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Weighting comparison analysis ROC and Full consistency Method (FUCOM) on MOORA in decision making

Nanda Dimas Prayoga[1)*], Muhammad Zarlis[2)], Syahril Efendi[3)]
[1,2,3)]Universitas Sumatera Utara, Medan, Indonesia
[1)]nandadimasp@gmail.com, [2)]m.zarlis@usu.ac.id, [3)]syahnyata1@gmail.com

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Abstract: Decision support system is a system that can assist companies in making policy. There are several methods in a decision support system, one of which is the MOORA method. The MOORA method does not have a systematic weight determination. In several studies, the determination of the weight value is determined by experts in their field so that the value is less objective. So in this study, the Rank Order Centroid (ROC) and Full Consistency Method (FUCOM) weighting methods will be used systematically and objectively which will be applied to the MOORA method and a comparison of the results of these methods will be carried out with the calculation of the accuracy of the confusion matrix. The purpose of this study was to analyze the results of the weighting comparison using Rank Order Centroid (ROC) and Full Consistency Method (FUCOM) on the MOORA method so as to produce good accuracy. Based on the results of the study, testing with ROC weights on MOORA obtained results of 77.78% accuracy, 84% precision and 84% recall. While testing with ROC weights on MOORA obtained results of 77.78% accuracy, 84% precision and 84% recall. And testing with ROC+FUCOM weights on MOORA obtained 91.67% accuracy, 94% precision and 94% recall. So it can be concluded that the ROC+FUCOM weighting on MOORA produces good accuracy.

Keywords: *Weighting*, ROC, *Full Consistency Method* (FUCOM), MOORA, *Confusion Matrix*

INTRODUCTION

A decision support system is a system that has a purpose in supporting company management in the decision-making process. SPK is intended as a tool for company management that requires decision making in facilitating policy making without replacing the position of company management in conducting assessments (Marbun & Sinaga, 2018; Pribadi et al., 2018).

There are several things that need to be considered in making decisions, one of which is determining the weight of the criteria. The weight of the criteria is one of the most important foundations of decision making. Because this weight will be the starting point in the assessment of the criteria of the alternative to be applied.

In several studies that have been carried out, the process of weighting the criteria values in the decision support system method, is still often done by assigning weight values based on assumptions or subjectively from decision makers or experts in their fields in determining the value of the criteria weights, so that it is considered less precise and accurate.

As in Sunardi's research, Fadlil and Pahlevi (2021) studied the Decision Making of Higher Education Quality Assurance System using MOORA, SAW, WP, and WSM. In this study, the MOORA method was quite effective in decision making and obtained a score of 75%. However, the weighting is determined subjectively by experts in their fields (Sunardi et al., 2021).

In other studies, the process of giving weights is done subjectively by decision making (Arief et al., 2021; Siregar et al., 2021). In the research of Sutarno, et al (2019), it was stated that decision makers only entered the criteria and weights that were used as priorities for the criteria to be made (Sutarno et al., 2019).

In the research, Budiman and Hairah (2021) said that it is important to give how much weight the criteria are in the decision-making process. The results of research from moora and vikor produce the best alternative preference from a series of targeted alternatives. The study said that the results of this study still require better performance optimization, one of which is the weighting method (Budiman & Hairah, 2021).

In this study using Rank Order Centroid (ROC) weighting which was carried out in determining the best teacher. In this study, it was stated that the acquisition of criterion weights with Rank Order Centroid greatly influences decision making in determining the best teacher (Lusiyanti et al., 2022).

*name of corresponding author

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In this study, the author will carry out other weighting, namely by comparing the Rank Order Centroid (ROC) and Full Consistency Method (FUCOM) methods, which are methods for determining the weight values that will be applied to the MOORA method with a case study determining the superior class students in SMA N. 1 Joman Water. The MOORA method was chosen because according to the author, this method is simple and objective in making decisions. As stated in the research of Perez-Dominguez, et al (2018) said that the MOORA method is mathematically very simple and presents a more objective assessment method (Pérez-Domínguez et al., 2018). Andani, et al (2019) also said that the MOORA method is simpler and easier to understand and provides objective results (Andani et al., 2019). Dauni, et al (2021) also suggested that the MOORA method has a good level of selectivity in decision making (Dauni et al., 2021)

The FUCOM method was chosen because it is able to provide consistent weights. As did Qingpeng Cao, et al (2019) in selecting the most appropriate contractor. In this study, FUCOM was used as the determination of consistent weight values and Gray SWARA as the contractor selection. The results of this study increase the confidence of decision makers in providing solar panel energy system installations to top ranking contractors (Cao et al., 2019).

