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Multiple Criteria Decision Analysis in HDMI Splitter Selection Using Complex Proportional Assessment Method

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ABSTRACT

High-Definition Multimedia Interface (HDMI) technology is used for devices such as HDTVs, Projectors, and DVD players. One HDMI cable can only connect one device, even though, when needed, one computer or laptop can be displayed on several televisions or projectors using HDMI Splitter. HDMI Splitter is an accessory that displays content on multiple screens. HDMI Splitter has been circulated with various brands that offer different capabilities and specifications. Therefore, Therefore, thorough consideration is needed in choosing the right HDMI Splitter. This study aims to build a decision support system with the Multiple Criteria Decision Analysis (MCDA) approach using Complex Proportional Assessment (COPRAS). The COPRAS method solves the selection problem by calculating the utility level of alternatives, which shows the extent to which an alternative is better or worse than other alternatives through a comparison process. Based on existing studies, the utility values of each alternative were obtained, namely: Robot HDMI Splitter producing a value of 53.73%, Vention HDMI Splitter producing a value of 65.63%, Bafo HDMI Splitter producing a value of 97.13, and PX HDMI Splitter producing a value of 100%. Hence, based on testing through the black box, the best alternative is PX HDMI Splitter.

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1. INTRODUCTION

Through the development of technology, information delivery activities such as learning media, promotional media, presentation media, and the like can use television or projectors. Today's televisions and projectors are equipped with High-Definition Multimedia Interface (HDMI) technology. HDMI is a multimedia

technology used as a connector to transfer high-definition audio and video from one device to another via a single cable (X. Peng, YS Geng, 2020).

HDMI technology is used with HDTVs, Projectors, DVD players, or Blu-ray players. One HDMI cable replaces three composite audio or video cables, connecting two devices to transmit audio and video signals more efficiently. HDMI can transmit standard, enhanced, high-definition video signals and up to 8 channels of digital audio signals (T. Shin, 2021). One HDMI cable can only connect one device, even though for various needs, one computer or laptop device can be displayed on several televisions or projectors using HDMI Splitter. HDMI Splitter is an accessory that can display content on multiple screens. So, from one input, it is, relayed into multiple outputs or screens simultaneously (HI-FI., 2022). An HDMI splitter takes content from a source and then breaks it down into multiple signals sent to several display screens. This device is beneficial, for example, for presentations in a roomy place. Likewise, it can be utilized for an electronic business, such as selling television, which requires displaying images on several televisions. HDMI Splitter has been widely circulated in the market with various brands that offer different capabilities and specifications. Choosing the appropriate HDMI Splitter is important to maximize the performance of the device in displaying several screens at the same time. Hence, a solution is needed to solve these problems by developing a system that can select and recommend HDMI Splitters according to user needs. A system that can assist in decision-making is a decision support system.

A decision support system (DSS) is a knowledge-based system and can provide the best alternative recommendations to assist in making a decision (Roberts, 2021). DSS supports decision makers in solving semi-structured problems through models and calculations that provide the best solution (Sànchez-Marrè., 2022). In this case, the selection of HDMI Splitter involves several criteria and several alternatives with subjective judgments. These problems can be solved using the Multiple Criteria Decision Analysis (MCDA) approach, which can be considered the best candidate for use in the evaluation, using a well-defined group of subjects (selected users) to achieve a good insight evaluation (Mantoro, 2006).

The MCDA approach decided to get the best alternative from several alternatives based on several criteria (Garg, Rakesh, R. Kumar, 2018). To implement a decision support system, the proper method or model is needed (Borman, Rohmat Indra, Helmi, 2018). One method that can be used is the Complex Proportional Assessment (COPRAS) method. COPRAS method was developed in 1996 by Vilnius Gediminas Technical University scientists Zavadskas and Kaklauskas and first published in a respective article (Vytautas, 2015). The COPRAS method is an approach that applies a step-by-step ranking and evaluates alternative procedures through significance and utility levels (Organ, Arzu, 2016). This method assumes a direct and proportional dependence of each alternative's significance level and utility against its conflicting criteria. The COPRAS method distinguishes both positive (benefit) and negative (cost) criteria, and are separate the calculation process (Sahir, 2019). The COPRAS method can solve election problems through the calculation of alternative utility levels that show the extent to which an alternative is better or worse than other alternatives through the process of comparing (Hutapea, 2019). **Table 1** shows some of the use of COPRAS in decision analysis of a several criteria.

