Decision Support System for Determining Flood Evacuation Locations in Kabupaten Bandung Using the Simple Additive Weighting (SAW) Method

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Abstract. *West Java Province is one of the provinces with the most flood disasters, which is 863 times and the highest number of floods occurred in Kabupaten Bandung is 228 times. Because floods often occur in Kabupaten Bandung make BPBD (Badan Penanggulangan Bencana Daerah) must respond to this problem, including by choosing a quick evacuation location. Choosing an appropriate evacuation route is very helpful in reducing losses and especially saving people's lives. So we need a computer-based system that can help BPBD in determining which location is most suitable as an evacuation location in Kabupaten Bandung by using the SAW (Simple Additive Weighting) method. This method is a simple weighting method or additional weighting to solve problems in a decision support system. The results of this study are a rank of recommendations for evacuation locations in Kabupaten Bandung. To test the feasibility and suitability of the system, a BlackBox test and user acceptance test was carried out.*

Keywords: *decision support system; evacuation location; flood; simple additive weighting*

I. INTRODUCTION

Floods are inundation on lands that is usually dry such as on agricultural lands, settlements, or city centers. Floods can occur because the discharge or volume of water in a river or drainage exceeds its flowing capacity. According to data from Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) which informs the potential for moderate to heavy rain of a local nature accompanied by strong winds, lightning, or thunderbolts in several areas. The areas that have the potential moderate to heavy rain are Kabupaten Garut, Kabupaten Cianjur, Kabupaten Bandung Barat, Kabupaten Bandung, Kota Bandung, Kota Cimahi, Kabupaten Cirebon, Kabupaten Kuningan, Kabupaten Bogor, Kota Bogor, Kabupaten Sukabumi, and Kota Sukabumi.

West Java Province is one of the provinces with a high number of flood events, which amounted to 863 times. The largest number of flood events was in Kabupaten Bandung, which is recorded 228 times. The high number of flood cases in Kabupaten Bandung is affected by the morphological conditions of the land, namely basins, and anthropogenic factors including transform forest land into agricultural land (Irawan, Hidayat, and Tjahjono 2018). According to a report from the Badan Penanggulangan Bencana Daerah (BPBD), Kabupaten Bandung areas that frequently experience flooding are Kecamatan Baleendah, Kecamatan Dayeuhkolot, and Kecamatan Bojongsoang.

The frequent flooding in Kabupaten Bandung makes BPBD respond to this problem, including the selection of evacuation locations quickly. So, a computer-based system is needed that can assist BPBD in determining the location of flood disaster evacuation with several established criteria. Therefore, choosing the right evacuation route is very helpful in reducing losses and especially saving lives. According to Peraturan Badan Nasional Penanggulangan

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Bencana Republik Indonesia Nomor 3 Tahun 2018, evacuation location is temporary shelters for disaster victims to evacuate, either in the form of mass shelters or families, or individuals. The development of this flood evacuation location determination system aims to provide calculation results using the SAW (Simple Additive Weighting) method to determine which location is the most suitable to be used as a flood evacuation location in Kabupaten Bandung.

II. RESEARCH METHOD

A Decision Support System (DSS) is a computer-based system that can assist in decision making by utilizing data and models for solving unstructured or semi-structured problems. The basic concept of a decision support system is a model-based system consisting of procedures for processing data and considering them to assist managers in making decisions. The system must be simple, easy to control, adaptable, and complete (Limbong et al. 2020).

The flows of the process to determining the evacuation location of a flood incident with a decision support system are shown in Figure 1.
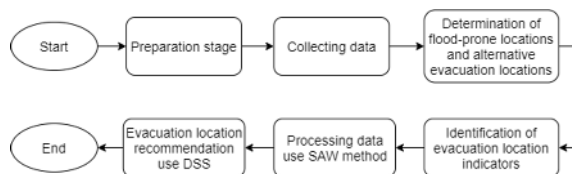

Figure 1. Research Methodology

Based on Figure 1, the first step is the preparation stage to find out the problem, then doing a literature study to solve the problem. Then the author collects data from Kabupaten Bandung area. After that, flood-prone locations will be determined then the alternative evacuation locations. The next step is to identify indicators of evacuation locations. Then the data processing is carried out using the SAW method so that later the output that will be obtained is a recommendation for flood evacuation locations in Kabupaten Bandung. The results of the recommendations are displayed in a decision support system for determining the evacuation location.

