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Application of simple additive weighting in the decision support system for determining the best location of temporary waste storage places

Isminarti [a,1,*], Deny Wiria Nugraha [b,2], Yuri Yudhaswana Joefrie [b,3], Andipa Batara Putra [b,4], Widya Wisanty [c,5]

[a] Politeknik Bosowa, Jl. Kapasa Raya No. 23, Makassar, South Sulawesi 90245, Indonesia
[b] Tadulako University, Jl. Soekarno Hatta Km. 9, Palu, Central Sulawesi 94119, Indonesia
[c] Universitas Sawerigading, Jl. Kandea No. 127, Makassar, South Sulawesi 90213, Indonesia
[1] isminarti@politeknikbosowa.ac.id*; [2] deny.wiria.nugraha@untad.ac.id; [3]yuri.yudhaswana@untad.ac.id, [4]andipabp@gmail.com, [5]wwisanty@gmail.com
* corresponding author

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ABSTRACT

Waste is a material that is discarded or discarded as a result of human or natural activities. The increase in waste is proportional to the level of human use of goods used in everyday life. Until now, the waste problem has always been a complaint for all people in cities and villages. One effective way to deal with the waste problem is to select the ideal location for a Temporary Waste Storage Site (TPS). This research aims to build a system that can determine the best location for waste TPS using a Decision Support System (DSS) method of Simple Additive Weighting (SAW). In this study, seven assessment criteria were used with 148 test data. The tests showed that the computing time required to get the ranking was 12,528 seconds, and memory usage was 226,2422 kb. Also, this system produces an accuracy level of 93.24%, which shows that it can function well using the SAW method and has a pretty good level of accuracy.

1. Introduction

Currently, the environment around the house cannot be separated from what is called rubbish, which is a material discarded or discarded due to human or natural activities. The increase in waste is proportional to the level of human use of goods used in daily life. One effective way to deal with the waste problem is to select the ideal location for a TPS. The role of waste TPS is vital for the community and the government in maintaining environmental cleanliness. In the Palu City area, there are still several problems related to waste TPS, including the number of waste TPS, which is still minimal, and there are complaints from the public about the placement of waste TPS in inappropriate locations and which are considered to disturb the comfort of several local communities. This is why many people throw rubbish carelessly, resulting in large piles of rubbish in an area. Based on the description above, the formulation of this research problem is how to design and build a decision support system to determine the best location for waste landfills using the SAW method. Meanwhile, this research aims to build a decision support system that can assist in making decisions efficiently to determine the best location for waste TPS using the SAW method, and the output of the system built is visualization mapping where the map will display the location of waste TPS, making it easier for the public. Know the location of the waste landfill.

There have been several previous studies related to decision support systems in determining the best location for waste landfills and the SAW method, a researcher A researcher developed two multi-criteria decision-making approaches involving subjective and objective criteria for warehouse location selection. The Brown and Gibson approach estimates the warehouse location selection index by combining subjective factor measurement (SFM) and objective factor measurement (OFM). This study finds that the proposed methodology is effective as a multi-criteria decision-making (MCDM) tool for evaluating and selecting warehouse locations in the supply chain [1]. Another researcher conducted the Decision Support System for Determining the Best Location for Temporary Waste Disposal Sites Using the Brown-Gibson Method. The results of this research produce an output ranking of priority values for alternative locations so that each alternative with the highest value has a greater chance of being the best location for making a temporary waste dump using the Brown-Gibson method and using visualization mapping as the output of the system created [2].

The researcher conducted the Decision Support System for Determining Final Disposal Locations for Samarinda City Waste, Desktop-Based Simple Additive Weighting Method. The results of this research build a desktop-based system by utilizing SPK to help people make decisions quickly, precisely, and consistently in determining the location of final waste disposal sites (TPA) using the SAW method [3]. Another research was conducted by regarding Decision Support Systems for Selecting Residential Housing in Housing Using the SAW method (Case Study: Samarinda City). The results of this research produce a system for selecting a residence in the desired housing complex from various existing housing options based on predetermined criteria using the SAW method so that the assessment process is better and can provide the best alternative in determining housing [4].