Table 1. Use of Complex Proportional Assessment (COPRAS) in decision analysis of a several criteria

Stage	Method	Article title and author	The calculation results
Best Fisherman Group	Copras	Decision Support System for Determining the Best Fisherman Group Applying the Copras Method (Sihite, 2020)	From the alternative calculation, A5, namely the Indonesian Fishermen Union, was selected as the best fishermen group with a quantitative utility (Ui) of 100, ranking 1
Selection of the Best Sales Marketing	Copras	The Best Sales Marketing Decision Support System in PT. Alfa Scorph Using COPRAS Method (Siregar, Alwali Daini Udda, Nelly Astuti Hasibuan, 2020)	From the alternative calculations, A5, namely Sales Marketing Alwain, was chosen as the best Sales Marketing with a Performance Index (Pi) of 100, ranking 1
Determining the Best Fabric	Copras	Copras Method to Determine The Best Fabric In Making Clothing at Batik Hatta Semarang Boutique (Cholil, Saifur Rohman, Setyawan, 2021).	From the alternative calculation, it means A 1, which is the best batik cloth with a performance index (Pi) value of 100, ranking 1.

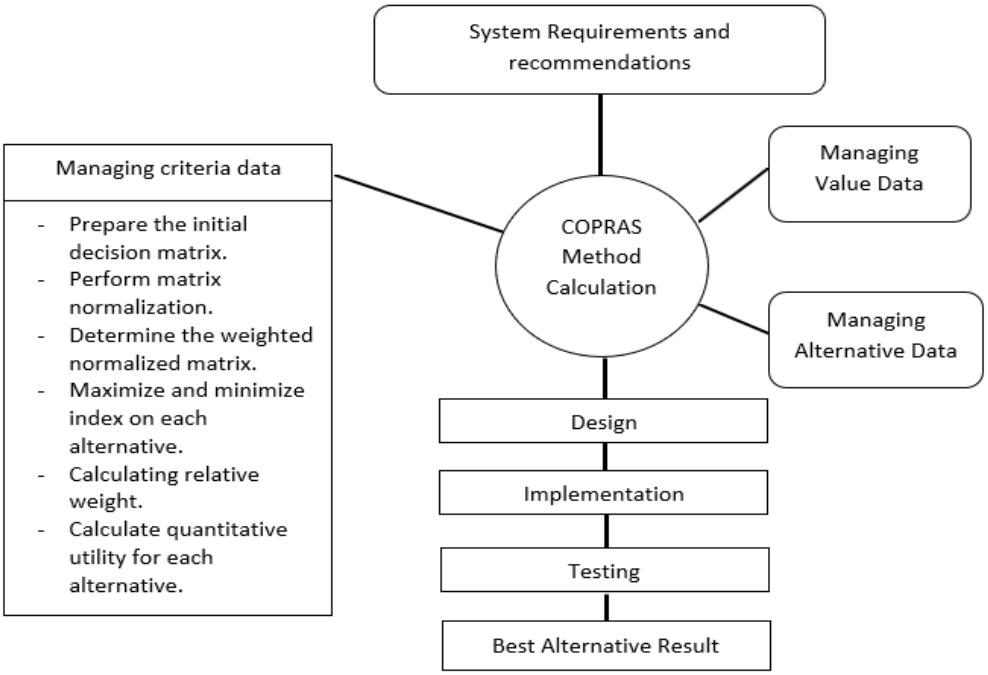

Figure 1. Research Stages and the flow of calculating the COPRAS method

This study aims to build a decision support system with Multiple Criteria Decision Analysis (MCDA) using Complex Proportional Assessment (COPRAS) to assist in selecting HDMI Splitter so that it can choose the suitable alternative according to user needs. The system is built on a website to be used anywhere and anytime. The criteria used for HDMI Splitter are based on price, Transmission length, the number of ports, audio and video support, and resources.

