

Figure 4. TOPSIS Flow

S.A.W. (Simple Additive Weighting)

The Simple Additive Weighting (S.A.W) method is often known as the weighted addition method. The basic concept of the S.A.W method is to find a weighted sum of the performance ratings for each alternative on all attributes. The S.A.W method requires a decision matrix normalization process (X) to a scale that can be compared with all existing alternative ratings. This S.A.W method requires the decision-maker to determine the weight for each attribute. The total score for the alternatives is obtained by adding up all the multiplication results between the rating (which can be compared across attributes) and the weight of each attribute. The rating of each attribute must be dimension-free in the sense that it has passed the previous matrix normalization process. The steps for completing the S.A.W are as follows:

a. Determine the criteria that will be used as a reference in making decisions, namely Ci.
b. Determine the suitability rating of each alternative for each alternative.
c. Making a decision matrix based on the criteria (Ci), then normalizing the matrix based on the equation adjusted for the type of attribute (profit attribute or cost attribute) in order to obtain a normalized matrix R.
d. The final result is obtained from the ranking process, namely the addition and multiplication of the normalized matrix R with the weight vector so that the largest value is chosen as the best alternative (Ai) as a solution. The formula for carrying out the normalization is as follows:

$$R_{ij} = \begin{cases} \dfrac{x_{ij}}{Max\ x_{ij}} & \text{If j is benefit} \\ \dfrac{Min\ x_{ij}}{x_{ij}} & \text{If j is cost attribute} \end{cases} \quad (10)$$

Where Rij is a normalized performance rating; Xij is the attribute value of each criterion; Max Xij is the greatest value of each criterion; Min Xij is the smallest value of each criterion; Benefit is the greatest value is the best; Cost is the smallest value is the best. Rij is the normalized performance rating of the alternatives Ai on attribute Cj; i = 1,2,..., m and j = 1,2,..., n. The preference value for each alternative (Vi) is given as:

$$Vi = \sum_{j=1}^{n} W_j R_{ij} \quad (11)$$

Where Vi is the ranking for each alternative, Wj is the weighted value of each criterion; Rij is the normalized performance rating value. A larger Vi value indicates that the alternative Ai is preferred.

Implementation – Step 3

At this stage, a decision support system is developed in determining the priority areas for flood disaster evacuation based on a website. At this stage, results were also tested to validate alternative rankings in determining priority areas for flood evacuation using the AHP and Topsis methods using manual calculations with system calculations

RESULTS AND DISCUSSION

This study combines the AHP and TOPSIS decision support system methods to determine priority areas for disaster evacuation in Bengkayang Regency where the AHP method is used for weighting and TOPSIS for ranking.

Implementation of AHP and TOPSIS

The implementation of the AHP and TOPSIS methods starts from the AHP process, which is to determine the level of importance of each criterion. The determination of the level of importance refers to an absolute rating scale of 1-9 where the level of importance can be seen in Table 3.

Table 3. Criteria Comparison Rating Scale

Intensity of Interest	Information
1	Both Elements have the same importance
3	One element is slightly more important than the other
5	One element is more important than the other
7	One element is clearly more absolutely important than the other
9	One element is absolutely more important than the other
2,4,6,8	Values between two adjacent values
The opposite	If activity i gets one point compared to activity j, then j has the opposite value compared to i.

The level of importance of each criterion in this study can be seen in Table 4.

Table 4. Criteria

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
C1	1	2	2	2	2	2	2	5	6	5	5	7	6	9
C2	0.5	1	1	2	2	2	2	5	6	5	5	7	6	9
C3	0.5	1	1	2	2	2	2	5	6	5	5	7	5	9
C4	0.5	0.50	0.50	1	2	2	2	5	6	5	5	7	5	9
C5	0.5	0.50	0.50	0.50	1	2	2	5	6	5	5	7	5	9
C6	0.5	0.50	0.50	0.50	0.50	1	2	5	6	5	5	7	5	9
C7	0.5	0.50	0.50	0.50	0.50	0.50	1	3	6	5	5	7	6	9
C8	0.2	0.20	0.20	0.20	0.20	0.20	0.33	1	2	2	3	5	5	7
C9	0.17	0.17	0.17	0.14	0.17	0.17	0.17	0.50	1	2	2	5	5	7
C10	0.2	0.20	0.20	0.20	0.20	0.20	0.20	0.50	0.50	1	2	5	3	7
C11	0.2	0.20	0.20	0.20	0.20	0.20	0.20	0.33	0.50	0.50	1	2	3	7
C12	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.20	0.20	0.20	0.50	1	2	5
C13	0.17	0.17	0.20	0.20	0.20	0.20	0.17	0.20	0.20	0.33	0.33	0.33	1	2
C14	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.14	0.14	0.14	0.14	0.20	0.50	1