The researcher conducted about the Decision Support System for Bidik Misi Scholarship Acceptance at POLIBAN Using the Web-Based SAW Method. The results of this research are the system that was built, the final results obtained from the calculation process using the SAW method with predetermined weights for each criterion, where the results of the ranking of Bidik Misi scholarship recipients who are closest to the criteria to those who are furthest from the criteria, from these results, an alternative is obtained. Who then received a Bidik Misi scholarship [5]. Research conducted by [6] regarding implementing the SAW Method in Decision Support Systems in Determining Road Repair Priorities. The result of this research is to build a system to assist in determining road repair priorities in the Kabu Raya Regency area by implementing the SAW method using predetermined criteria:

1. Research conducted by regarding Decision Support Systems for Determining Chili Planting Land Using the Simple Additive Weighting Method. The results of the research are a constructive decision support system for determining chilli planting land using the SAW method so that it can help chilli farmers in supporting decisions to determine chilli planting land, where the results are in the form of the highest recommended ranking value [7].
2. Research conducted about decision Support System Mapping Quality Agricultural Land to Increase Rice Production Using the SAW method. The results of this research utilize a decision support system to assist in determining the suitability of agricultural areas using the SAW method by the assessment criteria for an area, namely soil type, rainfall, waters, temperature and soil texture [8].
3. Research was conducted by regarding applying the SAW method in the decision support system for location selection for new branches of UD Food Stores. Indo Multi Fish. The results of this research build a system for finding the best locations for building new branches of UD stores. Indo Multi Fish uses the SAW method. In looking for the best location for a new branch, six criteria are used, namely the price of land for the location, distance to the old shop, distance to the storage warehouse, level of competition with other shops, investment value in the next three years, and the level of community that keeps fish [9].
4. Research was conducted regarding the decision support system for selecting boarding houses for students in Luwuk Banggai using the SAW method. The results of this research are implementing a decision support system in selecting a boarding house using the SAW method. This selection of boarding houses can help students choose the right boarding house and speed up their process of determining the results of choosing a boarding house [10][11].
5. Research conducted by [12] regarding the Decision Support System for Determining Priorities for the Distribution of Clean Water in Water Crisis Areas in the Bondowoso Regency Area Using the SAW method. This research results in creating a decision support system that can help determine priorities for distributing clean water using the SAW method.

6. Research conducted by regarding the Decision Support System for Determining the Best State Civil Apparatus at the Water Resources Management Service, Technical Implementation Unit of the Service using the Simple Additive Weighting Method. The results of this research utilize SPK to assist in conducting performance assessments and see the best employee performance using the SAW method in the selection process to assist the decision-making process using seven criteria, namely loyalty, work performance, responsibility, obedience, honesty, cooperation, and initiative [13].

Based on the objectives of the literature that have been described, this research is more focused on creating a decision support system for determining the best waste landfill location using the SAW method. The results of this research can help make decisions efficiently to determine the best waste TPS location using predetermined criteria.

1.1. Decision Support System (DSS)

A system is a collection of objects such as people, resources, concepts, and procedures intended to perform certain functions or fulfill a goal. The word decision means choice, namely the choice of two or more possibilities. Decisions can also mean choosing a strategy or action to solve a problem. Decision-making is the act of choosing a strategy or action that the manager believes will provide the best solution to something. SPK is a system that aims to support managers in making decisions in semi-structured problem conditions. SPK functions as a facility that can strengthen decision-makers' capabilities but only partially replaces the role of decision-makers [14], [15].

1.2. Simple Additive Weighting (SAW)

The SAW method is often also known as the weighted addition method. The basic concept of the SAW method is to find the weighted sum of the performance ratings for each alternative on all attributes. The SAW method is the most well-known and commonly used method for Multiple Attribute Decision Making (MADM) [16].

This SAW method requires decision-makers to determine the weight for each attribute. The total score for an alternative is obtained by adding up all the results by multiplying the ratings (which can be compared across attributes) and the weight of each attribute. The rating for each attribute must be dimension-free because it has gone through a previous matrix normalization process [16].

According to [16] The steps of the SAW method are:

1. Determine the criteria used as a reference in decision-making, namely C,
2. Determine the suitability rating matrix for each alternative for each criterion
3. Create a decision matrix based on criteria (C), then normalize the matrix based on equations adjusted to the type of attribute (profit attribute or cost attribute) to obtain a normalized matrix R.
4. The final result is obtained from the ranking process, namely the sum of the multiplications of the normalized matrix R with the weight vector to obtain the most significant value, which is selected as the best alternative (A) as a solution [17]–[20].