2. RESEARCH METHODOLOGY

In order to have the study running well, it is necessary to arrange the stages of the research. The research stages contain the steps in conducting research that is arranged in a structured and planned manner in order to achieve the research objectives (Jusman, 2021). The research stage used in this study can be seen in **Figure 1**.

Figure 1 describes the stages of research and the flow of calculating the

COPRAS method, starting from system requirements and user recommendations by managing value data, alternative data, and criteria data, then making application designs, implementing applications, testing, and getting the best alternative results.

2.1. System Requirement

At this stage, Engineering Requirements (ER) from the initial phase of product development was collected by the developer (Karl A. Hribernik, Klaus-Dieter Thoben Wellsandt, 2014). To determine the need, it is necessary to identify the problem to be solved. Based on the problems that have been obtained, then the system requirements analysis is carried out. Requirement analysis is based on functional requirements analysis. Functional requirements are statements about the features needed so that the system can provide services that are in accordance with the wishes of the user (Napianto, 2021). So, at this stage problems were identified, and needs were determined by the researcher based on existing problems so that functional requirements analysis can be obtained.

2.2. Multiple Criteria Decision Analysis With COPRAS

In completing decision making by determining the best alternative obtained from several alternatives and several criteria using the Multiple Criteria Decision Analysis (MCDA) approach. This approach is an approach that involves several underlying criteria in making decisions, through subjective assessments in order to solve election problems using alternative analysis (Hutapea, 2019). One method that can be used is the Complex Proportional Assessment (COPRAS) method. The COPRAS method is an approach that applies rankings in stages and evaluates alternative procedures through significance and utility levels (Organ, Arzu, 2016). This means that this method assumes a direct and proportional dependence of each alternative's level of significance and utility against its conflicting criteria. COPRAS has the advantage that it can solve election problems through the calculation of alternative utility levels that show the extent to which an alternative is better or worse than other alternatives through a process (Hutapea, 2019).

To apply the COPRAS method, there are several stages, including the following:

1) Prepare the initial decision matrix.

This step the attributes to be evaluated are entered into the decision matrix based on Equation (1).

$$D = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{14} \\ x_{21} & x_{22} & x_{23} & x_{24} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & x_{m3} & x_{mn} \end{bmatrix} \quad (1)$$

2) Perform matrix normalization.

To create a normalized matrix, Equation (2) is utilised.

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

3) Determine the weighted normalized matrix.

The next step is to determine the weighted normalized matrix using Equation (3).

$$D' = d_{ij} = X_{ij} \times W_{ij} \quad (3)$$

4) Maximize and minimize index on each alternative.

The next step is to calculate the maximum and minimum index values for each alternative using Equations (4) and (5) below.

$$equal\ S_{+i} = \sum_{j=1}^{n} y_{+ij} \quad (4)$$

$$S_{-i} = \sum_{j=1}^{n} y_{-ij} \quad (5)$$

5) Calculating relative weight.

The next step is to determine the relative priority of each alternative. To calculate the relative weight can use the following Equation (6) or (7).

$$Q_i = S_{+i} + \frac{S_{-i\,min} \sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} (S_{min}/S_{-i})} \quad (6)$$

$$Q_i = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} (1/S_{-i})} \quad (7)$$

6) Calculate quantitative utility for each alternative.

The next step is to calculate the utility (Ui) for each alternative through Equation (8).

$$U_i = \frac{Q_i}{Q_{max}} \times 100\% \quad (8)$$

2.3. Design

The design is the stage where the developer compiles the system modelling in the form of a particular diagram. The design used is through the use case diagrams. This diagram describes the relationship between actors that shows the functionality of the system being built (Borman, Rohmat Indra, Priandika, Adhie Thyo, Edison, 2020). In the use case diagram, there are functions that can be performed by actors on the system.

2.4. Implementation

The next process is coding, where in this stage the previous stages was implemented into a system using a certain programming language (Ahmad, Imam, Rahmanto, Yuri, Pratama, Devin, Borman, 2021). In this study, the system was built on a web-based basis, so coding using the PHP programming language used the Visual Code Studio text editor and MySQL for data storage.

2.5. Testing

After all the processes are done, the next step is testing. This stage has the aim of ensuring that the system developed is able to work well and is free from errors (Napianto, 2021).

