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The Implementation of Multi-Objective Optimization Based on Ratio Analysis Method to Determine KIP Participants

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ABSTRACT

Decision Support System (DSS) is a system with mathematical calculations that can assist a person in making decisions from various criteria, types, and options. The calculation is done accurately and according to the desired target. Institut Agama Kristen Negeri (IAKN) Tarutung is a state-owned religious higher education institution. In providing education, IAKN Tarutung provides several scholarships for outstanding students with economically disadvantaged students. One of them is the Kartu Indonesia Pintar (KIP). The purpose of this research is to develop the MOORA method to assist in decision making in determining which participants are eligible for KIP scholarships. Development of the Multi-Objective Optimization Based on Ratio Analysis (MOORA) method is expected to provide the best alternative solutions that are right on target without any personal interest.

Keyword : Decision Support System; **MOORA**; **Optimization; IAKN Tarutung**.

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1. INTRODUCTION

The best decisions will produce the best goals too. Speed and accuracy in determining a decision are very important. DSS implementation can support speed and accuracy in determining a decision. DSS is used to get the best decisions, data processing speed, and decisions that can be accounted for(Brauers & Zavadskas, 2006; Deniz Basar & Guneren Genc, 2019; Tim Kementerian Pendidikan dan Kebudayaan Republik Indonesia, 2020; Zeebaree & Aqel, 2009).

The state is obliged to educate the nation's life, through the world of education. Education aims to develop the skills, creativity, and self-expression possessed by students. Although the government should provide education, this does not mean that the cost of education is free. IAKN Tarutung is a state educational institution under the ministry of religion. Obliged to provide education to every student who has passed the new student admission selection. The backgrounds of each student are very different.

Not a few students come from backgrounds with weak family economies but have excellent academic achievements. In a situation like this, the country comes with a KIP program.

Students with weak economic backgrounds with qualified academic achievements can continue their education. With various conditions that must be met, it can potentially confuse the committee in determining the participants who are entitled to get the KIP. Because of the above problems, we need a system that can solve these problems. This designed system is expected to produce results that can be mathematically justified and without personal interference. MOORA is a multi-objective system that can optimize conflicting attributes simultaneously(Pérez-Domínguez et al., 2018). MOORA can optimize criteria that have value benefits and those that are not value or cost. The results obtained by taking into academic achievement and economic ability.

2. RESEARCH METHOD

The research used the MOORA method. There are 6 stages in the MOORA method, namely. Defining objectives for identifying the evaluation attributes concerned; Making a decision matrix; Normalization; Decrease maximax and minimax values; and Ranking(Deniz Basar & Guneren Genc, 2019).

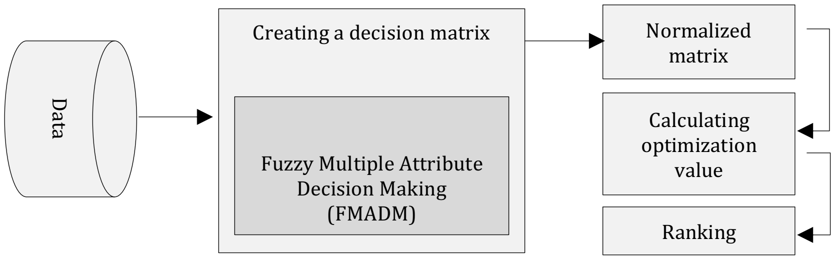

Fig 1. Step of MOORA method

A. Input criterion values

The initial stage is to input the criteria value. At this stage, the goal is to identify the relevant evaluation attributes and enter the criteria value in an alternative where the value will be processed and the results will be a decision.

B. Creating a decision matrix

Create a decision matrix that represents all available information for each attribute, as in equation 1.

$$x = \begin{bmatrix} x_{11} & \cdots & x_{1i} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{j1} & \cdots & x_{ji} & \cdots & x_{jn} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mi} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Equation 1 represents a matrix x_m x_n. The decision matrix is denoted by *x*. Where x_{ij} is the performance measurement of the i={1, 2, … , n} alternative in the j={1, 2, … , n} attribute, it is also called the alternative response *j* to the *i* criterion. A number of alternatives with the symbol *m*. While the number of attributes/criteria is symbolized by *n*.

