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Decision Support System for Determining School Branch Locations Using the Weighted Product (WP) Method and Multi-Attribute Utility Theory (MAUT)

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Abstract

The rapid development of information technology has encouraged educational institutions to adopt data-driven decision-making processes in order to improve accuracy, efficiency, and objectivity in strategic planning. One important decision faced by educational institutions is determining the most suitable location for establishing a new school branch. Sekolah Ikhwanul Muslimin plans to expand its educational services by opening new branches; however, the location selection process is complex because it involves several interrelated criteria, such as land area, land price, population density, number of existing schools, crime level, and public transportation availability. Manual decision-making may lead to subjective judgments and suboptimal location choices, which can affect investment efficiency and long-term institutional sustainability. Therefore, this study aims to develop a web-based Decision Support System (DSS) by integrating the Weighted Product (WP) method and Multi-Attribute Utility Theory (MAUT) as a cross-validation mechanism to verify ranking consistency and reduce potential bias from relying on a single method. The WP method is used to calculate preference values based on weighted criteria, while MAUT is applied to transform criterion values into utility scores so that each alternative can be compared more systematically. The system was developed using the Waterfall model and implemented using PHP and MySQL. Based on the calculation results, alternative A1, located on Jl. Desa Kolam, Percut Sei Tuan, obtained the highest final score of 0.464334 and became the most recommended location among the five alternatives analyzed. The results show that the proposed DSS can assist decision-makers in evaluating school branch location alternatives more objectively, systematically, and measurably.

Keywords: Decision Support System, Weighted Product, MAUT, School Branch Location, Location Selection

1 INTRODUCTION

The development of information technology has also encouraged educational institutions to adopt digital approaches in order to improve the accuracy and efficiency of decision-making processes. In the education sector, technology is increasingly used not only for learning activities but also for supporting institutional planning and resource management. Therefore, data-driven decision-making is considered important to help educational institutions minimize subjective judgments and improve the quality of strategic decisions [1], [2].

In the digital era, data-driven techniques and methods have rapidly developed, enabling organizations to manage resources and formulate strategies more effectively. In this context, a Decision Support System (DSS) has become a highly relevant tool, as it is capable of processing multiple criteria, generating comprehensive analytical results, and reducing potential subjective errors in decision-making. Sekolah Ikhwanul Muslimin is an educational institution committed to providing quality education to the community. In response to increasing demand and service expansion, the institution plans to establish new school branches in strategic locations [3]. However, this expansion process presents significant challenges. Determining the appropriate location is a strategic decision that affects operational effectiveness, investment costs, and long-term sustainability. In recent years, the institution has faced serious issues in selecting branch locations, including unsuccessful land acquisitions that failed to meet development requirements. These decisions resulted in financial losses and inefficiencies, primarily due to manual and unstructured decision-making processes without adequate data support. This condition highlights the importance of adopting a data-driven approach in selecting optimal school branch locations. This study employs the Weighted Product (WP) method and Multi-Attribute Utility Theory (MAUT) to address the problem. The WP method is used to evaluate alternatives based on weighted criteria, including population density, accessibility, cost, competition, and supporting facilities [4]. Meanwhile, MAUT transforms preference values into quantitative utility scores, enabling alternatives to be evaluated more objectively and systematically [5]. The integration of WP and MAUT in this study serves as a cross-validation mechanism rather than a mathematical aggregation. Since different MCDM methods may produce varying rankings due to their distinct mathematical principles, applying both methods allows the system to verify ranking consistency and reduce potential bias from relying on a single method.

Therefore, this research aims to develop a web-based DSS using PHP and MySQL by integrating WP and MAUT methods. The system utilizes macro-level data from the Central Bureau of Statistics (BPS) to objectively assess regional potential. For criteria that require more detailed information, such as accessibility and local competition, field observation data were collected to complement the BPS data and ensure a more comprehensive evaluation. Unlike the previous manual and unstructured approach that led to unsuccessful land acquisitions and financial losses, the proposed web-based DSS provides a systematic, transparent, and repeatable calculation process, enabling decision-makers to evaluate alternatives based on measurable criteria and reducing the risk of subjective errors in determining school branch locations.

