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# Combination of PIPRECIA-S and Complex Proportional Assessment Approaches for Selecting MSME Locations

Andrian Sah[a1], Indra[b2], Moh. Erkamim[c3], Jefri Rahmadian[d4]

[a]Information Systems Study Program, Faculty of Computer Science, Universitas Yapis Papua
Dr. Sam Ratulangi Street No. 11, Trikora, Jayapura Utara, Jayapura City, Papua, Indonesia
[1]cyberdefance23@gmail.com

[b]Information Systems Study Program, Faculty of Engineering, Universitas Sulawesi Barat
Prof. Dr. Baharuddin Lopa, S.H. Street, Talumung, Majene Regency, Sulawesi Barat, Indonesia
[2]indra@unsulbar.ac.id

[c]Smart City Information Systems Study Program, Universitas Tunas Pembangunan Surakarta
Balekambang Street No.1, Manahan, Banjarnegri, Surakarta City, Jawa Tengah, Indonesia
[3]erkamim@lecture.utp.ac.id

[d]Informatics Engineering Study Program, Sekolah Tinggi Teknologi Informatika NIIT
Asem II Street No. 22, Cipete Selatan, Cilandak, Jakarta Selatan City, Jakarta, Indonesia
[4]jefri@i-tech.ac.id

***Abstract***

*Micro, Small, and Medium Enterprises (MSMEs) play a crucial role in Indonesia's economy, but selecting a strategic business location often becomes a major challenge for MSME owners. The right location can determine business success, while poor decision-making is often due to subjectivity and limited data in manual processes. This study develops a Decision Support System (DSS) for MSME location selection by combining the Complex Proportional Assessment (COPRAS) method and the Simplified Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA-S) weighting technique. COPRAS was chosen for its ability to comprehensively evaluate alternatives based on complex criteria, while PIPRECIA-S was used to determine the criteria weights more systematically and effectively. The system is web-based, enabling the management of criteria, alternatives, and alternative evaluations to generate recommendations for business location rankings. The system developed has been running smoothly and fulfilling all intended functions, as evidenced by black-box testing, which showed that all core system functions produced "valid" results or operated properly.*

***Keywords:*** *MSME, Decision Support System, COPRAS, PIPRECIA-S, Location Selection*

## 1. Introduction

Micro, Small, and Medium Enterprises (MSMEs) play a crucial role in Indonesia's economy. MSMEs serve as one of the primary driving forces of the economy, absorbing a large workforce and making a significant contribution to the Gross Domestic Product (GDP) [1]. However, one of the greatest challenges faced by MSME entrepreneurs is selecting a strategic business location. The right location is critical for the success or failure of MSMEs, as it directly impacts customer access, operational costs, and business competitiveness [2]. Manual business location selection often encounters various obstacles, such as subjectivity in assessments, time-consuming decision-making processes, and the difficulty of considering all relevant factors simultaneously. MSME entrepreneurs frequently rely on intuition or limited information, which can result in suboptimal decisions. As a consequence, the chosen location may not align with the target market or may lack adequate infrastructure, ultimately reducing business performance. Furthermore, the manual process often complicates the objective comparison of alternative locations. Given the complexity of these decision-making processes, a Decision Support System (DSS) is required to

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assist MSME entrepreneurs in determining the optimal location. A DSS can provide more objective, data-driven recommendations, aiding decision-makers in making the right choices [3].

The application of DSS in business location selection has been the focus of several previous studies, utilizing various decision-making methods. The first study employed the Simple Additive Weighting (SAW) approach to determine the best business location [4]. In this approach, the best option is determined through normalization and weighted summation, resulting in rankings for each available alternative. Another study developed a DSS for selecting a laundry business location using the Weighted Product (WP) method [5]. This method determines the best option by calculating alternative rankings through weighting and exponentiation. Additionally, there is research on selecting a culinary business location using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approach [6]. This approach identifies the best option by measuring performance based on the distance closest to the positive ideal solution and farthest from the negative ideal solution.