Research conducted by Feizi, et al (2021) The results of the combined method of FUCOM and MOORA are interesting and accurate because the FUCOM weighting method has a minimum possible number of comparisons in theory, which leads to having a more reliable output compared to the previously used approach (Feizi et al., 2021).

In research conducted by Ahmad and Qahmash (2020). In this study, comparing Fuzzy AHP and FUCOM resulted in Fuzzy AHP getting coefficient values ranging between 0.9833 and 0.85 with an average value of 0.9390 and FUCOM coefficient values ranging between 0.9833 and 0.9000 with an average value of 0. .9500, thus showing a very high correlation. From these results, the FUCOM method is superior (Ahmad & Qahmash, 2020).

Then to measure the comparison of the results obtained in the weighting of the MOORA method, an accuracy calculation using the confusion matrix is carried out by testing the results obtained from the weighting and applied to the MOORA method. The confusion matrix is used in the comparison process between the actual information and the predicted results carried out in the classification system. The performance or performance of the classification system is usually evaluated using the data in the matrix (Utami et al., 2020).

LITERATURE REVIEW

Rank Order Centroid (ROC)

Method The Rank Order Centroid (ROC) method is based on the level of importance or priority of the criteria, the ROC technique gives weight to each criterion according to the ranking that is assessed based on the priority level. Usually formed with the statement "Criterion 1 is more important than criterion 2, which is more important than criterion 3" and so on until the nth criterion. To determine the priority, a rule is given, namely where the highest value is the most important value among other values. Or it can be explained as follows (Anwar et al., 2021):

If

$$Cr1 \geq Cr2 \geq Cr3 \ldots \geq Crn, \qquad (1)$$

Then

$$W1 \geq W2 \geq W3 \ldots \geq Wn, \qquad (2)$$

Furthermore, if k is the number of criteria, then

$$W1 = \frac{1 + \frac{1}{2} + \frac{1}{3} \ldots + \frac{1}{k}}{k}$$

$$W2 = \frac{0 + \frac{1}{2} + \frac{1}{3} \ldots + \frac{1}{k}}{k}$$

$$W3 = \frac{0 + 0 + \frac{1}{3} \ldots + \frac{1}{k}}{k}$$

$$W4 = \frac{0 + \cdots + 0 + \frac{1}{k}}{k}$$

In general, the ROC weighting can be formulated as follows:

$$Wk = \frac{1}{k} \sum_{i=n}^{k} \left(\frac{1}{i}\right) \qquad (3)$$

Where :

Wk : Normalization of the ratio of the estimated weight scale objectives

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i : Total number of objectives
k : Ranking of i objectives

Full Consistency Method (FUCOM)

The Full Consistency Method (FUCOM) method was first introduced as a new model to determine the weight coefficient criteria in the MCMD model by Dragan Pamucar, Zeljko Stevic and Sinisa Sremac in 2018, in a paper entitled "A New Model for Determining Weight Coefficients of Criteria in MCDM Models: Full Consistency Method (FUCOM)" which was developed based on the principle of pairwise comparison and validation of full consistency (Pamučar et al., 2018).

FUCOM needs more interaction from experts. Initially, each expert needs to rank a set of criteria, starting from the criteria that are expected to have the highest weight to the criteria of the smallest weight (Netto et al., 2021). By using this method, subjectivity in the decision-making process is reduced. This method, in conjunction with other methods for determining the subjective weight of the criteria (Mijajlović et al., 2020).

The following is a procedure for obtaining the value of the weighting criteria using FUCOM, namely (Sari et al., 2021).