2 LITERATURE REVIEW

2.1 Decision Support System (DSS)

A Decision Support System (DSS) is an interactive computer-based system designed to assist decision-makers in using data and decision models to solve semi-structured and unstructured problems [6]. DSS supports the decision-making process through several stages, including defining the problem, selecting relevant data, determining the appropriate decision-making approach, and evaluating available alternatives [6]. In line with this explanation, Niqotaini stated that a decision support system helps decision-making through the use of data and decision models to solve semi-structured or unstructured problems [7].

Therefore, DSS is considered relevant in this study because the selection of a school branch location involves several criteria and alternatives that need to be processed systematically. By using a DSS, the decision-making process can become more objective, structured, and measurable, especially in evaluating location alternatives based on predetermined criteria. A recent study in SisInfo also shows that DSS can support a more effective decision-making process by ranking alternatives based on relevant criteria, which is consistent with the objective of this study in producing location recommendations [8].

2.2 Weighted Product (WP) Method

The Weighted Product (WP) method is a multi-criteria decision-making approach that uses a multiplicative model, where each alternative value is raised to the power of its corresponding criterion weight to produce a preference value. This method is widely used due to its simplicity and effectiveness in ranking alternatives based on multiple criteria [9]. However, WP is sensitive to weight determination, which may influence the final results if not properly assigned [10]. The WP method is also considered suitable for decision-making problems involving several criteria because it processes each alternative value through multiplication after being raised to the power of its corresponding criterion weight. This calculation pattern allows the method to compare alternatives based on their weighted performance across multiple criteria [11]. Previous research also shows that WP can be applied to generate alternative rankings in decision support systems, particularly when the decision problem requires weighted comparison among several options [12].

2.3 Multi-Attribute Utility Theory (MAUT)

Multi-Attribute Utility Theory (MAUT) is a quantitative decision-making method that transforms various criteria into utility values within a scale of 0 to 1. This transformation enables more objective comparisons among alternatives [13]. MAUT is particularly useful in handling subjective preferences and converting them into measurable values. However, it requires proper normalization and careful utility function design to ensure accurate results [14].

2.4 Decision Criteria for Location Selection

Location selection involves multiple important criteria, such as population density, accessibility, cost, competition level, and supporting facilities. Population density reflects the potential number of users, while accessibility determines the ease of reaching the location. Cost is essential for investment efficiency, and competition level indicates the intensity of market rivalry. Supporting facilities, including infrastructure and public services, also influence location feasibility [15].

2.5 Previous Studies

Previous studies have demonstrated the effectiveness of DSS in various applications. Ahmadi et al. applied the WP method combined with Rank Order Centroid (ROC) to determine educational institution locations based on criteria such as opportunity, competitors, and demand [13]. Cholis implemented the Fuzzy Analytical Hierarchy Process (FAHP) to support coffee shop location selection using multiple business-related criteria [17]. Irawan and Muttaqin utilized the WP method to identify fire-prone areas, considering historical data and population density. Meanwhile, Naufal Rifqi and Tamara Aldisa combined ROC and MAUT methods to determine industrial locations based on factors such as raw materials, infrastructure, labor costs, and environmental impact [15].

Recent studies have increasingly adopted hybrid MCDM (Multi-Criteria Decision Making) approaches to enhance decision reliability. Gülmez integrated TOPSIS, PROMETHEE II, and VIKOR, demonstrating that combining multiple methods mitigates method-specific biases, as different MCDM techniques may produce varying rankings due to their distinct mathematical principles [18]. Goyal et al similarly applied hybrid MCDM techniques to rank public transport depots, confirming that multi-method comparison strengthens the robustness of results through cross-validation [19]. Following this approach, the present study integrates WP and MAUT not as a mathematical aggregation, but as a cross-validation mechanism to verify ranking consistency and reduce potential bias from relying on a single method.

2.6 Research Gap

Although previous studies have shown that DSS methods are effective, most of them rely on single methods or limited combinations. In addition, these studies have not specifically focused on school branch location selection. There is still a lack of integration between methods that combine mathematical computation and preference transformation in a single framework [20].

2.7 Proposed Approach

Therefore, this study proposes a Decision Support System that integrates the Weighted Product (WP) and Multi-Attribute Utility Theory (MAUT) methods. The WP method is used for initial evaluation, while MAUT is applied for normalization and refinement of results. The system is developed as a web-based application using PHP and MySQL to facilitate efficient data processing and decision-making. This approach is expected to provide more objective, accurate, and structured results in determining school branch locations.