However, previous studies on business location selection have not utilized techniques capable of evaluating decision alternatives based on proportional ratios between interconnected criteria. This capability is provided by the Complex Proportional Assessment (COPRAS) method. This has been demonstrated in several studies related to location selection, although not specifically for business locations, such as in the determination of Wi-Fi installation sites [7], selection of tourist destination locations [8], and research on cash deposit ATM location placement [9]. Nevertheless, previous research has not adopted the appropriate technique for determining criterion weights. This study proposes the combination of the COPRAS method with the Simplified Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA-S) weighting technique as a more comprehensive approach to developing a DSS for MSME business location selection. COPRAS was chosen for its ability to evaluate decision alternatives based on various complex and interrelated criteria [10]. COPRAS also excels in providing more comprehensive results, as this method can directly compare alternatives based on proportional ratios, making it highly suitable for decision-making cases with multiple criteria [11]. Meanwhile, PIPRECIA-S is a systematic and effective approach for determining criteria weights by considering the relative relationships between paired criteria [12]. PIPRECIA-S offers the advantage of assigning weights based on their structured influence on the decision, utilizing a pivot comparison that serves as a reference for determining the importance of each criterion [13].

This study aims to develop a DSS that can assist MSME entrepreneurs in selecting the optimal business location by combining the COPRAS method and the PIPRECIA-S weighting technique. The contribution of this research lies in the application of the COPRAS and PIPRECIA-S combination in the context of MSME business location selection, which has rarely been explored in previous studies. This combination offers advantages through proportional alternative ranking based on relevant criteria, as well as accurate and measured weighting. The DSS is developed as a web-based system, allowing it to be accessed anytime and anywhere, making it easier for MSME entrepreneurs to make quick, efficient, and data-driven decisions.

## 2. Reseach Methods

Research methods refer to a series of systematic procedures used to collect, process, and analyze data in order to achieve research objectives [14]. This method comprises several stages designed to ensure that the research is carried out as planned, as shown in Figure 1.

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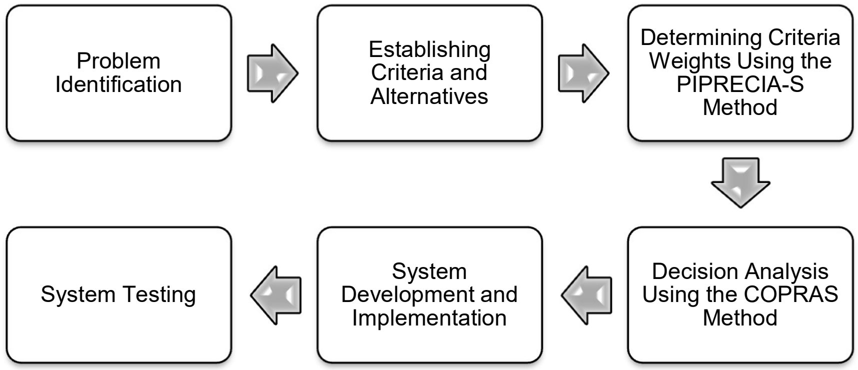


**Figure 1.** Research Stages

### 2.1. Problem Identification

The purpose of this stage is to clearly and specifically define the problem so that appropriate solutions can be found through system development [15]. Based on interviews with MSME actors and field observations, it was found that they had difficulty in determining strategic business locations. The manual selection process tends to be subjective and time-consuming, as MSME owners often rely on intuition or limited information. This leads to less optimal location choices, which can negatively affect business performance. Therefore, it is necessary to develop a Decision Support System (DSS) to help MSME owners in choosing business locations more quickly and accurately.

### 2.2. Establishing Criteria and Alternatives

This stage involves defining relevant and significant criteria for business location selection. Criteria refer to factors or aspects used to evaluate and compare various choices in decision-making, while alternatives are the available options to consider in the decision-making process [16]. Based on interviews with several MSME owners, the criteria used include: Rental Cost (C1), Accessibility (C2), Infrastructure (C3), and Number of Competitors (C4). Meanwhile, alternatives are flexible and dependent on the available locations. For the case study, the alternatives include: Angkasa Pura (A1), Nusa Indah (A2), Jayakarta (A3), Menara Teratai (A4), and Tirta Amarta (A5).

### 2.3. Determining Criteria Weights Using the PIPRECIA-S Method

The Simplified Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA-S) method is a simplified version of the original PIPRECIA, used to determine the weights of criteria in multi-criteria decision-making [13]. This approach is based on the relative evaluation between criteria, where each criterion is compared to the first criterion as a reference [17]. The PIPRECIA-S calculation process starts by determining the relative significance ($s_j$) of each criterion, except for the first criterion. The $s_j$ value indicates how important a criterion is compared to the first one. The $s_j$ is established using Equation (1):

$$s_j = \begin{cases} 1 \text{ if } c_j > c_1 \\ 1 \text{ if } c_j = c_1 \\ 1 \text{ if } c_j < c_1 \end{cases} \quad (1)$$

where j ≠ 1, and the value of $s_j$ ranges between 1 and 1.9 if $c_j$ is more important than $c_1$, $s_j$ = 1 if $c_j$ is equally important as $c_1$, and $s_j$ ranges between 0.1 and 1 if $c_j$ is less important than $c_1$.