Table 4 indicates the significance of each condition by referencing Table 3 upon determining the relative significance of each criterion. After that, the comparison matrix should be normalized, and the average value for each criterion should be determined. Table 5 displays the mean values for each criterion. The average results of each criterion can be seen in Table 5.

Table 5. Average Score Criteria

Criteria	Average Score
C1	0.159409
C2	0.132694
C3	0.131452
C4	0.11417
C5	0.104121
C6	0.095323
C7	0.084788
C8	0.042205
C9	0.035279
C10	0.032399
C11	0.026402
C12	0.01729
C13	0.015493
C14	0.008975

After getting the average value, the next step is to find the maximum Eigen value and also the CI value. The maximum eigenvalue obtained is Max λ = 16.03 and CI value = 0.156173014. So that the CR value is 0.099473258. where the CR value is less than 0.1. The CR value of 0.09 indicates that the weight of each criterion is fairly consistent so that this weighting can be used. The results of the weighting by the AHP method are used for the TOPSIS process. The alternative TOPSIS used in this study can be seen in Table 1. The alternatives shown in Table 1 are used to create a decision matrix based on the criteria in the AHP method. The decision matrix can be seen in Table 6.

Table 6. Decision Matrix

Alternative	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
A1	3	4	2	1	4	3	1	1	2	1	1	1	5	1
A2	1	4	4	1	2	2	3	4	1	3	2	1	2	1
A3	1	3	4	5	3	5	4	3	2	2	3	1	1	1
A4	4	1	2	3	5	2	2	4	2	3	4	2	2	5
A5	2	2	2	5	2	4	4	1	2	4	4	1	4	1
A6	2	4	4	2	1	3	3	4	2	2	3	1	4	3
A7	4	3	1	1	3	2	2	3	2	5	1	2	4	5
A8	3	3	3	5	1	3	3	3	1	1	3	3	1	5
A9	4	1	3	3	5	4	3	1	1	4	1	4	1	2
A10	4	1	4	1	3	5	2	2	2	1	2	2	1	2
A11	2	3	4	4	2	5	4	4	2	2	4	2	3	5
A12	3	2	4	4	3	4	5	1	1	2	3	2	1	2
A13	1	2	3	3	4	1	2	4	2	2	2	1	4	4
A14	2	2	1	4	5	5	3	1	2	4	1	2	2	4
A15	4	3	1	1	5	3	4	1	1	2	4	1	5	5
A16	3	1	3	5	3	5	2	2	1	1	2	2	2	5
A17	5	3	3	1	1	5	4	1	1	4	2	3	5	1

The decision matrix is then normalized. The results of the normalization are then used as material to make a weighted normalization matrix where the weight used is the weight of the results of the AHP calculation. The results can be seen in Table 7.