This study uses a test technique, namely black box testing, which is a test design based on the specifications of a software (Glenford J. Myers, Sandler, Corey. Badgett, 2015).

This method tests the system based on the functionality of the system so that the software has been tested for its functions well. So, in this study, testing was carried out using black box testing of the features that exist in the system being developed.

3. RESULTS AND DISCUSSION

To build an HDMI Splitter decision support system, the first step is problem identification. The main problem in this research is how to help get the best alternative or solution for choosing the right HDMI Splitter through the implementation of Multiple Criteria Decision Analysis (MCDA) with the COPRAS method. Furthermore, from these problems, functional requirements are arranged. The functional requirements of the built DSS include:

1) The system has the feature of managing criteria data.
2) The system has the feature of managing alternative data.
3) The system has the feature of managing weight data.
4) The system can manage the value of each alternative.
5) The system can perform calculations using the COPRAS method.

After knowing the functional requirements of the system, then the system is designed according to the requirement, and needs. System design using use case diagrams. Use case diagrams are utilized to describe the functions that can be run by actors on the system that is built. The use case diagram

of the system that was built is presented in **Figure 2**.

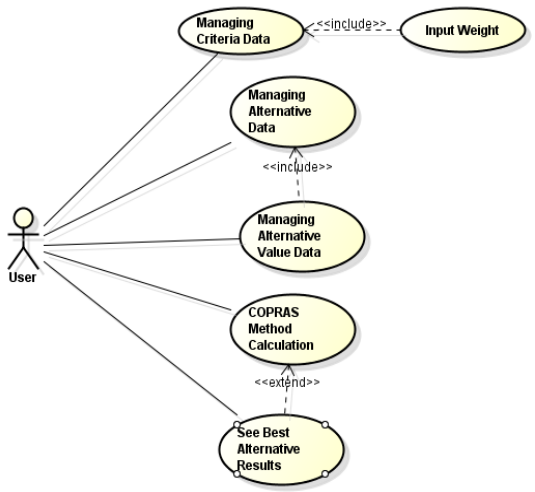

Figure 2. Use Case Diagram of the System Developed

Completion of Multiple Criteria Decision Analysis (MCDA) with the COPRAS method for the selection of HDMI Splitter begins with determining the criteria. The criteria set include:

1) Cost. This criterion is based on the cost of each HDMI Splitter which will be an alternative.
2) Transmission Length. This criterion is the maximum distance the HDMI Splitter can deliver audio and video signals to other devices.
3) Number of Ports. This criterion is the maximum number of HDMI Splitters that can be connected to devices, for example an HDMI Splitter has a total of 4 ports, meaning that the HDMI Splitter can display video and audio to 4 devices.
4) Video and Audio Support. Video support needs to be considered because the resolution supported by the HDMI splitter will affect what is displayed on the TV. In addition, audio support is also an important factor, it should be noted whether the HDMI Splitter can support audio with good quality.
5) Resource. In HDMI Splitter in general there are two support resources, namely adapter, and non-adapter. HDMI Splitter with adapter power source requires its own power source, while non-adapter HDMI Splitter does not need its own power source, because the power source is obtained from USB.

Based on these criteria, the range of criteria values and the conversion value of each criterion is determined. **Table 2** below show the range of values and value conversions for each criterion used.

Table 2. HDMI Splitter Selection Criteria

No	Criteria Code	Criteria Name	Criteria Value	Value Conversion
1	C1	Price	< Rp. 400,000	4
			Rp. 400,000 up to Rp. 800,000	3
			Rp. 800,000 up to Rp. 1.200.000	2
			> Rp. 1,200,000	1
2	C2	Transmission Length	> 10 Meters	1
			10 - 20 Meters	2
			21 - 30 Meters	3
			> 30 Meters	4
3	C3	Number of Ports	> 2 Ports	1
			2 - 4 Ports	2
			5 - 7 Ports	3
			> 8 Ports	4
4	C4	Video and Audio Support	Very Incomplete	1
			Incomplete	2
			Complete	3
			Very Complete	4
5	C5	Resource	Adapter	1
			Non-Adapter	2

In the COPRAS method, there are two types of criteria used, namely benefits and costs. For the benefit criteria type, the higher the value, the better the alternative, on the contrary, for the cost criteria type, the lower the value, the better. From the predetermined criteria, it is identified that the price criterion is a cost criterion, while the criteria for transmission length, number of ports, video, and audio support and resources are benefit criteria. Next, is to determine the weight or importance of the criteria for each criterion. As an example of a case study, this study uses the weight of the criteria presented in **Table 3**.