1.3. Temporary Waste Storage Site (TPS)

According to the Law of the Republic of Indonesia, Number 18 of 2008 concerning Waste Management, a Temporary Storage Place is a place before waste is transported to a recycling, processing and integrated waste processing site [21].

1.4. Rubbish

According to Law of the Republic of Indonesia Number 18 of 2008 concerning Waste Management, waste is the remains of daily human activities and natural processes in solid form. Waste can also come from animal and natural activities [21].

2. Method

This research uses qualitative research. Qualitative research seeks to understand and interpret the meaning of an event involving human behavior in certain situations according to the researcher's perspective. The researcher herself is the data collection tool or research instrument in qualitative methods.

2.1. Data collection technique

Data collection techniques in this research include:

1. Observation, The observations made in this research were by looking for existing problems and solutions to solve them and observing what data would be needed to build a decision support system for determining the best location for waste landfills,
2. Interview, Interviews are a data collection technique for orally obtaining data and information from research objects. The interview referred to in this research involves interviewing parties from the Palu City Environmental Service to obtain information on determining the location of waste landfills in the Palu City area using question and answer or dialogue.
3. Study of Literature, The literature study in this research was carried out by collecting library materials by reading, studying and recording essential things related to the research being carried out in order to obtain a theoretical picture. The intended reading sources are books, journals, and articles on the internet.

2.2. Research Stages

The stages carried out in this research are shown in Figure 1 below.

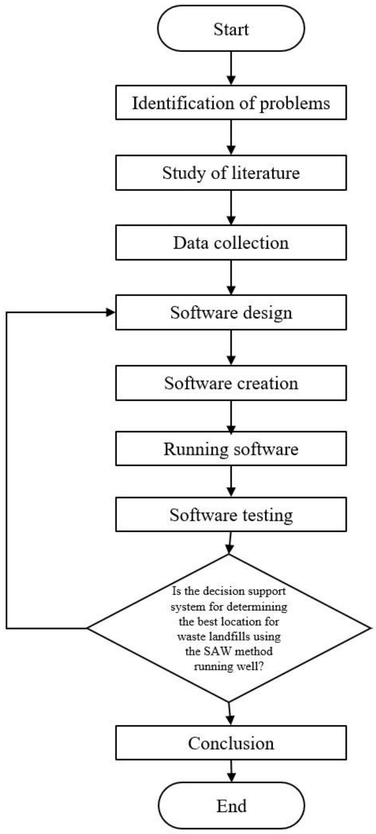


Fig. 1. Research stages

The following is an explanation of each stage of the research method carried out:

1. Identification of problems, At this stage, identify the problem to be solved and determine the solution. Finding the subject to be discussed, defining the problem, and figuring out the goals and advantages of the study are all done first by identifying the problem.
2. Study of Literature, Literature studies are carried out to solve problems by tracing written sources that have been written before. The literature study aims to find theoretical references relevant to the SAW method sourced from written texts, both printed and online.
3. Data collection, Data collection is carried out to collect the data needed for research. In this research, the data collected is primary and secondary data. Preliminary data in this research is obtained directly from the first party by conducting observations and interviews with the Palu City Environmental Service. Meanwhile, secondary data in this research is from

library materials related to SPK and the SAW Method, from journals, e-books, theses and online articles.

4. Software Design, The steps taken in designing the system equipment include creating a decision support system for determining the best location for waste landfills using the SAW method.
5. Software Creation, After designing the Software, the process continues with coding to build a decision support system for determining the best location for waste landfills using the SAW method.
6. Running Software, After the software creation is complete, run the Software to find out whether the system created is running well or not.
7. Software Testing, All developed system functionalities must be appropriately tested to ensure there are no defects or mistakes in the system. In this study, the author employs black box testing as a testing technique. Black box testing is done by examining the functionality of the Software. In the meantime, the SAW approach will be tested by contrasting the outcomes of calculations performed on the PHP-based website with manual computations previously performed using Microsoft Excel.
8. Conclusion, At this stage, the conclusion is the final result, which is expected to answer the research objectives, namely, producing a decision support system for determining the best location for waste landfills using the SAW method.

2.3. SAW Method Calculation

The following is an example of calculations for determining the best location for a waste landfill using the SAW method.