3 RESEARCH METHODS

The method used in this study is the Waterfall model. The Waterfall method is a sequential development approach in which each phase is carried out in an orderly manner [21]. This approach facilitates the development process, allows for the appropriate application of methods, and contributes to the development of a high-quality system. In the Waterfall model, each phase must be completed before proceeding to the next phase, and no overlapping between phases is allowed.

The Waterfall model consists of five main stages that represent the system development process from beginning to end, namely: requirements analysis, system design, implementation, testing, and deployment and maintenance. These stages ensure that the system is developed in a structured and systematic manner.

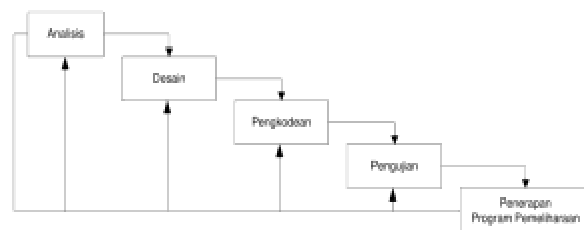

Figure 1. Waterfall Model Used in System Development

The Waterfall model consists of sequential stages, including analysis, design, coding, testing, and implementation with maintenance. In the analysis stage, system requirements are identified through interviews, observations, and literature studies. The design stage involves developing the system structure based on user needs and capabilities.

The coding stage implements the system according to the design while ensuring its functionality. This is followed by the testing stage to verify system performance and detect errors. Finally, the implementation and maintenance stage involves deploying the system for use and performing necessary improvements to ensure optimal performance.

In addition to the Waterfall model, this study also applies the Weighted Product (WP) method and Multi-Attribute Utility Theory (MAUT) as decision-making methods. The WP method is used to evaluate each alternative based on weighted criteria through a multiplication-based calculation process. Each criterion value is normalized according to its type, namely benefit or cost, and then processed using the assigned criterion weight to obtain the preference value of each alternative [22]. Meanwhile, the MAUT method is used to convert criterion values into utility values on a scale of 0 to 1, allowing alternatives with different measurement units to be compared more objectively [23].

The integration of WP and MAUT is applied to determine the final ranking of school branch location alternatives. In this study, the evaluated criteria include land area, land price, population density, number of existing schools, crime level, and public transportation availability [24]. The calculation results from both methods are combined to produce a final recommendation score for each alternative. The detailed calculation process of the WP and MAUT methods is presented in the Results and Discussion section [25].

4 RESULTS AND DISCUSSION

This section presents the results of the decision support system analysis for determining the most suitable school branch location. The data used in this study consisted of five alternative locations that were evaluated based on six criteria. The criteria included land area, land price, population density, number of existing schools, crime level, and public transportation availability. These criteria were selected because they represent important aspects in determining whether a location is feasible, strategic, and supportive for the establishment of a new school branch.

The five alternative locations used in this study are presented in Table 1. Each alternative was coded from A1 to A5 to simplify the calculation and comparison process. The use of alternative codes also helps make the presentation more concise, especially in journal format.

Table 1. Alternative data

Alternative	Location Name
A1	Jl. Desa Kolam, Percut Sei Tuan
A2	Jl. Medan Bt.Kuis Psr IX,Bandar Klippa, Percut Sei Tuan
A3	Jl Sidomulyo,Tembung, Percut Sei Tuan
A4	Jl. Raya Batang Kuis, Batang Kuis Pekan
A5	Jl. M. Yakub, Bandar Khalipah, Percut Sei Tuan

The criteria and weights used in this study are shown in Table 2. Each criterion has a different weight based on its level of importance in determining the feasibility of a new school branch location. Land price has the highest weight of 0.30 because investment cost is one of the most important considerations in location selection. Land area is assigned a weight of 0.25, as a wider land area provides better opportunities for school building development and supporting facilities. Population density is given a weight of 0.15 because it reflects the potential number of prospective students in the surrounding area. Meanwhile, the number of existing schools, crime level, and public transportation each have a weight of 0.10.