Table 3. Weight of HDMI Splitter Selection Criteria

Criteria	Weight
C1	20%
C2	30%
C3	20%
C4	20%
C5	10%

As a sample for the case study, the alternatives used in this research include Robot HDMI Splitter (A1), Vention HDMI Splitter (A2), Bafo HDMI Splitter (A3), PX HDMI Splitter (A4). Then the next step is to determine the value of the criteria for each alternative. The following **Table 4** shows the result of the assessment of each alternative against the predetermined criteria.

Based on the case study above, to complete the selection of HDMI Splitter using the COPRAS method, several stages were involved, including:

1) Prepare the initial decision matrix.

This step will include the attributes that will be evaluated in the decision matrix based on Equation (1). Thus, the initial decision matrix in this case is as follow,

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

2) Perform matrix normalization.

To create a normalized matrix, Equation (2) is utilized. Hence the calculation for normalization in this case study are as follows,

$$X_{11} = \frac{4}{4+4+2+2} = 0.3333$$

$$X_{21} = \frac{4}{4+4+2+2} = 0.3333$$

$$X_{31} = \frac{2}{4+4+2+2} = 0{,}1667$$

$$X_{41} = \frac{2}{4+4+2+2} = 0{,}1667$$

Table 4. Value of Each Criterion

Alternative	Price (C1)		Transmission Length (C2)		Number of Ports (C3)		Video & Audio Support (C4)		Resource (C5)	
	Results	Score	Results	Score	Results	Score	Results	Score	Results	Score
Robot HDMI Splitter (A1)	152.000	4	5 m	1	2 Ports	2	Incomplete	2	Non-Adapter	2
Vention HDMI Splitter (A2)	272.000	4	25 m	3	2 Ports	2	Incomplete	2	Adapter	1
Bafo HDMI Splitter (A3)	810.000	2	24 m	3	8 Ports	4	Very Complete	4	Adapter	1
PX HDMI Splitter (A4)	980.000	2	80 m	4	4 Ports	3	Very Complete	4	Adapter	1

Compute until all attributes or up to x54. After all, have been computed, values are normalized which are then entered into the normalized matrix. The resulting normalized matrix is given as:

$$X_{ij} = \begin{bmatrix} 0.3333 & 0.0909 & 0.1818 & 0.1667 & 0.4 \\ 0.3333 & 0.2727 & 0.1818 & 0.1667 & 0.2 \\ 0.1667 & 0.2727 & 0.3636 & 0.3333 & 0.2 \\ 0.1667 & 0.3636 & 0.2727 & 0.3333 & 0.2 \end{bmatrix}$$

3) Determine the weighted normalized matrix.

The next step is to determine the weighted normalized matrix using Equation (3). The weight of the criteria can be seen in Table 3, so the calculation for the weighted normalized matrix in this case study is as follows:

$$d_{11} = 0.3333 \times 20\% = 0.0667$$

$$d_{21} = 0{,}3333 \times 20\% = 0.0667$$

$$d_{31} = 0.1667 \times 20\% = 0.0333$$

$$d_{41} = 0.1667 \times 20\% = 0.0333$$

It is calculated continuously until all attributes have been multiplied by their weights or up to d_{54}. After all values have been multiplied by their weights, then they are entered into a weighted normalized matrix. The following is the result of the weighted normalized matrix.

$$D_{ij} = \begin{bmatrix} 0.0667 & 0.0273 & 0.0364 & 0.0333 & 0.04 \\ 0.0667 & 0.0818 & 0.0364 & 0.0333 & 0.02 \\ 0.0333 & 0.0818 & 0.0727 & 0.0667 & 0.02 \\ 0.0333 & 0.1091 & 0.0545 & 0.0667 & 0.02 \end{bmatrix}$$

4) Maximize and minimize the index on each alternative.