1. The following are the criteria, along with the criteria weight values used as consideration for making decisions, which can be seen in Table 1.

Table 1. The criteria weight values

Criteria	Information	Weight	Type
C1	Area of Land Prepared	10%	Profit
C2	Population density	25%	Cost
C3	Distance from Transport Route	20%	Cost
C4	Distance from Residential Settlements	10%	Profit
C5	Resident Comfort	15%	Profit
C6	Road Conditions	12%	Profit
C7	Soil Conditions	8%	Profit

2. From these criteria, a level of importance of the criteria is created based on the weight values that have been determined in the table, which can be seen in Table 2.

Table 2. Sub criteria value

Criteria	Sub Criteria	Mark
C1	0 – 2 (m2)	1
	3 – 4 (m2)	2
	5 – 6 (m2)	3
	7 – 8 (m2)	4
	> 9 (m2)	5
C2	0 – 250 (Soul)	1
	251 – 500 (Soul)	2
	501 – 750 (Soul)	3
	751 – 1,000 (Souls)	4
	>1,000 (Souls)	5
C3	0 – 500 (m)	1
	501 – 1,000 (m)	2
	1,001 – 1,500 (m)	3
	1,501 – 2,000 (m)	4
	> 2,000 (m)	5
C4	0 – 25 (m)	1
	26 – 50 (m)	2
	51 – 100 (m)	3

Criteria	Sub Criteria	Mark
	101 – 150 (m)	4
	> 150 (m)	5
C5	The area is not large, the population is large and the population does not agree	1
	The area is not large, the population is small. But the Residents Agree	2
	The location is large, the population is large, and the population agrees	3
	The location is large, the population is small, and the population agrees	4
C6	The road conditions are not good and cannot be passed by cars	1
	Road conditions are not good but cars can pass	2
	Road conditions are good and passable by cars	3
C7	Land Conditions in the Lowlands and Prone to Flooding	1
	Land Conditions in the Lowlands But Never Flooded	2
	Land Conditions in the Highlands and Never Flooded	3

3. Alternative values for each criterion can be seen in Table 3.

Table 3. Alternative Values for Each Criteria

Alternative	C1	C2	C3	C4	C5	C6	C7
A1	3	2	1	2	2	3	2
A2	1	2	1	3	3	2	2
A3	5	1	3	2	3	3	2
A4	2	1	4	2	3	3	1

4. Creating Matrix Normalization

Table 4. Matrix Normalization

C1	C2	C3	C4	C5	C6	C7
0.6	0.5	1	0.67	0.67	1	1
0.2	0.5	1	1	1	0.67	1
1	1	0.33	0.67	1	1	1
0.4	1	0.25	0.67	1	1	0.5

5. Ranking all existing alternatives, by adding up the results of multiplying the normalized matrix with the weight values which produces the preference value for each alternative (Vi).

   V1 = (0.10)(0.6) + (0.25)(0.5) + (0.20)(1) + (0.10)(0.67) + (0.15)(0.67) + (0.12)(1) + (0.08)(1) = 0.7525

6. A larger Vi value indicates that alternative Ai is more selected. So the final score results can be seen in Table 5.

Table 5. Final grade results

Alternative	The final result
A1	0.7525
A2	0.7554
A3	0.833
A4	0.717

3. Results and Discussion

3.1. Systems Analysis

1. Context Diagram, The context diagram of the Decision Support System for Determining the Best Location for TPS Using the SAW Method can be seen in Figure 2 below :