Table 2. Criteria and weight data

Criteria	Description	Weight	Type
C1	Land Area	0.25	Benefit
C2	Land Price	0.30	Cost
C3	Population Density	0.15	Benefit
C4	Number of Existing Schools	0.10	Cost
C5	Crime Level	0.10	Cost
C6	Public Transportation	0.10	Benefit

Based on Table 2, the criteria are divided into benefit and cost types. Benefit criteria indicate that higher values are preferred, such as land area, population density, and public transportation availability. In contrast, cost criteria indicate that lower values are preferred, such as land price, number of existing schools, and crime level. This classification is important because the normalization process in the WP and MAUT methods depends on whether a criterion is considered a benefit or a cost.

Some criteria, such as crime level and public transportation, use linguistic values. Therefore, these values must be converted into numerical weights before the calculation process. The conversion values are presented in Table 3.

Table 3. Weight values for crime level and public transportation

Description	Weight	Description	Weight
Low	1	No public transportation	1
Medium	2	Available without fixed route	2
High	3	Available with fixed route	3

The conversion process is carried out to ensure that all criteria can be processed mathematically. For the crime level criterion, a lower value indicates a safer location. Therefore, low crime level is given a value of 1, medium crime level is given a value of 2, and high crime level is given a value of 3. Since crime level is categorized as a cost criterion, a lower score is considered better. Meanwhile, public transportation is categorized as a benefit criterion. Therefore, locations with public transportation and fixed routes receive the highest score because they provide better accessibility for students, parents, teachers, and school staff.

After converting the linguistic data into numerical values, the compatibility rating data are shown in Table 4. This table presents the initial data that will be processed using the Weighted Product and Multi-Attribute Utility Theory methods.

Table 4. Compatibility rating data after weighting

Alt	C1	C2	C3	C4	C5	C6
A1	5,350	500,000	19,423	20	3	3

A2	1,700	1,250,000	38,315	45	3	3
A3	1,900	600,000	47,528	60	3	3
A4	4,500	600,000	6,427	7	2	3
A5	4,156	1,700,000	41,909	35	3	3

Based on Table 4, each alternative has different strengths and weaknesses. Alternative A1 has the largest land area among the five alternatives and also has the lowest land price, making it attractive from the perspective of development capacity and investment efficiency. However, A1 has a high crime level, which affects its suitability because crime level is categorized as a cost criterion.

Alternative A2 has a relatively high population density, which indicates a strong potential market for prospective students. However, this alternative has a smaller land area and a higher number of existing schools, which may indicate stronger competition in the surrounding area. Alternative A3 has the highest population density among the five alternatives, but it also has the highest number of existing schools. This condition shows that although the area has strong potential demand, the competition level is also relatively high.

Alternative A4 has a relatively large land area, affordable land price, the lowest number of existing schools, and a medium crime level. This makes A4 a balanced alternative because it performs well in several important criteria. Meanwhile, A5 has a relatively good land area and high population density, but its land price is the highest among the five alternatives. This high cost may reduce its overall feasibility, especially because land price has the highest weight in this study.

The WP method was applied by normalizing each criterion based on its type and multiplying each criterion value raised to its corresponding weight. This method emphasizes proportional comparison among alternatives. Meanwhile, the MAUT method was applied by transforming each criterion value into a utility value on a scale of 0 to 1. The integration of WP and MAUT provides a more balanced evaluation because WP focuses on weighted multiplication, while MAUT focuses on utility-based preference transformation.

4.1 Calculation Process of WP and MAUT Methods

Before calculating the final ranking, each criterion value was normalized based on its criterion type. In this study, C1, C3, and C6 are categorized as benefit criteria, while C2, C4, and C5 are categorized as cost criteria. Benefit criteria indicate that higher values are preferred, while cost criteria indicate that lower values are preferred.

For the WP method, the normalization formula for benefit criteria is:

$$X_{ij} = \frac{x_{ij}}{\max(x_j)}$$

The normalization formula for cost criteria is:

$$X_{ij} = \frac{\min(x_j)}{x_{ij}}$$

Based on the five alternatives used in this study, the maximum and minimum values are as follows:

$$C1\ max = 5{,}350$$
$$C2\ min = 500{,}000$$
$$C3\ max = 47{,}528$$
$$C4\ min = 7$$
$$C5\ min = 2$$
$$C6\ max = 3$$

4.1.1 WP Normalization Calculation

Based on the five alternatives used in this study, the maximum and minimum values used in the WP normalization process are as follows:

$$C1\ max = 5{,}350$$
$$C2\ min = 500{,}000$$
$$C3\ max = 47{,}528$$
$$C4\ min = 7$$
$$C5\ min = 2$$
$$C6\ max = 3$$

For the WP method, the normalization value for each criterion was calculated based on its criterion type. The WP normalization results are presented in Table 5.