Simple additive weighting is a simple weighting method or weighted addition to solving problems in a decision support system. The concept of this method is to find a ranking based on a priority scale for each alternative in all attributes (Nofriansyah and Defit 2017). The algorithm or steps taken to solve this method are:
a. Step 1: define the criteria that will be used as a pale for solving the problem.
b. Step 2: normalize each alternative value on each attribute by calculating the performance rating value.
c. Step 3: calculate the value of the preference weight on each alternative.
d. Step 4: do the ranking.

In the completion of the system for determining the location of flood disaster evacuation, it can be done with an agile development approach including rapid application development, SCRUM, XP, and others. For the case of determining the location of the flood disaster evacuation, flexible methods can be applied, therefore the agile method is chosen. The agile method that will be used is Rapid Application Development (RAD) because this project takes a fairly short time/rapid time, more flexible and easier if there are many changes. This RAD method has stages that have been shortened so that it cuts down on system design and work time (Matjik and Andry 2019). The following are the stages of the RAD method, namely planning, analysis, design, and implementation.

System testing is carried out to ensure that the function is fully operational so that it is said to be suitable for use. System testing is also carried out to find errors in each function that focuses on system data input, display, memory usage, and speed in data execution. System testing is done to find out the system designed is feasible to use and reduce errors that exist in the system. In addition, system testing is made to find out whether the system is following the initial objectives (Rosalina et al. 2020). In this study, two system tests will be carried out, namely blackbox testing and user acceptance tests.

Black-box testing is a test method performed on software to determine its internal performance. Software or software is seen as a black box or black box whose contents are never seen and it is enough to carry out a testing process on the outside. In black-box testing, the software is executed, and tests are carried out to meet user needs that have been defined in the initial goal (Salamah and Khasanah 2017)). According to Rosalina et al. (2020), the stages of black-box testing based on equivalence partitions are:

a. Create a test case design from the functions that exist in software testing,
b. Creating equivalence partitions test limits,
c. Create test models from scenarios and expected outcomes, and
d. Perform testing based on the model that has been made.

User Acceptance Test (UAT) is usually performed by the client or end-user. The reason for doing UAT is to identify what the system will do and what benefits will be obtained by end-users, where this test is carried out before the system is implemented (Mohd and Shahbodin 2015). UAT usually includes requirements focus, systems designed for testing, and usability considerations. A comprehensive UAT checklist ensures that the process is done the right way. The following is a guide for conducting UAT based on research by Pandit and Tahiliani (2015).

a. Use iterative, scalable, and documented processes
b. Make sure the functionality is acceptable to business users
c. Include business users as approvers at every stage of the project
d. Make the implementation available to the user community
e. Design user acceptance test to simulate
f. Get approval from the user to proceed to the next stage of development.

III.　RESULT AND DISCUSSION

Determination of the location of flood evacuation can be seen from several variables such as the location of the building, the condition of the building, and others. The following variable indicators that can be considered for determining flood disaster evacuation locations can be seen in Table 1. Alternative data for flood disaster evacuation locations in Kabupaten Bandung can be seen in Table 2.

Table 1. Evacuation Location Criteria

Author's research	Criteria	Sub-criteria
Suharyanto (2012)	Building condition	Location from the road
		Number of floors
		Volume capacity
	Function of bulidings	-
Ardana and Purwanto (2013)	Location altitude	-
Abror and Sigit (2019)	Flood height	-

Table 2 Location Alternative

Flood Area	Evacuation Location
Baleendah	Shelter Parunghalang
	Masjid Al Huda Andir
	GOR Kelurahan Baleendah
	Gedung INKANAS
Dayeuhkolot	Aula Desa Dayeuhkolot
	Masjid Ashofia
	Puskesmas Dayeuhkolot
	Masjid Al Mustofa
Bojongsoang	SMPN 1 Bojongsoang
	Gudang Tenggo
	Pom Cikarees