Next, the coefficient value ($k_j$) is calculated for each criterion using Equation (2).

$$k_j = \begin{cases} 1 \text{ if } j = 1 \\ 2 - s_j \text{ if } j > 1 \end{cases} \quad (2)$$

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Afterward, the temporary or recalculated weight ($q_j$) for each criterion is calculated using the coefficient values ($k_j$) obtained earlier. The recalculated weight is determined using Equation (3).

$$q_j = \begin{cases} 1 \text{ if } j = 1 \\ \frac{1}{k_j} \text{ if } j > 1 \end{cases} \quad (3)$$

The final step is to determine the relative weight of each criterion ($w_j$), which is normalized using Equation (4).

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \quad (4)$$

where $n$ is the total number of criteria.

### 2.4. Decision Analysis Using the COPRAS Method

The Complex Proportional Assessment (COPRAS) method is a multi-criteria evaluation technique designed to solve complex decision-making problems [18]. This method compares alternatives based on predefined criteria, with each criterion assigned a weight according to its importance [19]. Another advantage of COPRAS is its ease of use when handling data with different scales and flexibility in adjusting criteria weights as preferences or decision conditions change [20]. The COPRAS calculation process begins with creating a decision matrix that contains the values of each alternative for each predetermined criterion, using Equation (5).

$$D = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{14} \\ x_{21} & x_{22} & x_{23} & x_{24} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & x_{m3} & x_{mn} \end{bmatrix} \quad (5)$$

Next, normalization is performed on the decision matrix to ensure all values are on a uniform scale, calculated using Equation (6).

$$X_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \quad (6)$$

where $X_{ij}$ represents the value of the $i$-th alternative for the $j$-th criterion, and $m$ represents the total number of alternatives.

The next step is calculating the weighted normalized value, where each normalized value is multiplied by the relevant criterion weight, using Equation (7).

$$D' = d_{ij} = X_{ij} \times W_{ij} \quad (7)$$

where $W_{ij}$ is the weight of the $j$-th criterion.

Then, the maximum (benefit) and minimum (cost) values are calculated for each alternative using Equation (8) for benefits and Equation (9) for costs.

$$S_{+i} = \sum_{j=1}^{n} y_{+ij} \quad (8)$$

$$S_{-i} = \sum_{j=1}^{n} y_{-ij} \quad (9)$$

where $y_{+ij}$ is the weighted value of the benefit criteria, and $y_{-ij}$ is the weighted value of the cost criteria. $S_{+i}$ is the sum of positive values (benefit), while $S_{-i}$ is the sum of negative values (cost) for the $i$-th alternative.

The next step is to calculate the relative weight of each alternative, using Equation (10).

$$Q_i = S_{+i} + \left(\frac{\sum_{i=1}^{m} S_{-i}}{S_{-i}}\right) \quad (10)$$

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where $Q_i$ is the relative weight of the $i$-th alternative.

Finally, the utility value of each alternative is calculated, where the alternative with the highest utility value is recommended. The utility value is calculated using Equation (11).

$$U_i = \frac{Q_i}{Q_{max}} \tag{11}$$

where $U_i$ is the utility value of the $i$-th alternative, and $Q_{max}$ is the highest relative weight.

### 2.5. System Development and Implementation

The next stage is system development, where this process involves coding to create software that can be utilized by users [21]. The system is implemented as a web-based application, allowing users to access and use the system anytime and anywhere. The coding process is carried out using the Emacs text editor, and data storage is managed through a MySQL database.

### 2.6. System Testing

At this stage, testing was conducted to ensure the system operates as required and according to the specified requirements [22]. Functionality testing was performed using black-box testing. Black-box testing is a software testing method in which the tester evaluates the system's functionality without knowledge of its internal implementation, source code, or system architecture [23]. The tester focuses solely on the input provided and the output generated, with the goal of verifying that each function works as expected and delivers valid results as per the specifications. This testing covered various aspects of system functionality to ensure that each feature operates correctly and delivers accurate results.

## 3. Result and Discussion

To select a business location for MSMEs using the PIPRECIA-S weighting approach and COPRAS, the first step is to establish criteria based on interviews with MSME owners: Rental Cost (C1), Accessibility (C2), Infrastructure (C3), and Number of Competitors (C4). The PIPRECIA-S approach is then applied to determine the weights, where decision-makers assess the importance of each criterion relative to the first, assigning significance values ($s_j$) between 0.1 and 1.9. For this case, the values are $s_2$ = 1, $s_3$ = 1.5, and $s_4$ = 0.8. These values are used to calculate the coefficient values ($k_j$), as shown in Table 1.