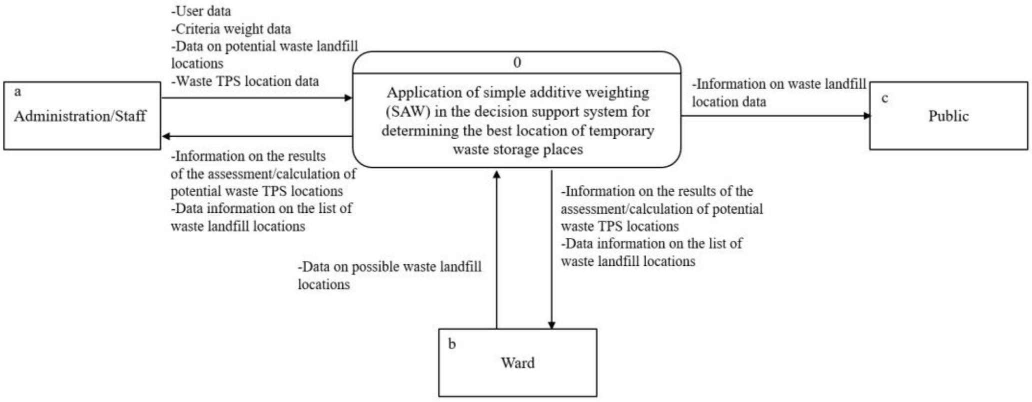


Fig. 2. Context diagram decision support system for determining the best location for temporary waste storage places (TPS) using the simple additive weighting (SAW) method

2. Use Case Diagram, Use Case Diagram of the Decision Support System for Determining the Best Location for TPS Using the SAW Method can be seen in Figure 3 below.

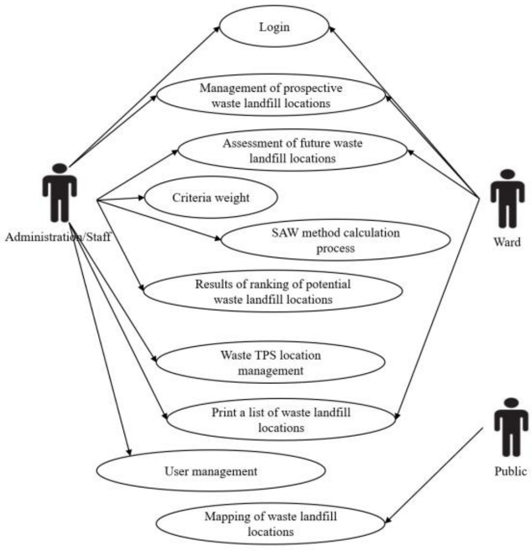


Fig. 3. Use Case Diagram of the Decision Support System for Determining the Best Location for Temporary Waste Storage Places (TPS) Using the Simple Additive Weighting (SAW) Method

3.2. System Implementation

1. The login page is the page used by users to enter the system. This page in Figure 4 is as follows.

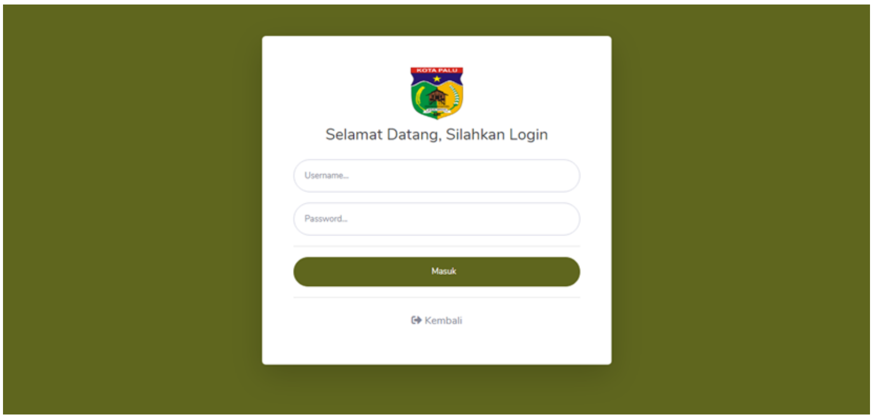


Fig. 4. Login page

2. Dashboard Page, The dashboard page is a page that displays information about the location of the polling station. The dashboard page in Figure 5 is as follows.

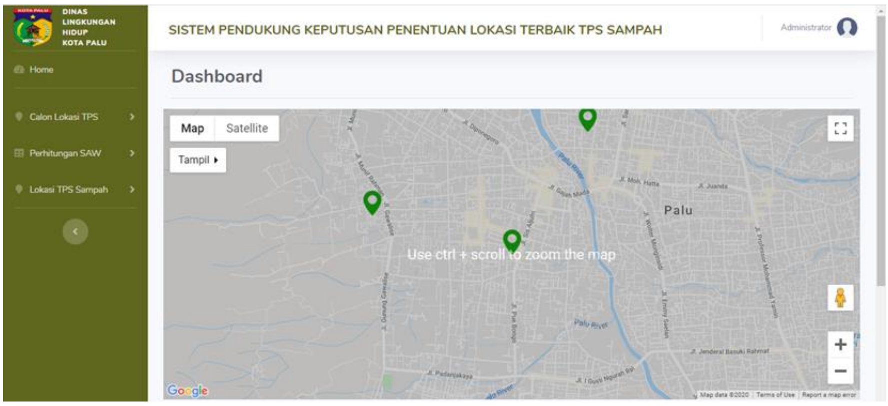


Fig. 5. Dashboard page

3. Prospective TPS Location Management Page, The management page for potential TPS locations is a page that shows a list of future TPS locations that have been entered and is also used to enter, change, and delete information on these locations, as shown in Figure 6.