Table 3 Weighting Criteria

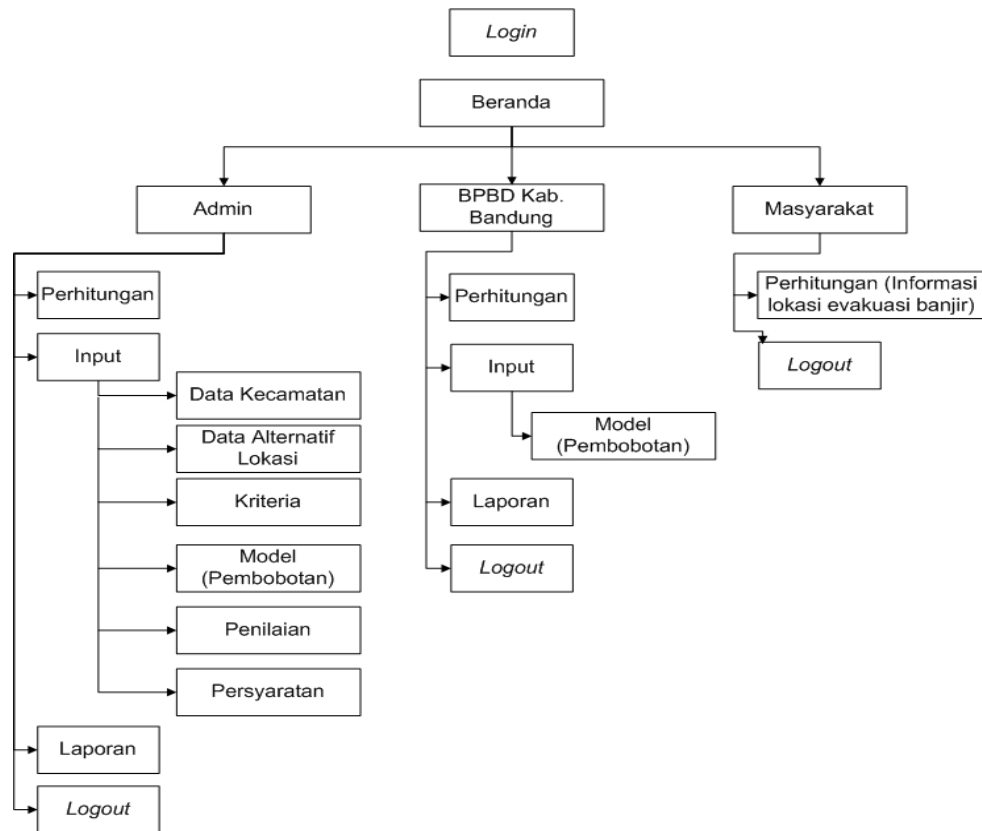| Criteria	Status	Weight
Location from the road	Min	0.2
Number of floors	Max	0.1
Volume capacity	Max	0.1
Function of bulidings	Max	0.2
Location altitude	Max	0.2
Flood height	Max	0.2

Figure 2 System Menu Structure

Table 4 Assestment of Alternative Location

Location Name	Building condition			Function of buildings	Location altitude	Flood height
	Location from road	Numbers of floors	Volume capacity			
Shelter Parung halang	3	3	2	2	2	2
Masjid Al Huda Andir	4	1	1	1	2	4
Gor Kelurahan Baleendah	3	1	4	2	3	4
Gedung INKANAS Baleendah	2	2	2	3	3	2
Aula Desa Dayeuhkolot	4	1	2	2	2	4
Masjid Ashofia	4	1	2	1	2	4
Puskesmas Dayeuholot	3	1	1	2	2	2
Masjid Al Mustofa	3	1	2	1	1	4
SMPN 1 Bojongsoang Bandung	4	1	3	1	2	2
Gudang Tenggo	1	4	4	2	4	4
Pom cikarees	4	1	1	1	1	2
Status	Min	Max	Max	Max	Max	Max

The weighted criteria for calculating the determination of the evacuation location and the status of the criteria can be seen in Table 3. The design of the evacuation location determination system is designed following the access rights of each user (admin, BPBD, and the community). The menu structure available in this system can be seen in Figure 2, where the admin has access to all menus. Then for BPBD have access to the home menu, input weight values in the model menu, see the results of the decision on flood evacuation locations in the calculation, report, and logout menu. Meanwhile, public can access the dashboard and see the results of the decision on the location of the flood evacuation.