Table 5. WP normalization results

Alt	C1	C2	C3	C4	C5	C6
A1	1.0000	1.0000	0.4087	0.3500	0.6667	1.0000
A2	0.3178	0.4000	0.8062	0.1556	0.6667	1.0000
A3	0.3551	0.8333	1.0000	0.1167	0.6667	1.0000
A4	0.8411	0.8333	0.1352	1.0000	1.0000	1.0000
A5	0.7768	0.2941	0.8818	0.2000	0.6667	1.0000

After the WP normalization values were obtained, the next step was calculating the vector S_i. The vector $S_i$was calculated by multiplying each normalized criterion value raised to the power of its corresponding criterion weight. The formula is shown as follows:

$$S_i = \prod_{j=1}^{n} (R_{ij})^{w_j}$$

where $S_i$is the vector value of alternative i, $R_{ij}$is the normalized value of alternative $i$on criterion j, and $w_j$is the weight of criterion j.

The criterion weights used in this calculation are:

$$w_1 = 0.25, w_2 = 0.30, w_3 = 0.15, w_4 = 0.10,$$
$$w_5 = 0.10, w_6 = 0.10$$

Based on the normalization results, the vector S_i calculation for each alternative is shown below.

$$S_1 = (1.0000)^{0.25} \times (1.0000)^{0.30} \times (0.4087)^{0.15} \times (0.3500)^{0.10} \times (0.6667)^{0.10} \times (1.0000)^{0.10}$$
$$S_1 = 0.7560$$
$$S_2 = (0.3178)^{0.25} \times (0.4000)^{0.30} \times (0.8062)^{0.15} \times (0.1556)^{0.10} \times (0.6667)^{0.10} \times (1.0000)^{0.10}$$
$$S_2 = 0.4402$$
$$S_3 = (0.3551)^{0.25} \times (0.8333)^{0.30} \times (1.0000)^{0.15} \times (0.1167)^{0.10} \times (0.6667)^{0.10} \times (1.0000)^{0.10}$$
$$S_3 = 0.5661$$
$$S_4 = (0.8411)^{0.25} \times (0.8333)^{0.30} \times (0.1352)^{0.15} \times (1.0000)^{0.10} \times (1.0000)^{0.10} \times (1.0000)^{0.10}$$
$$S_4 = 0.6716$$
$$S_5 = (0.7768)^{0.25} \times (0.2941)^{0.30} \times (0.8818)^{0.15} \times (0.2000)^{0.10} \times (0.6667)^{0.10} \times (1.0000)^{0.10}$$
$$S_5 = 0.5217$$

The total vector S_i value is:

$$\sum S_i = 0.7560 + 0.4402 + 0.5661 + 0.6716 + 0.5217 = 2.9557$$

The WP preference value V_i was calculated by dividing each vector S_i value by the total vector S_i value. The formula is shown as follows:

$$V_i = \frac{S_i}{\sum_{i=1}^{m} S_i}$$

The WP preference value for each alternative is calculated as follows:

$$V_1 = \frac{0.7560}{2.9557} = 0.2558$$
$$V_2 = \frac{0.4402}{2.9557} = 0.1489$$
$$V_3 = \frac{0.5661}{2.9557} = 0.1915$$
$$V_4 = \frac{0.6716}{2.9557} = 0.2272$$
$$V_5 = \frac{0.5217}{2.9557} = 0.1765$$

4.1.2 MAUT Utility Normalization

For the MAUT method, each criterion value was converted into a utility value between 0 and 1. The formula for benefit criteria is:

$$U(x_{ij}) = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$$

The formula for cost criteria is:

$$U(x_{ij}) = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}$$

Based on the five alternatives, the maximum and minimum values used in the MAUT calculation are as follows:

$$C1\ max = 5{,}350, min = 1{,}700$$
$$C2\ max = 1{,}700{,}000, min = 500{,}000$$
$$C3\ max = 47{,}528, min = 6{,}427$$
$$C4\ max = 60, min = 7$$
$$C5\ max = 3, min = 2$$
$$C6\ max = 3, min = 3$$

For C6, all alternatives have the same value (3), meaning all locations are equally served by public transportation with fixed routes. When all values are identical, the MAUT normalization formula produces a zero denominator (x_max − x_min = 0), resulting in a utility value of 0.0000 for all alternatives. This value does not indicate poor performance on this criterion, but rather reflects the mathematical property of the normalization formula when there is no variation among alternatives. Since all alternatives receive the same utility value, C6 does not influence the relative ranking and the final result remains unaffected.