**Table 1.** Coefficient Values for Each Criterion

| Criteria | C1 | C2 | C3 | C4 |
|---|---|---|---|---|
| Order | 1 | 2 | 3 | 4 |
| $s_j$ | - | 1 | 1.5 | 0.8 |
| $k_j$ | - | 1 | 0.5 | 1.2 |

Based on the coefficient values shown in Table 1, these serve as a reference for calculating the recalculated weights ($q_j$), which are obtained using Equation (3). The calculation process to obtain the calculation weight is as follows:

$$q_1 = 1$$
$$q_2 = 1$$
$$q_3 = \frac{1}{0.5} = 2$$
$$q_5 = \frac{1}{1.2} = 0.8333$$

The final step in the PIPRECIA-S weighting method is to calculate the final relative weight ($w_j$) for each criterion. This weight is determined using Equation (4). The calculation process is as follows:

$$w_1 = \frac{1}{1 + 1 + 2 + 0.8333} = 0.2069$$

$$w_2 = \frac{1}{1+1+2+0.8333} = 0.2069$$
$$w_3 = \frac{5}{1+1+2+0.8333} = 0.4138$$
$$w_4 = \frac{0.714}{1+1+2+0.8333} = 0.1724$$

The criterion weights obtained from the PIPRECIA-S weighting method are then summarized and presented in Table 2.

**Table 2.** Criteria Weights Based on PIPRECIA-S Method

| Criteria Code | Criteria | Criteria Type | Weight Value |
|---|---|---|---|
| C1 | Rental Cost | Cost | 0.2069 |
| C2 | Accessibility | Benefit | 0.2069 |
| C3 | Infrastructure | Benefit | 0.4138 |
| C4 | Number of Competitors | Cost | 0.1724 |

Once the weights for each criterion are determined based on Table 2, the next step is to establish the value ranges for each criterion along with their conversion values. This is done to facilitate the calculation process in the subsequent stages. In the case study of selecting MSME business locations in this research, the value ranges and conversion values for each criterion are outlined as shown in Table 3.

**Table 3.** Conversion of Values for Each Criterion

| Criteria Code | Criteria | Value Range | Conversion Value |
|---|---|---|---|
| C1 | Rental Cost | < 30,000,000 | 1 |
| | | >= 30,000,000 and < 60,000,000 | 2 |
| | | >= 60,000,000 and < 90,000,000 | 3 |
| | | > 90,000,000 | 4 |
| C2 | Accessibility | Not Easy | 1 |
| | | Somewhat Easy | 2 |
| | | Easy | 3 |
| | | Very Easy | 4 |
| C3 | Infrastructure | Not Complete | 1 |
| | | Somewhat Complete | 2 |
| | | Complete | 3 |
| | | Very Complete | 4 |
| C4 | Number of Competitors | < 4 Competitors | 1 |
| | | >= 4 Competitors and < 8 Competitors | 2 |
| | | >= 8 Competitors and < 12 Competitors | 3 |
| | | > 12 Competitors | 4 |

After establishing the criteria, the next step is to evaluate all available options. In this context, options or alternatives refer to the various choices that can be considered in decision-making. In the case study discussed, there are five options to be evaluated: Angkasa Pura (A1), Nusa Indah (A2), Jayakarta (A3), Menara Teratai (A4), and Tirta Amarta (A5). The evaluation results for each of these alternatives have been summarized and presented in Table 4.

**Table 4. Values for Alternatives**

| Kode Alternatif | Alternatif | Kriteria | | | |
|---|---|---|---|---|---|
| | | C1 | C2 | C3 | C4 |
| A1 | Angkasa Pura | 50,000,000 | Easy | Complete | 5 |
| A2 | Nusa Indah | 25,000,000 | Easy | Somewhat Complete | 10 |
| A3 | Jayakarta | 40,000,000 | Very Easy | Complete | 8 |
| A4 | Menara Teratai | 90,000,000 | Very Easy | Very Complete | 9 |

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| | | | | | |
|---|---|---|---|---|---|
| A5 | Tirta Amarta | 60,000,000 | Very Easy | Very Complete | 7 |

The next step is to convert all the alternative values listed in Table 5. This conversion process follows the guidelines for values that were previously established in Table 4. Once the conversion process is completed, all the converted results are compiled and presented in a structured manner in Table 6.