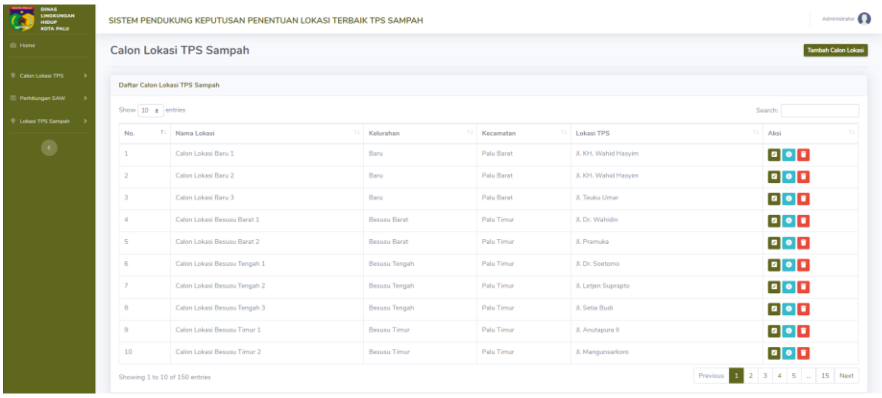


Fig. 6. Prospective TPS location management page

4. Criteria Management Page, The criteria management page is a page that displays the criteria weight data that has been input. This page also enters the weight value of each bar based on the importance of the criteria used in the SAW method calculations and can also delete the weight of these criteria. This page can be seen in Figure 7.

Fig. 7. Criteria management page

5. Assessment Page for Candidate TPS Locations,

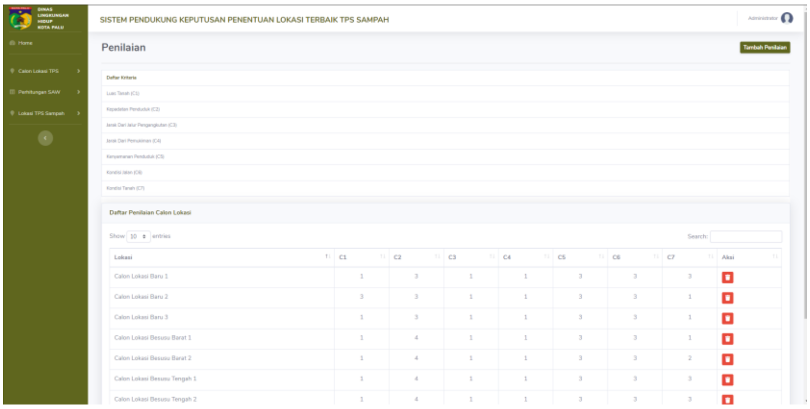
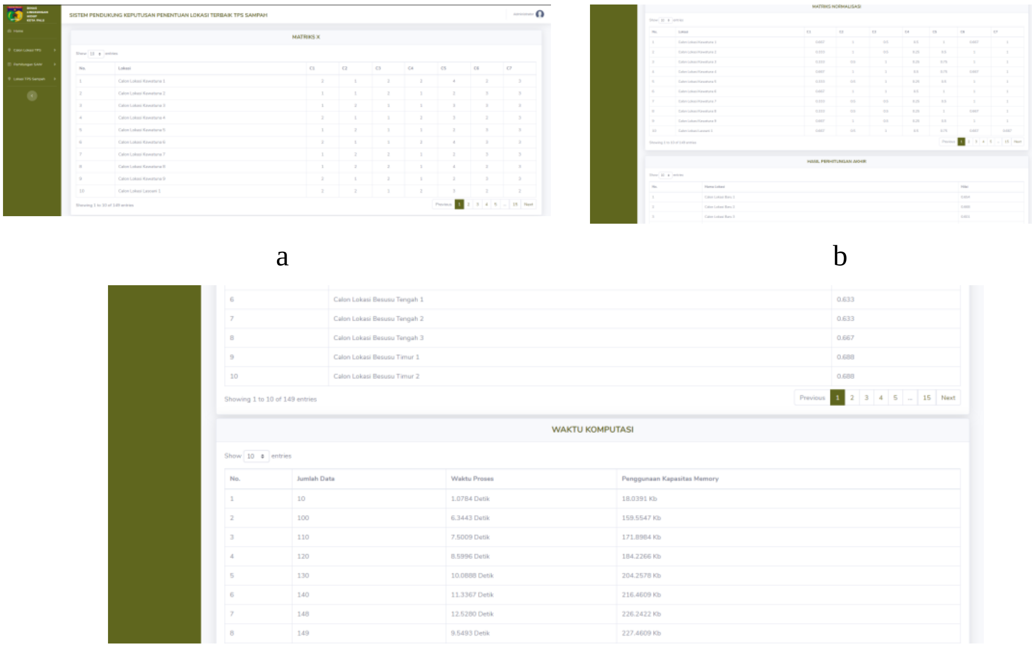