C. Normalized matrix

Normalization aims to unify each matrix element so that the elements in the matrix have uniform values.

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\left[\sum_{j=1}^{m} x_{ij}^{2}\right]}} \quad (2)$$

The alternative matrix j on i criterion denoted by x_{ij}, i={1, 2, … , n} is the sequence number of the attribute or criterion, j={1, 2, … , m} is the alternate sequence number, x^{*}_{ij} is the alternative normalization matrix j on criterion i.

D. Calculating optimization value

If the criteria have weights, it indicates that an attribute or criterion that is more important can be multiplied by the appropriate weights.

$$y^{1} = \sum_{j=1}^{g} w_j x_{ij}^{*} - \sum_{j=g+1}^{n} w_j w_{ij}^{*} \quad (3)$$

If the attributes or criteria for each alternative are given a weighted value of importance.

$$y^{1} = \sum_{j=1}^{g} x_{ij}^{*} - \sum_{i=g+1}^{i=n} x_{ij}^{*} \quad (4)$$

E. Ranking

After all the stages have been passed, a table will be formed. This table will contain the results of all calculations. The contents of the table will be sorted, starting from the largest to the smallest value. The alternative that has the lowest final value (yi) is the worst alternative from the existing data. Whereas the alternative that has the highest final value (yi) is the best alternative from the existing data, this alternative will be chosen according to the existing problems because this is the best choice(Limbong et al., 2018)(A.R. Lubis et al., 2019)(Arif Ridho Lubis et al., 2019).

3. RESULTS AND DISCUSSION

The large number of student data to be selected made the committee confused in determining which participants were eligible for KIP. Apart from confusion, the committee also took a long time to determine the right result. Each condition will be matched with the predetermined conditions. So that there will be mistakes and also personal interference.
The requirements to become KIP recipient participants are:

1. The class ranking starting from 1st semester to 5th semester must be in the top 10.
2. Maximum of parents' combined gross income is IDR. 4.000.000.
3. The maximum of combined gross income of parents divided by the number of family members is IDR 750,000.
4. The physical condition of the participant's house.
5. Non-academic achievement.

These criteria will be made into the table, as in table 1. The fuzzy calculation will be performed for each criterion(Ersöz et al., 2018).

A. Criterion and weight

Table 1. Criteria determination

	Criteria
C1	class ranking starting from 1st semester to 5th semester
C2	parents' combined gross income
C3	combined gross income of parents divided by the number of families
C4	physical condition of the participant's house
C5	non-academic achievement

C (Criteria), C = {1, 2, 3, 4, 5}

Table 2. Criteria weight

C	Range	Fuzzy	Weight
C1	>= 40 and <= 50	Poor	10
	>= 30 and < 40	Enough	20
	>= 20 and < 30	Good	30
	>= 10 and < 20	Pretty god	40
	>= 5 and < 10	Very good	50
C2	>= 3.000.000 and <= 4.000.000	Enough	10
	>= 2.000.000 and < 3.000.000	Small	20
	< 2.000.000	Poor	30
C3	>= 400.000 and <= 750.000	Enough	10
	< 400.000	Poor	20
C4	Worthy	Enough	10
	decent enough	Small	30
	concerned	Poor	50
C5	0	Poor	10
	1 or 2	Enough	20
	3 or 4	Good	30
	4 and more	Very good	40

Fuzzy Multiple Attribute Decision Making (FMADM) is a method used to find optimal alternatives from several alternatives with certain criteria. The essence of FMADM is to determine the weight value for each attribute, then proceed with a ranking process that will select the alternatives that have been given(A.R. Lubis et al., 2018)(Arif Ridho Lubis et al., 2019).