**Table 6.** Results of Alternative Value Conversion

| Kode Alternatif | Alternatif | Kriteria | | | |
|---|---|---|---|---|---|
| | | C1 | C2 | C3 | C4 |
| A1 | Angkasa Pura | 2 | 3 | 3 | 2 |
| A2 | Nusa Indah | 1 | 3 | 2 | 3 |
| A3 | Jayakarta | 2 | 4 | 3 | 3 |
| A4 | Menara Teratai | 4 | 4 | 4 | 3 |
| A5 | Tirta Amarta | 3 | 4 | 4 | 2 |

Table 6 shows the converted values for each available alternative. In the COPRAS method, to determine the most optimal alternative, the first step is to create the initial decision matrix, which includes all the attributes. This process involves evaluating each alternative based on the previously established criteria. These values are then organized in matrix format, following the formula provided in Equation (5). For this case study, the initial decision matrix is as follows:

$$D = \begin{bmatrix} 2 & 3 & 3 & 2 \\ 1 & 3 & 2 & 3 \\ 2 & 4 & 3 & 3 \\ 4 & 4 & 4 & 3 \\ 3 & 4 & 4 & 2 \end{bmatrix}$$

After successfully creating the initial decision matrix, the next step is to normalize each of the attributes. To obtain the normalized values for each attribute, calculations are performed using the formula provided in equation (6). Below is a detailed explanation of the calculation process used to obtain the normalized attribute values:

$$X_{11} = \frac{2}{2+1+2+3+3} = 0.2667$$
$$X_{21} = \frac{1}{2+1+2+3+3} = 0.1333$$
$$X_{31} = \frac{2}{2+1+2+3+3} = 2.0000$$
$$X_{41} = \frac{4}{2+1+2+3+3} = 0.1333$$
$$X_{51} = \frac{3}{2+1+2+3+3} = 0.2667$$
$$X_{12} = \frac{3}{3+3+4+4+4} = 0.2667$$
$$X_{22} = \frac{3}{3+3+4+4+4} = 0.1333$$
$$X_{32} = \frac{4}{3+3+4+4+4} = 2.0000$$
$$X_{42} = \frac{4}{3+3+4+4+4} = 0.1333$$
$$X_{52} = \frac{4}{3+3+4+4+4} = 0.2667$$
$$X_{13} = \frac{4}{4+2+3+4+4} = 0.2667$$
$$X_{23} = \frac{2}{4+2+3+4+4} = 0.1333$$
$$X_{33} = \frac{3}{4+2+3+4+4} = 2.0000$$
$$X_{43} = \frac{4}{4+2+3+4+4} = 0.1333$$
$$X_{53} = \frac{4}{4+2+3+4+4} = 0.2667$$
$$X_{14} = \frac{2}{2+3+3+3+2} = 0.1538$$
$$X_{24} = \frac{3}{2+3+3+3+2} = 0.2308$$
$$X_{34} = \frac{3}{2+3+3+3+2} = 0.2308$$
$$X_{44} = \frac{3}{2+3+3+3+2} = 0.2308$$
$$X_{54} = \frac{2}{2+3+3+3+2} = 0.1538$$

After all the attribute values have been normalized, the results are then placed into the following normalization matrix:

$$X_{ij} = \begin{bmatrix} 0.1667 & 0.1667 & 0.1875 & 0.1538 \\ 0.0833 & 0.1667 & 0.1250 & 0.2308 \\ 0.1667 & 0.2222 & 0.1875 & 0.2308 \\ 0.3333 & 0.2222 & 0.2500 & 0.2308 \\ 0.2500 & 0.2222 & 0.2500 & 0.1538 \end{bmatrix}$$

The next step is to calculate the weighted normalization value with equation (7). The weight for each criterion used in this step is based on the calculation of the PIPRECIA-S method which has been previously presented in Table 2. The following is the calculation process:

$$d_{11} = 0.1667 \times 0.2069 = 0.0350$$
$$d_{21} = 0.0833 \times 0.2069 = 0.0175$$
$$d_{31} = 0.1667 \times 0.2069 = 0.0350$$
$$d_{41} = 0.3333 \times 0.2069 = 0.0700$$
$$d_{51} = 0.2500 \times 0.2069 = 0.0525$$
$$d_{12} = 0.1667 \times 0.2069 = 0.0350$$
$$d_{22} = 0.1667 \times 0.2069 = 0.0350$$
$$d_{32} = 0.2222 \times 0.2069 = 0.0467$$
$$d_{42} = 0.2222 \times 0.2069 = 0.0467$$
$$d_{52} = 0.2222 \times 0.2069 = 0.0467$$
$$d_{13} = 0.1875 \times 0.4138 = 0.0769$$
$$d_{23} = 0.1250 \times 0.4138 = 0.0513$$
$$d_{33} = 0.1875 \times 0.4138 = 0.0769$$
$$d_{43} = 0.2500 \times 0.4138 = 0.1025$$
$$d_{53} = 0.2500 \times 0.4138 = 0.1025$$
$$d_{14} = 0.1538 \times 0.1724 = 0.0262$$
$$d_{24} = 0.2308 \times 0.1724 = 0.0392$$
$$d_{34} = 0.2308 \times 0.1724 = 0.0392$$
$$d_{44} = 0.2308 \times 0.1724 = 0.0392$$
$$d_{54} = 0.1538 \times 0.1724 = 0.0262$$

After all attribute values have been normalized and multiplied by their respective weights, the results are then placed into the weighted normalization matrix as follows:

$$D_{ij} = \begin{bmatrix} 0.0350 & 0.0350 & 0.0769 & 0.0262 \\ 0.0175 & 0.0350 & 0.0513 & 0.0392 \\ 0.0350 & 0.0467 & 0.0769 & 0.0392 \\ 0.0700 & 0.0467 & 0.1025 & 0.0392 \\ 0.0525 & 0.0467 & 0.1025 & 0.0262 \end{bmatrix}$$

After obtaining the weighted normalized decision matrix, the next step is to calculate the maximum and minimum index values. This calculation is differentiated based on the type of criteria – for benefit criteria, the formula in Equation (8) is used, while for cost criteria, the formula in Equation (9) is applied. Referring to the data in Table 3, it can be identified that C2 and C3 fall under benefit criteria, while C1 and C4 are cost criteria. The following is the calculation process for obtaining the maximum values:

$$A_{+1} = 0.0350 + 0.0769 = 0.1119$$
$$A_{+2} = 0.0350 + 0.0513 = 0.0863$$
$$A_{+3} = 0.0467 + 0.0769 = 0.1235$$
$$A_{+4} = 0.0467 + 0.1025 = 0.1492$$
$$A_{+5} = 0.0467 + 0.1025 = 0.1492$$

For the minimum value, the calculation process is as follows:

$$A_{-1} = 0.0350 + 0.0262 = 0.0612$$
$$A_{-2} = 0.0175 + 0.0392 = 0.0567$$
$$A_{-3} = 0.0350 + 0.0392 = 0.0742$$
$$A_{-4} = 0.0700 + 0.0392 = 0.1092$$
$$A_{-5} = 0.0525 + 0.0262 = 0.0787$$

The next step involves calculating the relative weight values, which are derived using Equation (10). The results of the calculation for obtaining the relative weight values are as follows:

$$Q_1 = 0.1119 + \left(\frac{0.3800}{4.2392}\right) = 0.2015$$

$$Q_2 = 0.0863 + \left(\frac{0.3800}{3.9326}\right) = 0.1829$$

$$Q_3 = 0.1235 + \left(\frac{0.3800}{5.1457}\right) = 0.1974$$

$$Q_4 = 0.1492 + \left(\frac{0.3800}{7.5718}\right) = 0.1994$$

$$Q_5 = 0.1492 + \left(\frac{0.3800}{5.4523}\right) = 0.2189$$

The final step is to calculate the Utility value ($U_i$) for each alternative using the formula in equation (11). The alternative with the highest Utility value is considered the most recommended option. The following are the steps to obtain the Utility value:

$$U_1 = \frac{0.2015}{0.2189} \times 100 = 91.09$$

$$U_2 = \frac{0.1829}{0.2189} \times 100 = 92.07$$

$$U_3 = \frac{0.1974}{0.2189} \times 100 = 83.56$$

$$U_4 = \frac{0.1994}{0.2189} \times 100 = 90.19$$

$$U_5 = \frac{0.2189}{0.2189} \times 100 = 100$$

Once the Utility values have been calculated, the next step is to rank these values from the highest to the lowest, as shown in Table 7.