Table 6 Normalization

Location Name	Building condition			Function of buildings	Location altitude	Flood height
	Location from road	Numbers of floors	Volume capacity			
Shelter Parung halang	0,67	1,00	0,50	0,67	0,67	0,50
Masjid Al Huda Andir	0,50	0,33	0,25	0,33	0,67	1,00
Gor Kelurahan Baleendah	0,67	0,33	1,00	0,67	1,00	1,00
Gedung INKANAS Baleendah	1,00	0,67	0,50	1,00	1,00	0,50
Aula Desa Dayeuhkolot	0,75	1	1	1	1	1
Masjid Ashofia	0,75	1	1	0,5	1	1
Puskesmas Dayeuholot	1	1	0,5	1	1	0,5
Masjid Al Mustofa	1	1	1	0,5	0,5	1
SMPN 1 Bojongsoang Bandung	0,25	0,25	0,75	0,75	0,5	0,5
Gudang Tenggo	1	1	1	1	1	1
Pom cikarees	0,25	0,25	0,25	0,25	0,25	0,5

Table 7 Ranking

Name of Location	Building condition			Function of buildings	Location altitude	Flood height	Total	Rank
	Location from road	Numbers of floors	Volume capacity					
Weight	0,2	0,1	0,1	0,2	0,2	0,2		
Shelter Parung halang	0,13	0,10	0,05	0,13	0,13	0,10	0,65	3
Masjid Al Huda Andir	0,10	0,03	0,03	0,07	0,13	0,20	0,56	4
Gor Kelurahan Baleendah	0,13	0,03	0,10	0,13	0,20	0,20	0,80	2
Gedung INKANAS Baleendah	0,20	0,07	0,05	0,20	0,20	0,10	0,82	1
Aula Desa Dayeuhkolot	0,15	0,10	0,10	0,20	0,20	0,20	0,95	1
Masjid Ashofia	0,15	0,10	0,10	0,10	0,20	0,20	0,85	3
Puskesmas Dayeuholot	1	1	0,5	1	1	0,5	0,85	2
Masjid Al Mustofa	1	1	1	0,5	0,5	1	0,80	4
SMPN 1 Bojongsoang Bandung	0,25	0,25	0,75	0,75	0,5	0,5	0,50	2
Gudang Tenggo	1	1	1	1	1	1	1,00	1
Pom cikarees	0,25	0,25	0,25	0,25	0,25	0,5	0,30	3

Because the application is designed in Indonesian, the following in Table 7 is the identification of the criteria in the system (in Indonesian).

Table 5 Identification Criteria

Criteria in English	Criteria in Indonesia
Location from the road	'Jarak dari jalan'
Number of floors	'Jumlah lantai'
Volume capacity	'Kapasitas bangunan'
Function of bulidings	'Fungsi bangunan'
Location altitude	'Ketinggian Lokasi'
Flood height	'Ketinggian Banjir'

The calculation results of the designed system are adjusted and must be the same as the results of manual calculations, to ensure that the calculation results are appropriate. Table 4 shows the assessment for each alternative evacuation location according to the existing criteria based on the actual conditions or conditions according to the alternative location.

After the assessment, the normalization calculation is carried out which can be seen in Table 5. The normalization calculation uses the formula below, where the max for each matrix element is divided by the max value of the matrix row while the min for the minimum value of the matrix column is divided by each matrix element. The ranking stage is done by multiplying the weight of the criteria with the normalized value matrix row. Then look for the number or total for each alternative and determine the ranking. Table 6 shows the recommended alternative evacuation sites to be selected based on their ranking. The calculation results above have the same value as the application. So that the results of this manual calculation can ensure that the functionality of

the system or application runs well for the calculation process.

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{max\,x_{ij}} \\ \dfrac{min\,x_{ij}}{xij} \end{cases} \tag{1}$$

The functionality analysis from the results of the design system for determining evacuation locations in Kabupaten Bandung can be seen in next paragraphs.

Login is the first interface was shown when the user accesses the system. Users will login by inputting the username and password according to the role. During the login process, the system will process the username and password that are inputted according to the database. If the data is correct, the user will be able to get into the dashboard page. However, if the username and password data do not match, the system will display the login page.

On the home page, the appearance of the homepage will be the same for all users, it will display a welcome greeting page.

Figure 5 shown the calculation results for flood evacuation locations. The 'Perhitungan' menu can be seen by all users. On this page, we can see postal code information, selected locations with values for each kecamatan. Where the values here are sorted by priority from highest to lowest. The greater the value shown for each alternative, the more recommended.