The next step is to calculate the maximum and minimum index values for each alternative using Equations (4) and (5). Based on the predetermined criteria, it was identified that the benefit criteria were C2, C3, C4, and C5, while the cost criteria were C1. Then the calculation of the maximum value of S_{+i} (C2, C3, C4, and C5) for the index of each alternative is as follows:

$$A_1 = 0.0273 + 0.0364 + 0.0333 + 0.04 = 0.1370$$

$$A_2 = 0.0818 + 0.0364 + 0{,}0333 + 0.02 = 0.1715$$

$$A_3 = 0.0818 + 0.0727 + 0{,}0667 + 0.02 = 0.2412$$

$$A_4 = 0.1091 + 0.0545 + 0{,}0667 + 0.02 = 0.2503$$

As for the minimum value of S_{+i} (C1) the index of each alternative is as follows:

$$A_1 = 0.0667$$

$$A_2 = 0.0667$$

$$A_3 = 0{,}0333$$

$$A_4 = 0{,}0333$$

5) Calculating relative weight.

The next step is to determine the relative priority of each alternative. To calculate the relative weight can use Equations (6) or (7). In this case study the relative priorities for each alternative are as follows:

$$Q_1 = 0.1370 + \frac{0.2}{6} = 0.1703$$

$$Q_2 = 0.1715 + \frac{0.2}{6} = 0.2048$$

$$Q_1 = 0.2412 + \frac{0.2}{3} = 0{,}3079$$

$$Q_4 = 0.2503 + \frac{0.2}{3} = 0.3170$$

6) Calculate quantitative utility for each alternative

The next step is to calculate the utility (U_i) for each alternative through Equation (8). The utility value has a range between 0% to 100%. The alternative that has the highest utility is the best alternative. Based on the results of the Q_i calculation, the value of Q_{max} is 0.3170. Then the calculation of the utility value of each alternative is as follows:

$$U_1 = \frac{0.1730}{0.3170} \times 100\% = 53.73$$

$$U_2 = \frac{0,2048}{0.3170} \times 100\% = 65.63$$

$$U_3 = \frac{0,3079}{0.3170} \times 100\% = 97.13$$

$$U_4 = \frac{0.3170}{0.3170} \times 100\% = 100$$

Based on the calculation of the utility value (U_i) that has been carried out, the utility value of each alternative is obtained as in **Table 5**.

Table 5. Utility rating value on each alternative

Alternative	Utility Value
Robot HDMI Splitter (A1)	53.73%
Vention HDMI Splitter (A2)	65.63%
Bafo HDMI Splitter (A3)	97.13%
PX HDMI Splitter (A4)	100%

The highest utility value (U_i) is the best alternative. So based on **Table 5**, in this case study the best alternative is the PX HDMI Splitter (A4) with a utility value (U_i) of 100%.

The implementation of Multiple Criteria Decision Analysis (MCDA) using a Complex Proportional Assessment (COPRAS), the selection of an HDMI Splitter is implemented based on a website.

So, for the implementation process using the PHP programming language with a text editor Visual Code Studio and for data storage using a MySQL database. HDMI Splitter selection system main page interface is presented in **Figure 3**.

The main page of the HDMI Splitter selection system displays a graph of the COPRAS calculation results and the main features of the system, including Criteria, Alternative, Alternative Values and COPRAS Calculation features. In the Criteria feature, users can manage criteria data, where users can add, edit and delete criteria data. Besides, the user can also enter the weight of the criteria according to the level of importance of each criterion. The Criteria feature interface can be seen in **Figure 4.**