**Table 7.** Utility Value Rankings

| Alternative Code | Alternative | Utility Value | Ranking |
|---|---|---|---|
| A5 | Tirta Amarta | 100 | 1 |
| A2 | Nusa Indah | 92.07 | 2 |
| A1 | Angkasa Pura | 91.09 | 3 |
| A4 | Menara Teratai | 90.19 | 4 |
| A3 | Jayakarta | 83.56 | 5 |

According to the results presented in Table 7, the ranking of alternatives based on utility values, from highest to lowest, is as follows: Tirta Amarta (A5) takes the top spot with a maximum score of 100, followed by Nusa Indah (A2) in second place with a score of 92.07. Angkasa Pura (A1) ranks third with a score of 91.09, while Menara Teratai (A4) comes in fourth with a score of 90.19. Jayakarta (A3) holds the last position with a score of 83.56. From this analysis, it can be concluded that Tirta Amarta (A5) is the most recommended alternative in this case study.

The next process is implementation, where the decision support system is realized through the coding process. The coding is carried out using the Emacs text editor, with data storage managed by MySQL as the database. The system requires user authentication for access, after which the user is directed to the DSS dashboard for MSME business location selection, as shown in Figure 3.

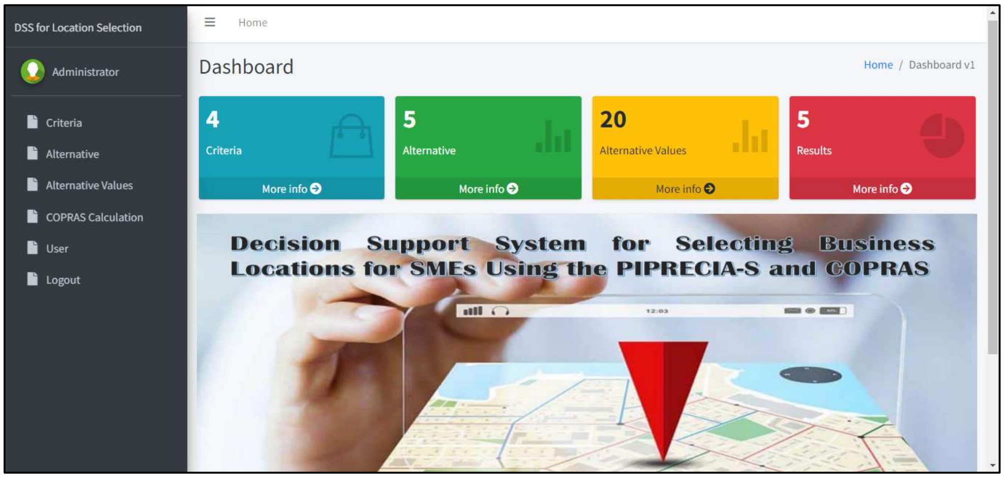


**Figure 3.** Dashboard Page

Figure 3 displays the dashboard page, which functions as the control center, presenting the system's main features. These core features include managing criteria, alternatives, evaluating alternatives, and performing calculations using the COPRAS method. To begin the process of selecting a business location for MSMEs, the user must first manage the criteria through the Criteria feature. This feature allows users to add, modify, or delete data criteria that will be used for decision-making. Next, the user can manage alternative data, which consists of business location options to be considered, through the Alternatives feature. Users can add, modify, or delete alternative data. Once the criteria and alternative data are managed, the next step is to evaluate each alternative using the Alternative Values feature. Here, the user can assess each alternative based on the given criteria. The interface for adding alternative value data is shown in Figure 4.

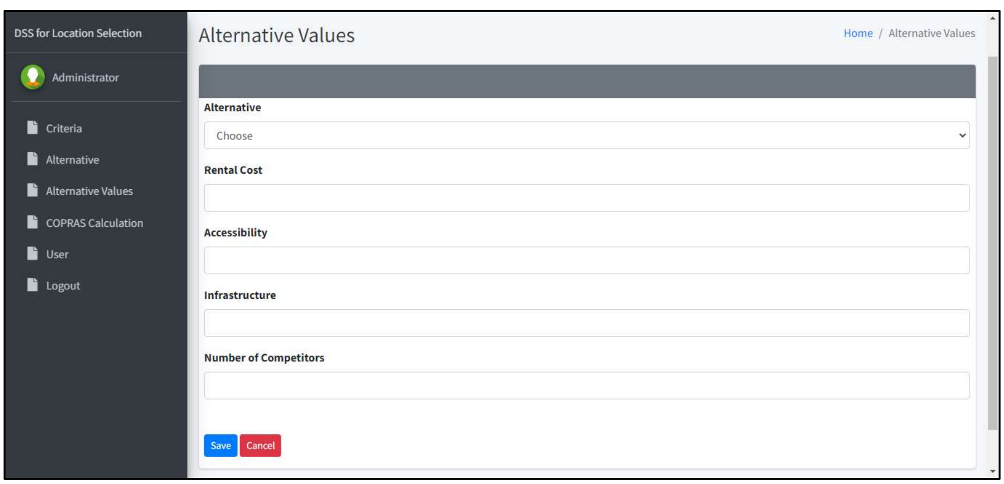


**Figure 5.** Page for Adding Alternative Value Data

After entering the alternative value data, users can view the best alternatives in the COPRAS Calculation menu. This feature displays each step of the COPRAS calculation process in detail, along with the final recommendation in the form of a ranked list of alternatives, ordered from the highest to the lowest score. The final calculation results can be seen in Figure 6.