Table 7. Weighted Normalized Decision Matrix Results

Alternative	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
A1	0.038	0.048	0.021	0.008	0.030	0.018	0.006	0.004	0.010	0.003	0.002	0.002	0.006	0.001
A2	0.013	0.048	0.042	0.008	0.015	0.012	0.019	0.015	0.005	0.008	0.005	0.002	0.002	0.001
A3	0.013	0.036	0.042	0.042	0.023	0.030	0.026	0.011	0.010	0.006	0.007	0.002	0.001	0.001
A4	0.050	0.012	0.021	0.025	0.038	0.012	0.013	0.015	0.010	0.008	0.009	0.004	0.002	0.003
A5	0.025	0.024	0.021	0.042	0.015	0.024	0.026	0.004	0.010	0.011	0.009	0.002	0.005	0.001
A6	0.025	0.048	0.042	0.017	0.008	0.018	0.019	0.015	0.010	0.006	0.007	0.002	0.005	0.002
A7	0.050	0.036	0.011	0.008	0.023	0.012	0.013	0.011	0.010	0.014	0.002	0.004	0.005	0.003
A8	0.038	0.036	0.032	0.042	0.008	0.018	0.019	0.011	0.005	0.003	0.007	0.006	0.001	0.003
A9	0.050	0.012	0.032	0.025	0.038	0.024	0.019	0.004	0.005	0.011	0.002	0.008	0.001	0.001
A10	0.050	0.012	0.042	0.008	0.023	0.030	0.013	0.008	0.010	0.003	0.005	0.004	0.001	0.001
A11	0.025	0.036	0.042	0.034	0.015	0.030	0.026	0.015	0.010	0.006	0.009	0.004	0.004	0.003
A12	0.038	0.024	0.042	0.034	0.023	0.024	0.032	0.004	0.005	0.006	0.007	0.004	0.001	0.001
A13	0.013	0.024	0.032	0.025	0.030	0.006	0.013	0.015	0.010	0.006	0.005	0.002	0.005	0.002
A14	0.025	0.024	0.011	0.034	0.038	0.030	0.019	0.004	0.010	0.011	0.002	0.004	0.002	0.002
A15	0.050	0.036	0.011	0.008	0.038	0.018	0.026	0.004	0.005	0.006	0.009	0.002	0.006	0.003
A16	0.038	0.012	0.032	0.042	0.023	0.030	0.013	0.008	0.005	0.003	0.005	0.004	0.002	0.003
A17	0.063	0.036	0.032	0.008	0.008	0.030	0.026	0.004	0.005	0.011	0.005	0.006	0.006	0.001

The next step is to determine the matrix of positive and negative ideal solutions, the results of which are shown in Table 8.

Table 8. Results Matrix of Positive and Negative Ideal Solutions

Criteria	Positive	Criteria	Negative
Y1+	0.063	Y1-	0.013
Y2+	0.048	Y2-	0.012
Y3+	0.042	Y3-	0.011
Y4+	0.042	Y4-	0.008
Y5+	0.038	Y5-	0.008
Y6+	0.030	Y6-	0.006
Y7+	0.032	Y7-	0.006
Y8+	0.015	Y8-	0.004
Y9+	0.010	Y9-	0.005
Y10+	0.014	Y10-	0.003
Y11+	0.009	Y11-	0.002
Y12+	0.008	Y12-	0.002
Y13+	0.006	Y13-	0.001
Y14+	0.003	Y14-	0.001

Table 8 shows a matrix of positive and negative ideal solutions for each criterion. The next step is to determine the value of positive and negative solutions for each alternative. The results of the determination can be seen in Table 9.

Table 9. Value of the Positive and Negative Solutions of Each Alternative

Alternative	Positive	Negative
A1	0.058596	0.052436
A2	0.069383	0.052219
A3	0.055781	0.063321
A4	0.054344	0.055279
A5	0.056768	0.049669
A6	0.058308	0.055162
A7	0.058708	0.050438
A8	0.048034	0.056593
A9	0.047935	0.06055
A10	0.058636	0.057743
A11	0.047827	0.060192
A12	0.042693	0.060624
A13	0.068321	0.040087
A14	0.058843	0.051992
A15	0.053698	0.059354
A16	0.053955	0.055627
A17	0.050265	0.068148

The results in Table 9 are used to find preference values which are then sorted (ranking) based on the highest value. The ranking can be seen in Table 10.

Table 10. Ranking

Alternative	Preference
Sungai Raya	0.630218215
Capkala	0.570574863
Monterado	0.537886322
Lembah Bawang	0.533346389
Sungai Raya Kepulauan	0.530905427
Bengkayang	0.527742814
Lumar	0.513861006
Seluas	0.503837256
Ledo	0.49573687
Teriak	0.492369126
Suti Semarang	0.474981524

Jagoi Babang	0.468345904
Samalantan	0.459101086
Siding	0.442763893
Sanggau Ledo	0.441857167
Tujuh Belas	0.424490095
Sungai Betung	0.41322653

Based on Table 10, it is found that the priority area for flood disaster evacuation is the Sungai Raya sub-district with a preference value of 0.63. Next, try to compare the results obtained with the S.A.W. (Simple Additive Weighting) method. The initial data are C1-C14 as shown in Table 2. After that, determine whether to include benefits or costs and the weight vector which is shown in Table 11.