Fig. 8. Assessment Page for Candidate TPS Locations

6. SAW Calculation Process Page,



a b

c

Fig. 9. SAW Calculation Process Page, (a). Normalization matrix, (b). Final calculation results, (c). Computing time

7. Ranking Results Page,

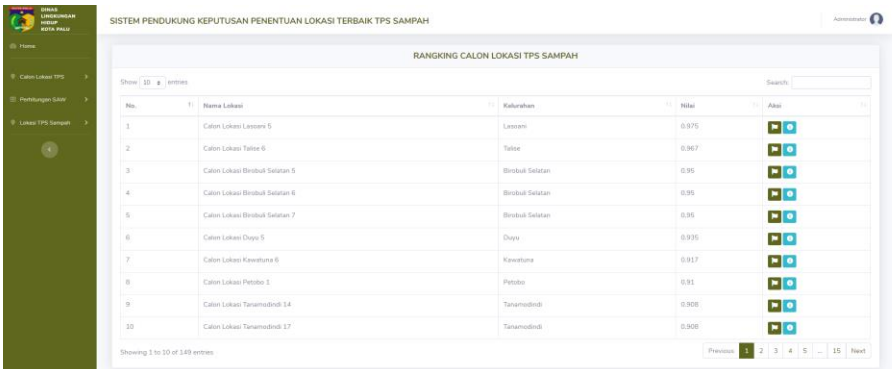


Fig. 10. Ranking results page

8. Reports Page,

Fig. 11. Reports page

9. User Management Page,

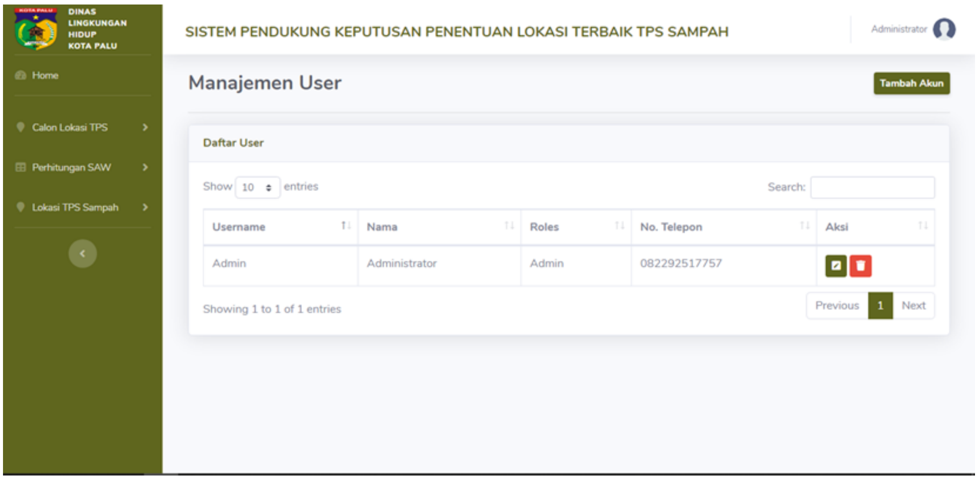


Fig. 12. User management page

10. TPS Location Mapping Page,

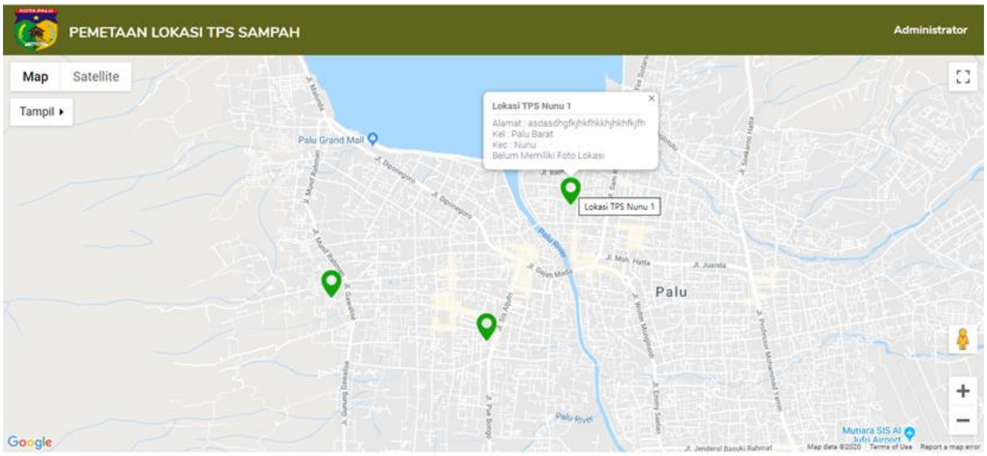


Fig. 13. TPS location mapping page

3.3. System Testing

1. Method Testing, In testing this method there were 148 data that had been calculated manually. The results of these calculations are compared with the results of calculations from a system using the SAW method. The results of manual calculations can be seen in Table 6.

Table 6. Manual calculation results

No.	Location Name	Mark
1	Location of Lasoani 5	0.97500
2	Talise 6 location	0.96667
3	Location of South Birobuli 5	0.95000
4	Location South Birobuli 6	0.95000
5	Location South Birobuli 7	0.95000
…	….	…
…	….	…
…	….	…
147	Kamonji Location 4	0.52750
148	Location of Talise Valangguni 3	0.51833

The calculation results of the system can be seen in Figure 14.

Fig. 14. System calculation results

2. Accuracy Testing, from 148 data contained above, all the data contained in the system is in accordance with test data obtained from the Palu City Environmental Service office, so to calculate the level of accuracy of the system as follows:

$$\text{Accuracy} = \left(\frac{\text{Jumlah data yang benar}}{\text{Jumlah data yang diuji}}\right) \text{x } 100\%$$

$$= \left(\frac{138}{148}\right) \text{X } 100\% = 93.24\%$$