Figure 6 shown the name of the kecamatan that is prone to flooding. In this menu, admin can input or edit the names of flood-prone areas and in this case there are three kecamatan, there are Bojongsoang, Baleendah, and Dayeuhkolot.

On this page, the admin can input or edit information on areas or places that are alternative locations for flood evacuations with available information, namely postal code, kecamatan,
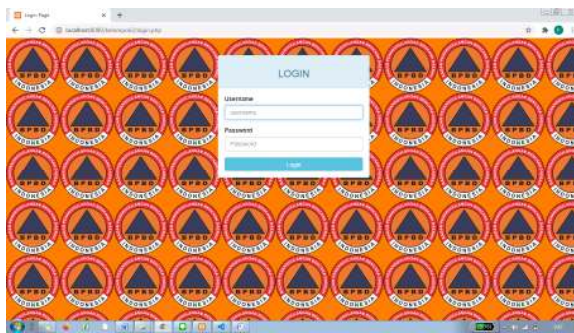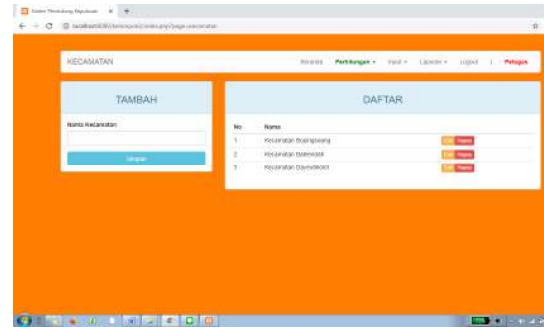