Table 11. Attribute and Weight of S.A.W.

Code	Criteria	Attribute	Weight
C1	Distance from river to settlement	Cost	0.15
C2	Flood Retaining Building	Cost	0.125
C3	Flood Detection Infrastructure	Cost	0.125
C4	Knowledge about flood	Benefit	0.025
C5	Flood Disaster Preparedness	Benefit	0.025
C6	Vulnerability Analysis	Cost	0.025
C7	Warning standard forecast	Cost	0.025
C8	Education	Benefit	0.05
C9	Gender	Benefit	0.125
C10	Age	Benefit	0.125
C11	Sick person	Cost	0.075
C12	Work	Cost	0.05
C13	Riches	Benefit	0.05
C14	Family members	Cost	0.025
	TOTAL		1.000

After that, Make a decision matrix based on the criteria on table 6 then normalizing the matrix based on the equation (10) adjusted for the type of attribute (profit attribute or cost attribute) in order to obtain a normalized matrix R as show in Table 12.

Table 12. S.A.W.'s Normalized

Alternative	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
A1	0,33	0,25	0,50	0,20	0,80	0,33	1,00	0,25	1,00	0,20	1,00	1,00	1,00	1,00
A2	1,00	0,25	0,25	0,20	0,40	0,50	0,33	1,00	0,50	0,60	0,50	1,00	0,40	1,00
A3	1,00	0,33	0,25	1,00	0,60	0,20	0,25	0,75	1,00	0,40	0,33	1,00	0,20	1,00
A4	0,25	1,00	0,50	0,60	1,00	0,50	0,50	1,00	1,00	0,60	0,25	0,50	0,40	0,20
A5	0,50	0,50	0,50	1,00	0,40	0,25	0,25	0,25	1,00	0,80	0,25	1,00	0,80	1,00
A6	0,50	0,25	0,25	0,40	0,20	0,33	0,33	1,00	1,00	0,40	0,33	1,00	0,80	0,33
A7	0,25	0,33	1,00	0,20	0,60	0,50	0,50	0,75	1,00	1,00	1,00	0,50	0,80	0,20
A8	0,33	0,33	0,33	1,00	0,20	0,33	0,33	0,75	0,50	0,20	0,33	0,33	0,20	0,20
A9	0,25	1,00	0,33	0,60	1,00	0,25	0,33	0,25	0,50	0,80	1,00	0,25	0,20	0,50
A10	0,25	1,00	0,25	0,20	0,60	0,20	0,50	0,50	1,00	0,20	0,50	0,50	0,20	0,50
A11	0,50	0,33	0,25	0,80	0,40	0,20	0,25	1,00	1,00	0,40	0,25	0,50	0,60	0,20
A12	0,33	0,50	0,25	0,80	0,60	0,25	0,20	0,25	0,50	0,40	0,33	0,50	0,20	0,50
A13	1,00	0,50	0,33	0,60	0,80	1,00	0,50	1,00	1,00	0,40	0,50	1,00	0,80	0,25
A14	0,50	0,50	1,00	0,80	1,00	0,20	0,33	0,25	1,00	0,80	1,00	0,50	0,40	0,25
A15	0,25	0,33	1,00	0,20	1,00	0,33	0,25	0,25	0,50	0,40	0,25	1,00	1,00	0,20
A16	0,33	1,00	0,33	1,00	0,60	0,20	0,50	0,50	0,50	0,20	0,50	0,50	0,40	0,20
A17	0,20	0,33	0,33	0,20	0,20	0,20	0,25	0,25	0,50	0,80	0,50	0,33	1,00	1,00

Implementation System

This stage is used for the application development stage. The developed system is a website-based application. The system was developed using the PHP programming language and MySQL database. The process of this application begins by entering data, then the calculation process occurs. After doing the calculation process using AHP and TOPSIS based on the input on the previous forms, the ranking results are obtained. Display application implementation as well ranking results can be seen in Figure 5.