FMADM has 3 approaches to find the attribute weight value, namely the subjective approach, the objective approach, and the integrated approach between subjective and objective. In the subjective approach, the weight value is determined based on the subjectivity of the decision-makers, so that several factors in the alternative ranking process can be determined independently. In the objective approach, the weight value is calculated mathematically so that it ignores the subjectivity of the decision-maker(Naibaho, 2019).

Fig 2. Fuzzy number value for C1

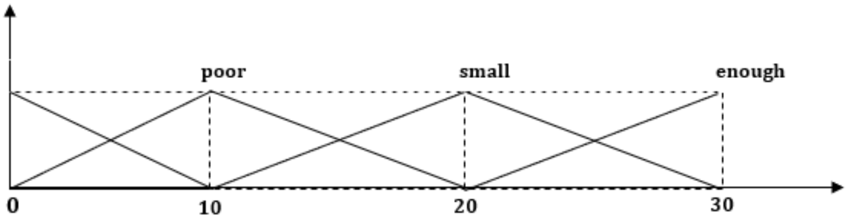

Fig 3. Fuzzy number value for C2

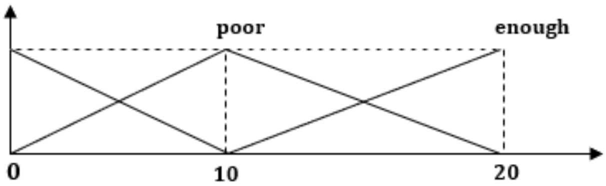

Fig 4. Fuzzy number value for C3

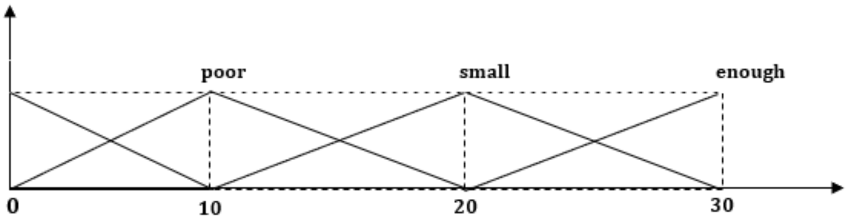

Fig 5. Fuzzy number value for C4

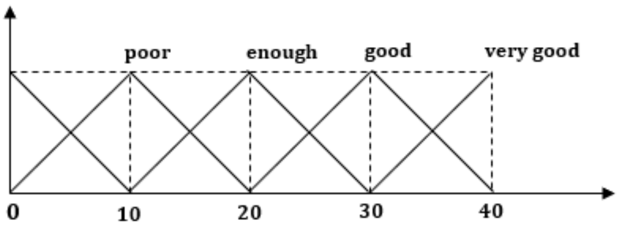

Fig 6. Fuzzy number value for C5

B. The fuzzy number for each criterion

Data from the participants were collected. Then the data is entered into the table. As in table 3.

Table 3. Preliminary data collection

Alternate	Ranking S1	S2	S3	S4	S5	C1	C2	C3	C4	C5
P1	3	1	4	1	2	11	3,200,000	750,000	worthy	2
P2	7	4	8	8	6	33	2,000,000	640,000	concerned	3
P3	9	6	3	5	2	25	1,800,000	500,000	concerned	0
P4	5	3	1	4	7	20	3,900,000	450,000	decent enough	1
P5	9	8	6	5	10	38	3,800,000	400,000	decent enough	0
P6	1	6	5	7	5	24	1,500,000	610,000	decent enough	2
P7	2	9	6	10	8	35	4,000,000	450,000	decent enough	4
P8	6	8	10	6	3	33	2,000,000	560,000	decent enough	3
P9	9	5	10	9	7	40	3,400,000	730,000	decent enough	2
P10	10	8	7	6	4	35	2,800,000	300,000	decent enough	3
P11	6	9	7	7	10	39	3,900,000	340,000	worthy	0
P12	5	4	2	3	7	21	3,500,000	320,000	decent enough	3
P13	3	3	1	5	7	19	4,000,000	600,000	worthy	3
P14	5	2	1	2	6	16	2,600,000	420,000	worthy	3
P15	4	5	2	9	9	29	3,200,000	740,000	decent enough	4
P16	8	3	1	2	7	21	2,900,000	390,000	worthy	3
P17	6	1	8	1	9	25	3,000,000	700,000	decent enough	0
P18	9	6	5	8	7	35	2,500,000	610,000	concerned	0
P19	5	6	3	1	2	17	2,000,000	390,000	worthy	4
P20	4	1	2	5	3	15	2,800,000	650,000	decent enough	0