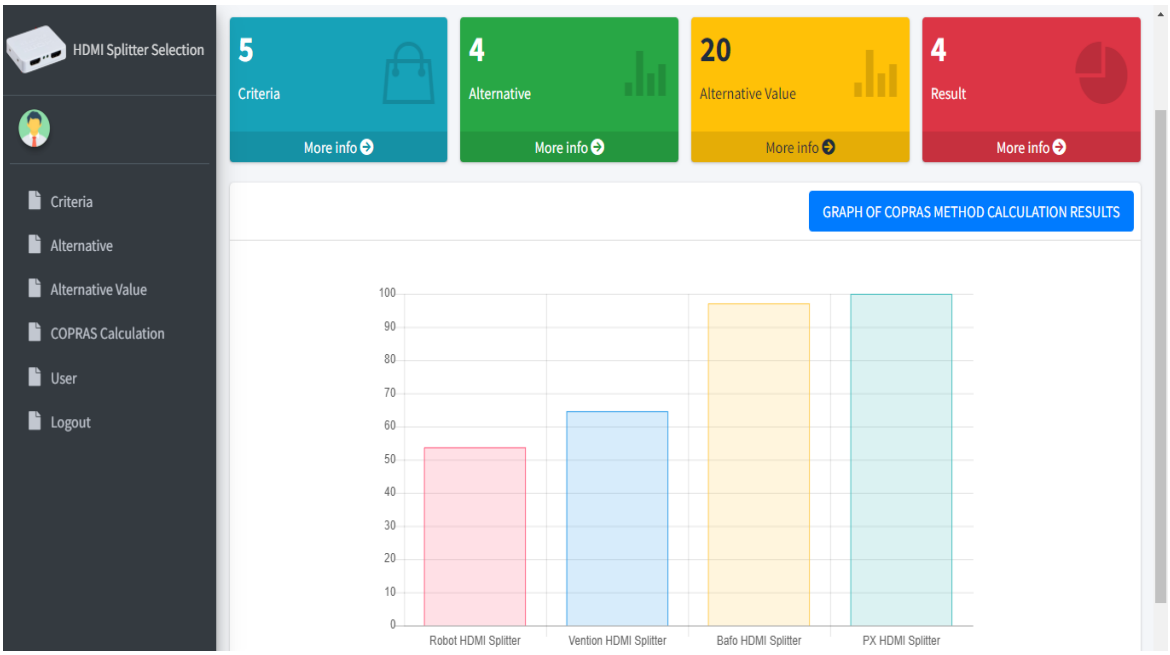

Figure 3. Main Menu Interface

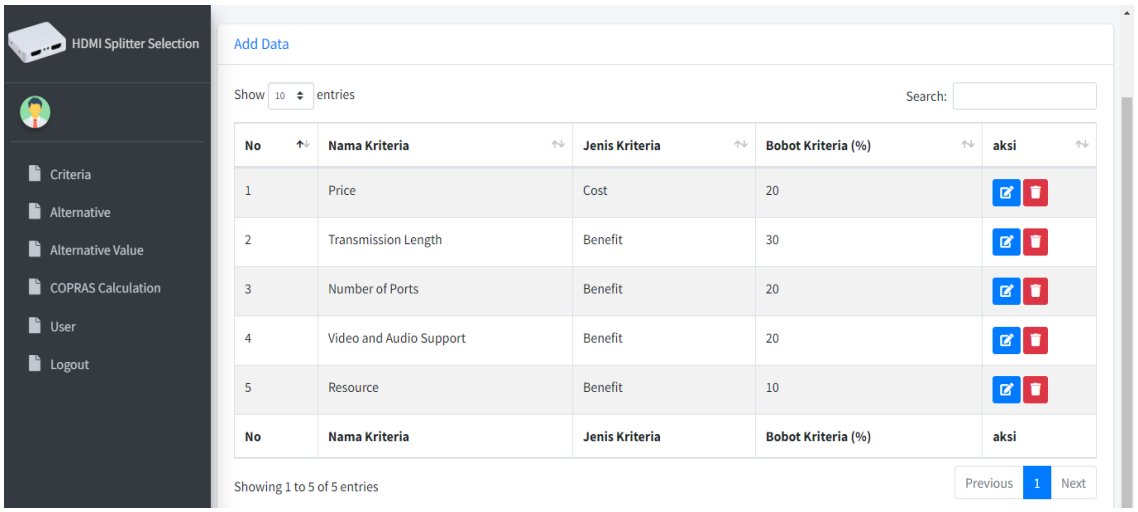

Figure 4. Criteria Menu Interface

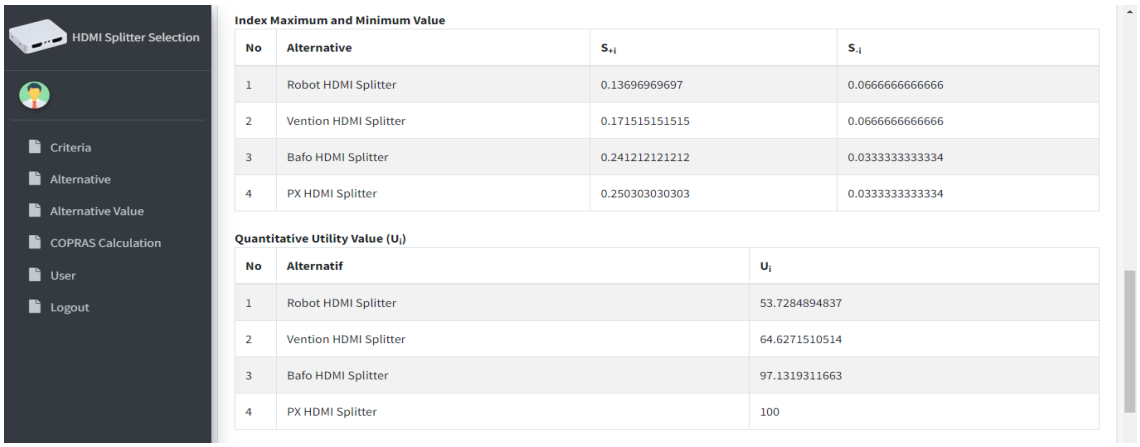

Figure 5. COPRAS Method Calculation Interface

Next, the user can enter conditions in the Alternative menu. In this menu, the user can add, change and delete alternatives. After the alternative has been filled in, the user can then assign a value to the alternative through the Alternative Value feature. In this feature, the user will assign a value to each alternative based on predetermined criteria. After each alternative has been assigned a value, the user can select the HDMI Splitter using the COPRAS method in the COPRAS Calculation feature. This feature will display the calculation process using the COPRAS method and the results of the recommendations from the system. The interface for the COPRAS calculation results can be seen in **Figure 5**.

The next stage is to test the system to ensure the system can run properly and is free from errors. The test used is by using black-box testing, which performs tests based on system functionality. The results of the black-box testing can be seen in **Table 6.** Based on **Table 6**, it can be seen that the conclusions on each test feature in application HDMI Splitter Selection are "Valid". This means the system has been running well. In addition, the calculation results issued by the system with the results of calculating manually show the same results. This shows that the implementation of the COPRAS method is appropriate.

Table 6. Black-Box Testing Results

No	Test Features	Expected Results	Conclusion
1	Main Menu Features	The system can display the main menu containing system features and display a graph of the COPRAS method calculation results.	Valid
2	Criteria Features	Users can manage criteria such as adding, changing, and deleting criteria.	Valid
3	Alternative Features	Users can perform alternative management such as adding, changing, and deleting alternatives.	Valid