Figure 5. Ranking Result

The results of system calculations and manual calculations have the same results, namely recommending Sungai Raya sub-district as an evacuation priority area with a preference value of 0.630218215. With the developed decision support system, it can facilitate and speed up the Bengkayang BPBD in making decisions in determining priority areas for flood disaster evacuation. The final result is obtained from the ranking process, namely the addition and multiplication of the normalized matrix R with the weight vector based on equation (11) so that the largest value is chosen as the best alternative (Ai) as a solution as shown in table 13.

Table 13. S.A.W. Ranking

Alternative	Preference	Ranking
Sungai Raya	0,564583	1
Sungai Raya Kepulauan	0,568333	2
Monterado	0,596667	3
Lembah Bawang	0,60875	4
Ledo	0,61875	5
Jagoi Babang	0,5175	6
Capkala	0,681667	7
Bengkayang	0,361667	8
Sanggau Ledo	0,54375	9
Lumar	0,49125	10
Suti Semarang	0,492917	11
Siding	0,3875	12
Seluas	0,685417	13
Teriak	0,684583	14
Tujuh Belas	0,4975	15
Sungai Betung	0,474167	16
Samalantan	0,43875	17

Both ranking results on table 10 and table 13 placed “Sungai Raya” at first place. The Difference starts from the second until the seventeenth.

In the AHP process, pairwise comparison matrices are created for each criterion, followed by normalization and calculation of average values for each criterion to be used as weights. The equations used for calculating the Maximum Eigenvalue, Consistency Index (CI), and Consistency Ratio (CR) are also applied. For TOPSIS, a decision matrix is created and normalized. The weights from the AHP results are applied to this matrix, and then positive and negative ideal solutions are determined. The distance between each alternative and these ideal solutions is calculated, leading to the final preference values for each alternative. The SAW (Simple Additive Weighting) method, mentioned briefly, involves normalizing a decision matrix and determining weights for each attribute, leading to a weighted sum of performance ratings for each alternative. Benchmarking involves comparing the results obtained from the AHP and TOPSIS methods with those derived from the SAW method. This comparison is crucial to evaluate the effectiveness and reliability of the proposed method. To perform this benchmarking, the results (preference values and rankings) obtained from the AHP and TOPSIS methods are compared with the rankings derived from the SAW method. This comparison is visualized in Table 13, where each alternative's ranking according to both methods is displayed. Accuracy in this context refers to how closely the rankings obtained from the proposed method (AHP and TOPSIS) align with those from the SAW method. The closer the rankings, the more accurate the proposed method is considered. The study shows that both methods rank 'Sungai Raya' as the highest priority area for flood evacuation, indicating a degree of accuracy in the proposed method. The consistency in the top-ranking alternative suggests that the proposed method is reliable in identifying priority areas for flood evacuation. In summary, the values in the tables are generated based on the detailed methodologies of AHP and TOPSIS, as well as the SAW. method. The benchmarking between the proposed method and SAW. Ranking, specifically in terms of their alignment and accuracy, demonstrates the efficacy of the proposed decision-support system in identifying priority areas for flood evacuation in Bengkayang Regency.

CONCLUSION

The research was conducted utilizing data obtained from Bengkayang Regency and BNPB. The prioritization of flood evacuation places in Bengkayang Regency is conducted through a hybrid approach involving the Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methodologies. This approach incorporates 14 criteria and evaluates 17 alternative areas. The flood evacuation priority zones have been determined, and the Sungai Raya area has been identified as the top priority with a Preference value of 0.630218215. The implemented system generates the same rankings as the developed system. A recommendation for future research is to incorporate additional variables and employ specific methodologies to mitigate subjectivity in assessing the amount of relevance as perceived by users.

ACKNOWLEDGEMENT

The authors express gratitude to the Indonesia Ministry of Education and Culture for providing the financial assistance through grant specifically allocated for research conducted by novice lecturers (PDP). The authors would like to acknowledge LLDIKTI 11 for providing the study contract, as well as the LPPM Shanti Bhuana Institute for their aid in conducting this research, and the BNPB Bengkayang for their support.

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