**Maximum and Minimum Index Values**

| No | Alternative | $S_{+i}$ | $S_{-i}$ |
|---|---|---|---|
| 1 | Angkasa Pura | 0.111875 | 0.0611538461539 |
| 2 | Nusa Indah | 0.0862500000001 | 0.0567307692307 |
| 3 | Jayakarta | 0.123541666667 | 0.0742307692308 |
| 4 | Menara Teratai | 0.149166666667 | 0.109230769231 |
| 5 | Tirta Amarta | 0.149166666667 | 0.0786538461538 |

**Nilai Utilitas Kuantitatif ($U_i$)**

| No | Alternative | $U_i$ |
|---|---|---|
| 1 | Angkasa Pura | 92.0739053303 |
| 2 | Nusa Indah | 83.5589273574 |
| 3 | Jayakarta | 90.1892128462 |
| 4 | Menara Teratai | 91.0857585259 |
| 5 | Tirta Amarta | 100 |

**Figure 6.** Page for Calculation Results and Alternative Ranking

Figure 6 shows the calculation results of the COPRAS method, which displays the utility ranking. In this result, Tirta Amarta (A5) ranks at the top with a score of 100. Based on the COPRAS calculation results in this case study, the system produced outputs consistent with manual calculations, validating that the system's results are accurate.

The process continues with testing the developed DSS. The testing approach used is black box testing. Black box testing examines the system without considering its internal structure or implementation. The test is conducted by providing input into the system and checking the output to ensure that the system operates according to the specified requirements. The results of black box testing for each system function are presented in Table 8.

**Table 8.** Black-Box Testing Results

| No | Test Features | Expected Function | Result |
|---|---|---|---|
| 1 | Login Menu | The system allows users to log in by entering their username and password. | Valid |
| 2 | Main Menu | The system can display the main page or dashboard along with all available features. | Valid |
| 3 | Criteria Management | The system can manage criteria data, including adding, editing, and deleting criteria. | Valid |
| 4 | Alternative Management | This system allows management of alternative data, including adding, changing, and deleting alternatives. | Valid |
| 5 | Alternative Values | The system supports the management of alternative values, including adding, modifying, and deleting alternative values. | Valid |
| 6 | COPRAS Calculation Process | The system can display the COPRAS method calculations correctly. | Valid |
| 7 | Ranking Results | The system can display the ranking results of alternatives based on COPRAS calculations. | Valid |
| 8 | User Management | The system can manage user data, including adding, editing, and deleting users. | Valid |

The results of the black-box testing, as shown in Table 8, indicate that all the primary system functions operate correctly and as expected. Every functionality tested, from the login menu, main menu, to the management of criteria, alternatives, and users, produced valid outcomes. This confirms that the system meets the defined functional specifications. Additionally, the system successfully executed the COPRAS method calculations and accurately displayed the ranking results. Overall, this testing confirms that the system is ready for use by users, both in terms of accessibility, data management, and the system's calculation process. No errors or malfunctions were detected during testing, indicating that the system's functionality is reliable.

## 4. Conclusion

This research has successfully implemented the combination of the Complex Proportional Assessment (COPRAS) method and the PIPRECIA-S weighting technique in a decision support system (DSS) for selecting MSME business locations. The COPRAS method is effective in evaluating multiple decision alternatives by considering complex and interrelated criteria. Meanwhile, the PIPRECIA-S technique provides a structured approach for determining criterion weights by using pivot comparisons as a reference to establish the importance level of each criterion. The DSS was designed as a web-based application with core features, including data management for criteria, alternatives, and alternative evaluation, ultimately providing recommendations in the form of alternative rankings. The black-box testing results showed that all the key system functions performed well and in accordance with the specified requirements. This indicates that the system operates optimally and fulfills all designed functionalities. For future research, improvements could include incorporating fuzzy logic algorithms to enhance the objectivity of determining relative significance values in the PIPRECIA-S approach, as these values are highly dependent on user subjectivity. Furthermore, additional testing should be conducted to assess the accuracy of the decisions generated by the system.

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