4	Criteria Value Features	Unser can perform alternative value management such as adding, changing, and deleting values.	Valid
5	COPRAS Calculation Features	Users can see the calculation process using the COPRAS method	
6	Best Alternative Results	Users can see the ranking results and system recommendations for the best alternative	Valid

4. CONCLUSION

In this study, a Multiple Criteria Decision Analysis (MCDA) has been completed using a Complex Proportional Assessment (COPRAS) on the selection of HDMI Splitter. The COPRAS method is able to solve the selection problem through the calculation of the utility level which shows the extent to which an alternative is better or worse than other alternatives through a comparison process. Based on the case studies conducted, the utility values of each alternative were obtained, namely Robot HDMI Splitter producing a value of 53.73%, Vention HDMI Splitter producing a value of 65.63%, Bafo HDMI Splitter producing a value of 97.13, and PX HDMI Splitter producing a value of 100%. So, the best alternative HDMI Splitter Selection is PX HDMI Splitter. The calculation results of the COPRAS method generated by the system with manual calculations produce the same values and results. The system built has features such as managing criteria data, determining weights, managing alternatives, assigning a value to each alternative, seeing the results of the COPRAS method calculations, and seeing the ranking of system recommendations. Based on testing through the black box testing method, it shows that the system built has been running well. However, for further study improvements, several suggestions can be considered, including using another Multiple Criteria Decision Analysis (MCDA) method to get a more optimal model. In addition, the system can be developed based on Android so that the system can be used on a smartphone without the need to open a browser.

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