The MAUT utility normalization results are presented in Table 6.

Table 6. MAUT utility normalization results

Alt.	C1	C2	C3	C4	C5	C6
A1	1.0000	1.0000	0.3162	0.7547	0.0000	0.0000
A2	0.0000	0.3750	0.7758	0.2830	0.0000	0.0000
A3	0.0548	0.9167	1.0000	0.0000	0.0000	0.0000
A4	0.7671	0.9167	0.0000	1.0000	1.0000	0.0000
A5	0.6729	0.0000	0.8633	0.4717	0.0000	0.0000

The total utility value in the MAUT method was calculated by multiplying each utility value by its corresponding criterion weight and then summing the results. The formula is shown as follows:

$$U_i = \sum_{j=1}^{n} w_j \times U(x_{ij})$$

where U_i is the total utility value of alternative i, w_j is the weight of criterion j, and $U(x_{ij})$ is the utility value of alternative i on criterion j.

Based on the utility normalization results, the MAUT total utility value for each alternative is calculated as follows:

$$U_1 = (0.25 \times 1.0000) + (0.30 \times 1.0000) + (0.15 \times 0.3162) + (0.10 \times 0.7547) + (0.10 \times 0.0000) + (0.10 \times 0.0000)$$

$$U_1 = 0.2500 + 0.3000 + 0.0474 + 0.0755 + 0.0000 + 0.0000 = 0.6729$$

$$U_2 = (0.25 \times 0.0000) + (0.30 \times 0.3750) + (0.15 \times 0.7758) + (0.10 \times 0.2830) + (0.10 \times 0.0000) + (0.10 \times 0.0000)$$

$$U_2 = 0.0000 + 0.1125 + 0.1164 + 0.0283 + 0.0000 + 0.0000 = 0.2572$$

$$U_3 = (0.25 \times 0.0548) + (0.30 \times 0.9167) + (0.15 \times 1.0000) + (0.10 \times 0.0000) + (0.10 \times 0.0000) + (0.10 \times 0.0000)$$

$$U_3 = 0.0137 + 0.2750 + 0.1500 + 0.0000 + 0.0000 + 0.0000 = 0.4387$$

$$U_4 = (0.25 \times 0.7671) + (0.30 \times 0.9167) + (0.15 \times 0.0000) + (0.10 \times 1.0000) + (0.10 \times 1.0000) + (0.10 \times 0.0000)$$

$$U_4 = 0.1918 + 0.2750 + 0.0000 + 0.1000 + 0.1000 + 0.0000 = 0.6668$$

$$U_5 = (0.25 \times 0.6729) + (0.30 \times 0.0000) + (0.15 \times 0.8633) + (0.10 \times 0.4717) + (0.10 \times 0.0000) + (0.10 \times 0.0000)$$

$$U_5 = 0.1682 + 0.0000 + 0.1295 + 0.0472 + 0.0000 + 0.0000 = 0.3449$$

The final score was obtained by combining the WP preference value and the MAUT utility value with the same proportion. The formula is shown as follows:

$$Final\ Score_i = \frac{V_i + U_i}{2}$$

Where Final $Score_i$ is the final combination score of alternative i, V_i is the WP preference value obtained from dividing each alternative's vector S_i by the total vector sum, and U_i is the MAUT total utility value calculated by summing the weighted utility scores across all criteria for alternative i. Both methods contribute equally with a proportion of 50% each, ensuring a balanced evaluation between the weighted multiplication approach of WP and the utility-based transformation of MAUT.