1. In the first step, the criteria from a set of evaluation criteria are defined and ranked. The ranking is carried out according to the suitability of the criteria, starting from the criteria that are expected to have the highest coefficient weight to the least significant criteria. Thus, the criteria that are sorted according to the expected value of the weight coefficient are obtained:

$$(1) > C_{j(2)} > \cdots > C_{j(k)} \qquad (4)$$

2. In the second step, a comparison of the ranking criteria is carried out and a comparative priority (($\varphi k/(k+1)$), $k = 1,2, \ldots, n$; where k represents the ranking criteria) of the evaluation criteria determined:

$$\Phi = (\varphi 1/2, \varphi 2/3, \ldots, \varphi k/(k+1)) \qquad (5)$$

3. In the third step, the final value of the weight coefficient of the evaluation criteria is calculated:

$$\left|\frac{W_k}{W_{k+1}} = \varphi(k)/(k+1)\right| \leq \chi, \forall j$$

$$\left|\frac{W_k}{W_{k+2}} = = \varphi(k)/(k+1) \otimes \varphi(k+1)/(k+2)\right| \leq \chi, \forall j \qquad (6)$$

$$\sum_{j=1}^{n} Wj = 1, \forall jn$$

$$Wj \geq 0, \forall$$

Multi-Objective Optimization Method on the basis of Ratio Analysis (MOORA)

Multi-Objective Method Optimization on the basis of Ratio Analysis (MOORA) is a mathematical calculation method for DSS that was popularized by Brauers and Zavadkas in 2004 (Alinezhad & Khalili, 2019). The method introduced by Brauers is relatively new to be used in multi-criteria decision making. This method occupies a level of flexibility and ease to follow when dividing subjective criteria during the evaluation stage into multivariable decision weight criteria (Ramadiani et al., 2019). In an international journal suggested that this method is an efficient method for solving multi-criteria decision-making problems, which involve conflicting criteria (Mathew & Sahu, 2018).

The uniqueness of the MOORA method is that it involves minimal mathematical operations and is thus very simple despite having a higher degree of toughness and reliability (Mitra, 2022).

This method has five stages that must be followed:

1. Define objectives and identify the evaluation attributes concerned.
2. Displays all information in the form of a decision matrix X which can be represented as follows:

$$\mathbf{X} = \begin{bmatrix} X_{11} & X_{12} & X_{1n} \\ X_{21} & X_{22} & X_{2n} \\ \ldots & \ldots & \ldots \\ X_{m1} & X_{m2} & X_{mn} \end{bmatrix} \qquad (7)$$

Where:
Xij = performance measure of the i-th alternative on the j-th attribute
m = the number of alternatives
n = the number of attributes.

3. Normalization matrix which is the best choice of the sum of the squares of the quadrant roots on each attribute.formula is:

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$$X_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^{m} X_{ij}^2}} \qquad (8)$$

Description:
Ratio Xij = 1st alternative on jth criteria,
m = number of alternatives,
n = number of criteria.

4. In multi-objective optimization, the results of normalization are maximizing the sum of beneficial attributes and minimizing the reduction of unfavorable attributes (cost). So the optimization calculation becomes:

$$Y_i = \sum_{j=1}^{g} X_{ij} \sum_{j=g+1}^{n} X_{ij} \qquad (9)$$

Description:
g = maximized attribute value,
(n-g) = value minimized attribute,
Yi = alternative normalization value of i all attributes.

5. In other cases, sometimes identifying attributes that are considered important. The important attributes are given the appropriate weight (significant coefficient). If the weight of this important attribute is considered, then the Yi formula is as follows:

$$Y_i = \sum_{j=1}^{g} W_j X_{ij} \sum_{j=g+1}^{n} W_j X_{ij} \qquad (10)$$

Description:
Wj = attribute weight j.

6. Rank based on Yi value.
Yi can be positive or negative, depending on the maximum number of benefit criteria and the minimum cost criteria in the decision multiplication (matrix) (Hanifatulqolbi et al., 2019).

Confusion Matrix

Confusion Matrix is used in the comparison process between actual information and predicted results in the classification system. The performance or performance of the classification system is usually evaluated using the data in the matrix. The following table shows the confusion matrix for the two classification classes (Utami et al., 2020).