Figure 3 Login
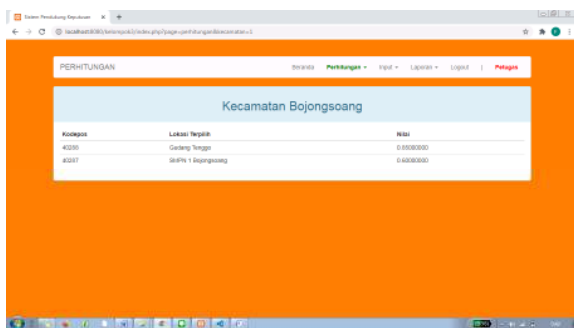

Figure 4 Home Page

Figure 6 Input Kecamatan Menu
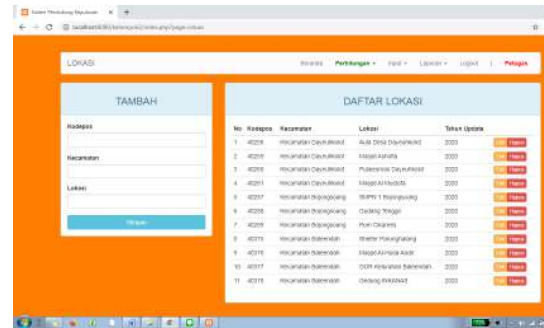

Figure 5 Calculation Result
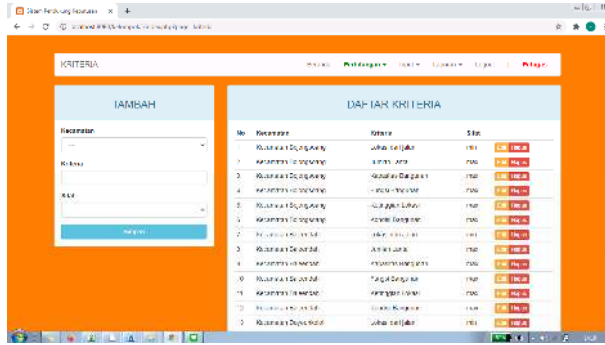

Figure 7 Input Location
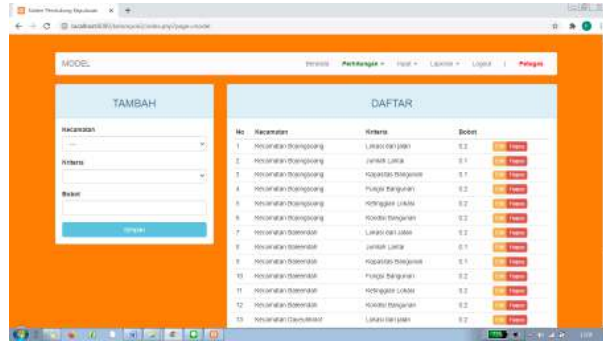
Figure 8 Input Criteria
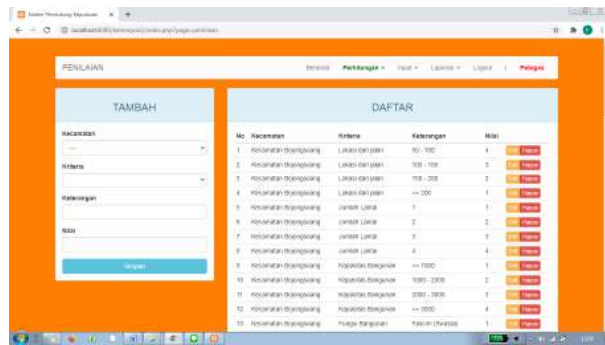

Figure 9 Input Model Menu
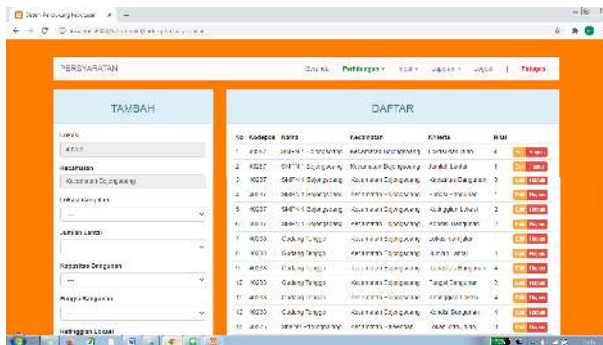

Figure 10 Input Assesment

Figure 11 Input Requirement

location name, and year of update from the information shown in Figure 7.

Figure 8 shown the criteria input page. In this menu, it can be seen that the admin can input or edit the criteria data for each kecamatan with the information displayed, namely kecamatan, criteria, and characteristics (max which indicates the greater the value the better and min for vice versa).

Figure 9 shown the menu for inputting the weight values of each kecamatan based on the criteria. Where admin or BPBD can input or edit the weight value data based on the kecamatan and its criteria which can then be stored as input for calculating decisions in the system. The weight value is assumed in this case.

In addition to the weight input page, there is also a page for input values for each alternative location criteria or data crips. Admin will input crips data in the form of kecamatan, criteria, and information for each criterion with a predetermined value. After the admin saves the assessment input, the data entered will be visible

in the list table. Then if the assessment data has been inputted, the admin can enter the requirements menu.

Figure 11 shown the view of the requirements menu. This menu contains information on alternative evacuation locations, namely postal codes, place names, kecamatan criteria, and values. On this page the admin will enter location data and information on criteria based on the information that has been made on the assessment menu and this input is adjusted to the alternative reality conditions. After inputting the information, the admin can save it. The data will be stored by the system and become the basis for determining evacuation location decisions.

In accordance development of RAD, a cutover stage is carried out which includes the system testing stage. This test is carried out to determine the suitability of the system that has been designed. In this case, the testing method used is blackbox testing and User Acceptance Test (UAT). Blackbox testing is a test that is run by

Table 8 Blackbox Testing

Scenario	System	Status
All user (Admin, BPBD and public)		
User login to the system	Users can login to the system with the display according to their respective access rights.	Succeed
User login with the wrong username and password.	User cannot login and it will return to login page	Succeed
User can see the visualization of the results of the decision of the flood evacuation location for each kecamatan	System display the results of the decision on the location of the flood disaster evacuation for each kecamatan	Succeed
Admin		
Admin inputs information of kecamatan, alternative evacuation locations and criteria	System shown information of kecamatan, alternative evacuation locations and criteria	Succeed
Admin changes or edits information of kecamatan, alternative evacuation locations and criteria	System shown information of kecamatan, alternative evacuation locations and criteria after being changed or edited	Succeed
Admin inputs information for each criterion with the value that has been set and saves it	System save the data and display the data saved in the list table	Succeed
Admin changes the description for each criterion with the value that has been set and saves it	System save the data and display the data saved in the list table after being changed	Succeed
Admin inputs alternative location data regarding criteria based on the information that has been made on the assessment menu and can save it	System save the data and display the requirements information data	Succeed
Admin changes alternative data regarding criteria based on information made on the assessment menu and can save it.	System stores the latest data and displays the latest requirements information data.	Succeed
BPBD Kabupaten Bandung		
BPBD input the weight of each criterion for each kecamatan in the model menu and save it.	System save the data and display alternative location information along with the weights in the list table.	Succeed
BPBD input the weight of each criterion for each kecamatan in the model menu and save it.	System save the data and displays alternative location information along with the latest weights in a list table.	Succeed
BPBD input the total weight does not match	System will remain on the weight input page	Succeed