Based on the WP and MAUT results, the final score for each alternative is calculated as follows:

$$Final\ Score_{A1} = \frac{0.2558 + 0.6729}{2} = 0.4643$$

$$Final\ Score_{A2} = \frac{0.1489 + 0.2572}{2} = 0.2031$$

$$Final\ Score_{A3} = \frac{0.1915 + 0.4387}{2} = 0.3151$$

$$Final\ Score_{A4} = \frac{0.2272 + 0.6668}{2} = 0.4470$$

$$Final\ Score_{A5} = \frac{0.1765 + 0.3449}{2} = 0.2607$$

Using these formulas, the final ranking results are presented in Table 7.

Table 7. Comparison of WP, MAUT, and Final ranking

Alt.	WP Score	MAUT Score	Final Score	Rank
A1	0.2558	0.6729	0.464334	1
A2	0.1489	0.2572	0.203062	5
A3	0.1915	0.4387	0.315122	3
A4	0.2272	0.6668	0.447004	2
A5	0.1765	0.3449	0.260698	4

Based on Table 7, alternative A1 obtained the highest final score of 0.464334 and was ranked first. This result indicates that Jl. Desa Kolam, Percut Sei Tuan is the most recommended location among the five alternatives analyzed. Alternative A4 ranked second with a final score of 0.447004, followed by A3 with a final score of 0.315122. Meanwhile, A5 ranked fourth with a final score of 0.260698, and A2 ranked fifth with a final score of 0.203062. These results show that the WP-MAUT combination can provide a structured ranking of alternative locations by considering both weighted preference values and utility values. Therefore, the proposed decision support system can assist decision-makers in evaluating school branch location alternatives more objectively, systematically, and measurably.

4.2 Requirement System

4.2.1 Use Case Diagram

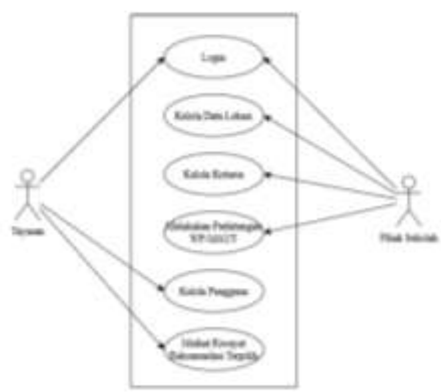

Figure 2. Use Case Diagram

The use case diagram shows a decision support system for selecting school branch locations using the WP-MAUT method. The system has two actors: Yayasan and Pihak Sekolah. Both can log in to the system. Pihak Sekolah manages location data, criteria, and calculation processes, while Yayasan manages users and views recommendation history. Use case diagrams are useful for describing user interaction, system functions, and access rights in the system design process [23], [24].

4.2.2 Sequence Diagram and Database Design

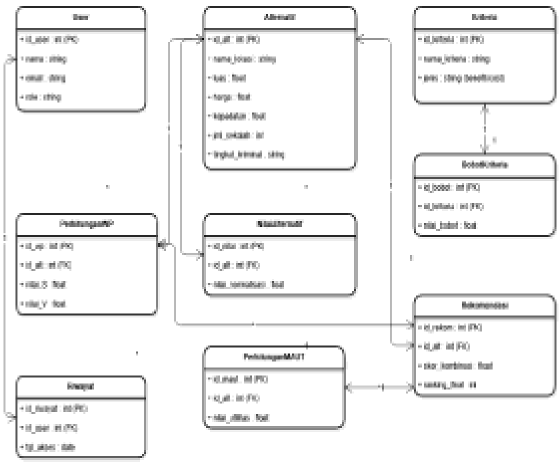

Figure 3. Sequence Diagram

The ERD illustrates a location recommendation system that applies the Weighted Product (WP) and Multi-Attribute Utility Theory (MAUT) methods to support decision-making. The system consists of several main entities, including User, Alternative, Criteria, Criteria Weight, Alternative Value, WP Calculation, MAUT Calculation, Recommendation, and History. Each alternative location is evaluated based on multiple criteria such as area, price, population density, number of schools, and crime level. The criteria are assigned specific weights to represent their importance in the evaluation process. The system then performs calculations using the WP and MAUT methods to obtain utility values, recommendation scores, and final rankings for each alternative. Additionally, the History entity records user access activities within the system. UML-based design is useful for describing system requirements, structure, and relationships among system components [26], [27].