Table 1. *Confusion Matrix*

		Actual	
		Positive	Negative
Prediction	Positive	*True* Positive (TP)	*False* Negative (FP)
	Negative	*False* Negative (FN)	*True* Negative (TN)

Where:
True Positive (TP) = class that is predicted to be positive, and the fact is positive.
True Negative (TN) = the class that is predicted to be negative and the fact is negative
False Positive (FP) = the class that is predicted to be positive and the fact is negative
False Negative (FN) = the class that is predicted to be negative and the fact is positive

Based on the values of TP, TN, FP, and FN will Accuracy value is obtained from the application of the algorithm. The accuracy value describes how accurately the system can classify the data correctly. From the accuracy value, the following equation is obtained:

$$Accuracy = \frac{TP + TN}{(TP + TN + FP + FN)} x\ 100\% \qquad (11)$$

$$Precision = \frac{TP}{(TP + FP)} x\ 100\% \qquad (12)$$

$$Recall = \frac{TP}{(TP + FN)} x\ 100\% \qquad (13)$$

METHOD

This research was conducted by analyzing the weighting comparison of ROC and Full Consistency Method (FOCOM) on the MOORA method in case study decision making to determine the superior class at SMA Negeri 1 Air Joman. The following describes the general process of research that will be carried out to achieve the objectives.

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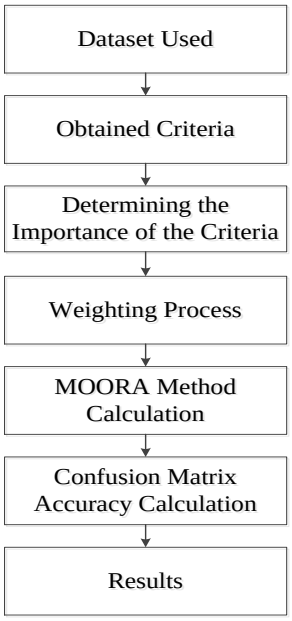

Fig 1. Research Stages

1. Dataset used
   At this stage, the data set used in the study will be collected to be applied to the weighting and MOORA method.
2. Obtained criteria
   After getting the data set, the obtained criteria will be coded such as C1, C2, C3, C4, C5, C6 and C7.
3. Determining the importance of the criteria
   At this stage, the authors determine the level of importance of the criteria assisted by experts in determining the superior class.
4. Weighting process
   At this stage, the authors carry out the weighting process of each weighting method with the ROC and FUCOM weighting stages which will be applied to the MOORA method.
5. Calculation of the MOORA method
   At this stage after getting the weight value of each weighting, the author performs the calculation steps on the MOORA method.
6. Confusion matrix accuracy calculation
   After getting the weighting results and applied to the MOORA method, the author calculates the accuracy of the confusion matrix measuring accuracy, precision, and recall to get the conclusions.
7. Results
   The results obtained will be concluded with the final results in this study to see whether the results obtained make a contribution to the research.

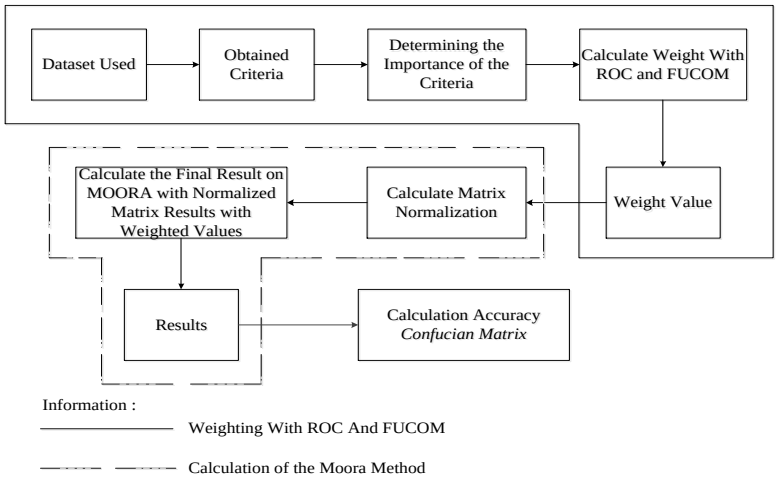

Fig 2. General Architecture

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In the picture above which is the general architecture in this study, the first thing to do is to weight the criteria values in the ROC and FUCOM methods, which will be interviewed which criteria are the most important from other criteria after that they are sorted by importance ranking, Then the calculation of each formula for the ROC and FUCOM methods is carried out which will be the value of the weight of the criteria.