the user by running the system in search of alternative recommendations for evacuation locations which can be seen in Table 8. UAT testing is carried out by making and filling out questionnaires by stakeholders (users) which can be used as feedback for the system that has been made. UAT testing can be seen in Table 9.

Based on Table 9, information on the results of the User Acceptance Test (UAT) can be seen. The results are presented in percentages value, where the percentage of system testing with yes answers gets 100% results, while the percentage with no answers is 0%. From these results, it can

be concluded that the designed system belongs to the very good category. So that the website-based flood disaster location determination system with the SAW method can be accepted by users.

IV. CONCLUSION

From the results of data gathering, it can be seen that there are three kecamatan in Kabupaten Bandung that are prone to flooding, namely Baleendah District, Dayeuhkolot District, and Bojongsoang District. For the alternative locations in each kecamatan, there are:

Table 9 UAT

Parameter		Question	Result Yes	Result No	Notes
Design	1	Is the system interface design attractive/appealing?	√		
	2	Is the menu system well comprehending?	√		
	3	Is the data displayed in accordance with the requirement of the user?	√		
Performance	1	Does the system response run quickly when accessed by the user?	√		
	2	Does the system respond according to the given action?	√		
Conformance	1	Has the system been able to represent the determination of the location of flood disaster evacuation in Bandung Regency?	√		
	2	Is the system able to coordinate the data and information needed to determine the location of flood disaster evacuation in Kabupaten Bandung?	√		
Features	1	Can the system features help in determining the policy of flood evacuation locations in Kabupaten Bandung for the future?	√		
	2	Are the features and structure of the system easy for users to understand?	√		
Trust	1	Can the system save the data and be trusted to manage information on the best alternative decisions for flood evacuation locations in Kabupaten Bandung?	√		

Table 10 UAT Result

Parameter	Result Yes	%	No	%
Design	3/3	100%	0	0%
Performance	2/2	100%	0	0%
Conformance	2/2	100%	0	0%
Features	2/2	100%	0	0%
Trust	1/1	100%	0	0%

1. Kecamatan Baleendah: Shelter Parunghalang, Masjid Al Huda Andir, GOR Kelurahan Baleendah, and Gedung INKANAS Baleendah.
2. Kecamatan Dayeuhkolot: Aula Desa Dayeuhkolot, Masjid Ashofia, Puskesmas Dayeuhkolot, and Masjid Al Mustofa.
3. Kecamatan Bojongsoang: SMPN 1 Bojongsoang, Gudang Tenggo, and Pom Cikarees.

From the data that has been collected, then a decision support system is designed that can perform data processing using the SAW method to produce alternative flood evacuation locations in Kabupaten Bandung. The input data are flood-prone areas, criteria for evacuation locations, alternative evacuation locations, and weight input from BPBD. After the results of manual SAW calculation or the results of the SAW calculation on the system are same, so it can be concluded that the system to be developed can be used as decision support for determining the location of flood disaster evacuation in the Kabupaten Bandung area.

After blackbox testing, where the planned scenario is following the results of the existing system, the system test is said to be successful. Therefore, if all the planned scenarios are successfully tested using blackbox testing, the system is appropriate and can be used as a decision support system for determining the location of flood evacuation in Kabupaten Bandung area.

In this study, there are still some limitations, and it has become suggestions that are expected to be applied to further research for improvement in this system. The suggestions are:
1. It is necessary to develop applications in feature or interface in accordance to technological and information developments, or the system is expected to be more flexible to changes.
2. For the access rights function, it can be improved that the accounts in the application are still divided based on roles, not usernames.

3. Visualization of alternative flood evacuation locations like maps and access points.
4. Use other decision support methods such as WSM, TOPSIS, AHP, and others.

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