4.2.3 Implementation

The system was implemented as a web-based application using PHP and MySQL. PHP was used to build the server-side application logic, while MySQL was used to store alternative location data, criteria, weights, calculation results, recommendation scores, and recommendation history. The use of PHP and MySQL supports the development of a web-based decision support system that can manage data, process calculations, and display recommendation results efficiently [21], [22].

Figure 4. Alternative

The alternative location data were implemented in the web-based decision support system interface. This page allows users to manage candidate location data, including land area, land price, population density, number of surrounding schools, crime level, and transportation value.

Figure 5. Criteria and Weight Data

The criteria and weight data were also implemented in the decision support system interface. This page allows the system to manage each criterion, including its weight and criterion type, which are later used in the WP-MAUT calculation process.

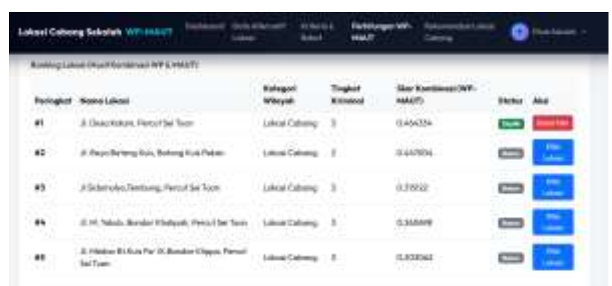

Figure 6. Location Selection

The calculation process was implemented in the system through the WP-MAUT calculation interface. This page displays the processing stage used to calculate normalized values, vector values, utility values, and final combination scores for each alternative. The calculation process interface of the WP-MAUT method is shown final ranking generated by the decision support system The system displays the ranking order, location name, region category, crime level, WP-MAUT combination score, and location selection action.

Figure 7. Final Recommendation

The figure presents the final recommendation result produced by the WP-MAUT decision support system for selecting the most suitable school branch location. Based on the evaluation and calculation process, the recommended location is “Jl. Desa Kolam, Percut Sei Tuan,” which achieved a combined WP-MAUT score of 0.464334. The recommendation was determined by considering several assessment criteria, including regional category and crime level, which were processed using the Weighted Product (WP) and Multi-Attribute Utility Theory (MAUT) methods. The system displays detailed information about the selected location, the calculation method used, and the date and time when the recommendation was generated. This result demonstrates how the system assists decision-makers in identifying the most appropriate location based on predefined criteria and weighted evaluations.

5 CONCLUSION

Based on the results of the analysis, testing, and calculation process, the integration of the Weighted Product (WP) and Multi-Attribute Utility Theory (MAUT) methods can be implemented effectively in a decision support system for determining the most suitable school branch location. The combination of these two methods provides a systematic and measurable approach in evaluating multiple alternatives based on several predefined criteria.

The evaluation process in this study was carried out using six important criteria, namely land area, land price, population density, number of existing schools, crime level, and public transportation availability. Each criterion was assigned a specific weight according to its level of importance in supporting the decision-making process for selecting a strategic school branch location.

During the normalization and calculation stages, the public transportation criterion did not produce any variation among the alternatives because all alternatives had the same assessment value for this criterion. As a result, this criterion did not significantly influence the final ranking and was considered a non-discriminating criterion in the MAUT normalization process.

The calculation results obtained from the integration of the WP and MAUT methods showed that alternative A1, located on Jl. Desa Kolam, Percut Sei Tuan, achieved the highest final WP-MAUT combination score of 0.464334. Therefore, A1 was identified as the most recommended location among the five alternative locations evaluated in this study.

The implementation of the decision support system demonstrates that the proposed approach can help decision-makers evaluate location alternatives more objectively, consistently, systematically, and accurately. By utilizing the WP and MAUT methods, the system reduces subjectivity in decision-making and provides clearer recommendations based on quantitative calculations.

In addition, the developed system is capable of presenting recommendation results in the form of ranking scores, making it easier for decision-makers to compare available alternatives and identify the most suitable location for establishing a new school branch. This feature improves the efficiency and effectiveness of the decision-making process.

For future research and system development, several improvements can still be made, such as increasing the number of alternative locations, utilizing more detailed geographic and demographic data, and adding new evaluation criteria such as accessibility to main roads, surrounding public facilities, economic growth potential, and projected student demand. These enhancements are expected to improve the accuracy and reliability of the recommendation results.

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