So, it can be concluded that the accuracy of this system based on the 148 data tested is 93.24%, which shows that this system can function well and has a fairly good level of accuracy.

3. Computational Testing, The SAW method was used to determine the length of time needed and the amount of memory used when carrying out the calculation process using the SAW method on a system that was created and used for 148 data being tested. The test results can be seen in Table 7.

Table 7. Computational test results

No	Amount of data	Computation Time (s)	Amount of Memory Used (Kb)
1	10	1.078	18.039
2	20	1.965	38.945
3	30	3.244	51.289

No	Amount of data	Computation Time (s)	Amount of Memory Used (Kb)
4	40	3.653	65.383
5	50	3.885	77.727
6	60	3.979	89.758
7	70	4.767	106.445
8	80	4.886	118.898
9	90	5.280	147.242
10	100	6.344	159.555
11	110	7.501	171.898
12	120	8.599	184.227
13	130	10.089	204.258
14	140	11.337	216.461
15	148	12,528	226.242

4. Conclusion

Based on the results of testing and analysis of the decision support system for determining the best location for waste landfills using the SAW method, conclusions can be drawn, including that the SAW method can be implemented for ranking and determining the best locations for waste TPSs based on criteria determined in the decision support system for determining the best locations for waste TPSs in Palu City, in testing, processing 148 test data using the SAW method took 12,528 seconds and used a memory of 226,2422 kb. Test results by comparing manual calculations with calculations using the system produced an accuracy level of 93.24% from 148 test data. These results show this system can function well and have a relatively good level of accuracy.

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