After calculating the ROC and FUCOM to get the criteria weight value, then the weight value will be used in the calculation of the MOORA method. The first step is the normalized calculation using the MOORA method, then multiplying the results of the normalized matrix with the weight values from the ROC and FUCOM methods. From these results will produce superior class students.

After getting the ranking results from the weighting in the MOORA method, a confusion matrix calculation will be carried out to get good accuracy in the weighting results with the MOORA method.

RESULT

In this study, the dataset used was the superior class data at SMA N 1 Air Joman with a total of 72 datasets to be analyzed in the study. After getting the dataset, it is done to determine the importance of the criteria to be applied to the Rank Order Centroid (ROC) and Full Consistency Method (FUCOM) weighting methods, which are in table 2 below.

Tabel 2. Tingkat Kepentingan Kriteria

Code Criteria	Criteria	Interest
C1	IQ	Importand First
C2	SKHU	Importand Second
C3	Science	Importand Third
C4	Social Studies	Importand Fourth
C5	Maths	Importand Fifth
C6	English	Importand Sixth
C7	Indonesian	Importand Seventh

ROC+MOORA Method Testing

First, a weighting process will be carried out using the ROC method, which is done by following the rules in table 2. the level of importance of the criteria will then be applied to formula (3). After getting the results of the ROC weights, the MOORA method will be applied using the stages of the MOORA method using the formula (7)-(10). After getting the final results from MOORA, a confusion matrix accuracy calculation will be carried out, which results in table 3 below:

Table 3. Confusion Matrix ROC+MOORA Results

		Actual	
		Positive	Negative
Prediction	Positive	42 (TP)	8 (FP)
	Negative	8 (FN)	14 (TN)

Based on the values of TP, TN, FP and FN, the accuracy calculation process on MOORA will then be carried out with ROC weights as follows:

$$Accuracy = \frac{42 + 14}{(42 + 14 + 8 + 8)} \text{x } 100\% = 77{,}78\%$$

$$Precision = \frac{42}{(42 + 8)} \text{x } 100\% = 84\%$$

$$Recall = \frac{\text{TP}}{(\text{TP} + \text{FN})} \text{x } 100\%$$

FUCOM+MOORA Method Testing

First, the weighting process will be carried out using the FUCOM method, which is done by following the rules in table 2. the importance of the criteria then the initial weight is given by the expert which will be applied to the formula (4)-(6). After getting the results of the FUCOM weights, the MOORA method will be applied using the stages of the MOORA method using the formula (7)-(10). After getting the final results from MOORA, the confusion matrix accuracy calculation will be carried out, which results in table 4 below:

Table 4. Confusion Matrix FUCOM+MOORA Results

		Actual	
		Positive	Negative
Prediction	Positive	42 (TP)	8 (FP)

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Negative	8 (FN)	14 (TN)

Based on the values of TP, TN, FP and FN, then the accuracy calculation process will be carried out on MOORA with FUCOM weights as follows:

$$Accuracy = \frac{42 + 14}{(42 + 14 + 8 + 8)} \text{x } 100\% = 77{,}78\%$$

$$Precision = \frac{42}{(42 + 8)} \text{x } 100\% = 84\%$$

$$Recall = \frac{\text{TP}}{(\text{TP} + \text{FN})} \text{x } 100\%$$

(ROC+FUCOM)+MOORA Method Testing

After getting the ROC result then the ROC weight will be multiplied with the weight given by the expert. After that, a weighting process will be carried out using the FUCOM method, which is carried out by following the rules in table 2. the level of importance of the criteria then the weight generated by the ROC is multiplied by the initial weight given by the expert then it will be applied to the formula (4)-(6). After getting the results of the ROC+FUCOM weights, the MOORA method will be applied using the MOORA method stages using the formula (7)-(10). After getting the final results from MOORA, a confusion matrix accuracy calculation will be carried out, which results in table 5 below:

Table 5. Confusion Matrix (ROC+FUCOM)+MOORA Results

		Actual	
		Positive	Negative
Prediction	Positive	47 (TP)	3 (FP)
	Negative	3 (FN)	19 (TN)

Based on the values of TP, TN, FP and FN, then the accuracy calculation process on MOORA will be carried out with ROC+FUCOM weights as follows:

$$Accuracy = \frac{47 + 19}{(47 + 19 + 3 + 3)} \text{x } 100\% = 91{,}67\%$$

$$Precision = \frac{47}{(47 + 3)} \text{x } 100\% = 94\%$$

$$Recall = \frac{47}{(47 + 3)} \text{x } 100\% = 94\%$$

DISCUSSIONS

Based on the test results in the case study determine the class The flagship in this study begins with the ROC, Full Consistency Method (FUCOM) and ROC + FUCOM weighting process, then the weighting is included in the calculation of the MOORA method. The results of the comparison of the accuracy of each test result are obtained by calculating the confusion matrix.

The results of the comparison of each weighting criteria in the MOORA method in sorting the best alternatives in this study which are calculated from the results of the weighting test to get the results of accuracy, precision and recall as follows:

Table 6. Comparison of Weighting Accuracy

No	**Weighting**	**Comparasion**		
		Accuracy	**Precision**	**Recall**
1	ROC+MOORA	77,78%	84%	84%
2	FUCOM+MOORA	77,78%	84%	84%
3	(ROC+FUCOM)+MOORA	91,67%	94%	94%

To facilitate understanding in the comparison of the weighting accuracy, it will be translated into a graph in the following image:

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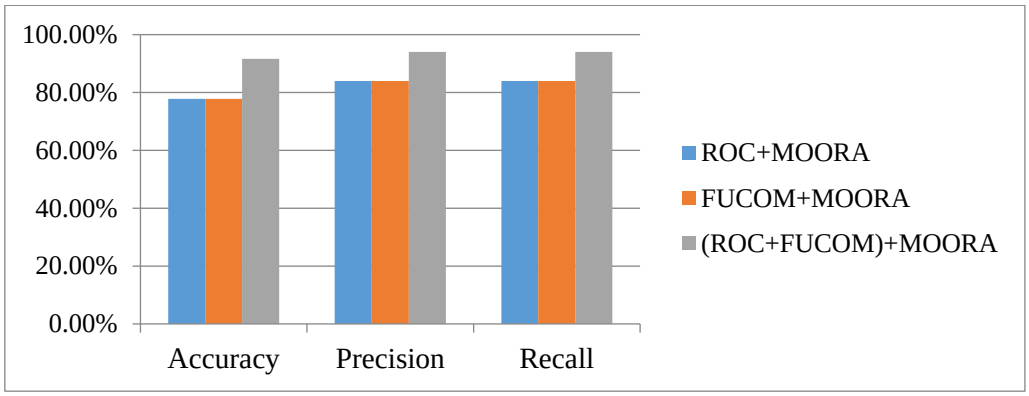

Fig 3. Weighting Accuracy Graph

Based on Fig 3 which shows the results of the comparison of accuracy on the weights with different accuracy gains in each test, the weights ROC+MOORA and FUCOM+MOORA have the same accuracy and the weights (ROC+FUCOM)+MOORA have different accuracy.

From the results of the ROC+MOORA calculation test, the results from testing 72 data from the preference value of each alternative obtained produce different values with the ROC+MOORA method. In testing with ROC weights on MOORA, the results obtained are 77.78% accuracy, 84% precision and 84% recall.

Then from the results of the FUCOM+MOORA calculation test, the results from testing 72 data from the preference value of each alternative obtained produce different values with the FUCOM+MOORA method. In testing with FUCOM weights on MOORA, the results obtained are 77.78% accuracy, 84% precision and 84% recall.

Then from the results of the calculation test (ROC+FUCOM)+MOORA, the results from testing 72 data from the preference value of each alternative obtained produce different values with the (ROC+FUCOM)+MOORA method. In testing with ROC+FUCOM weights on MOORA, the results obtained are 91.67% accuracy, 94% precision and 94% recall.

CONCLUSION

Based on the results of the research that has been carried out, the results of testing with ROC weights on MOORA obtained results for accuracy of 77.78%, precision of 84% and recall of 84%. While testing with ROC weights on MOORA obtained results of 77.78% accuracy, 84% precision and 84% recall. And testing with ROC+FUCOM weight on MOORA obtained 91.67% accuracy, 94% precision and 94% recall. The weighting comparison analysis in this study proves that ROC+FUCOM is able to provide better accuracy on the MOORA method in decision making.

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*name of corresponding author