P (Participants), P = {1, 2, … , 20}
S (Semester), S= {1, 2, 3, 4, 5}
Based on the data in table 2 and table 3, table 4 can be made, to enter the criteria value for each alternative.

Table 4. Value of the criteria for each alternative

Alternate	C1	C2	C3	C4	C5
P1	40	10	10	10	20
P2	20	20	10	50	30
P3	30	30	10	50	10
P4	30	10	10	30	20
P5	20	10	10	30	10
P6	30	30	10	30	20
P7	20	10	10	30	30
P8	20	20	10	30	30
P9	10	10	10	30	20
P10	20	20	20	30	30
P11	20	10	20	10	10
P12	30	10	20	30	30
P13	40	10	10	10	30
P14	40	20	10	10	30
P15	30	10	10	30	30
P16	30	20	20	10	30
P17	30	10	10	30	10
P18	20	20	10	50	10
P19	40	20	20	10	30
P20	40	20	10	30	10

C. Normalization matrix

The next step according to equation (2) is to determine the normalized value for each criterion of each alternative and make it a normalized matrix. Detailed calculations for each criterion and alternative are as follows:
Normalization matrix (1,1) of line 1, column 1 (C1)

$$X_{1,1} = \frac{X_{1,1}}{\sqrt{X_{1,1}^2+X_{2,1}^2+X_{3,1}^2+X_{4,1}^2+X_{5,1}^2+X_{6,1}^2+X_{7,1}^2+X_{8,1}^2+X_{9,1}^2+X_{10,1}^2+X_{11,1}^2+X_{12,1}^2+X_{13,1}^2+X_{14,1}^2+X_{15,1}^2+X_{16,1}^2+X_{17,1}^2+X_{18,1}^2+X_{19,1}^2+X_{20,1}^2}}$$

$$X_{1,1} = \frac{40}{\sqrt{40^2+20^2+30^2+30^2+20^2+30^2+20^2+20^2+10^2+20^2+20^2+30^2+40^2+40^2+30^2+30^2+30^2+20^2+40^2+40^2}}$$

$$X_{1,1} = \frac{40}{\sqrt{17200}} = 0.30500$$

$X_{10,1} = \frac{20}{\sqrt{17200}}$ = 0.15250

$X_{20,1} = \frac{40}{\sqrt{17200}}$ = 0.30500

Normalization matrix (1,2) of line 1, column 2 (C2)

$$X_{1,2} = \frac{X_{1,2}}{\sqrt{X_{1,2}^2+X_{2,2}^2+X_{3,2}^2+X_{4,2}^2+X_{5,2}^2+X_{6,2}^2+X_{7,2}^2+X_{8,2}^2+X_{9,2}^2+X_{10,2}^2+X_{11,2}^2+X_{12,2}^2+X_{13,2}^2+X_{14,2}^2+X_{15,2}^2+X_{16,2}^2+X_{17,2}^2+X_{18,2}^2+X_{19,2}^2+X_{20,2}^2}}$$

$$X_{1,2} = \frac{10}{\sqrt{10^2+20^2+30^2+10^2+10^2+30^2+10^2+20^2+10^2+20^2+10^2+10^2+10^2+20^2+20^2+10^2+20^2+20^2+20^2+20^2}}$$

$X_{1,2} = \frac{10}{\sqrt{6000}}$ = 0.12910

$X_{10,2} = \frac{20}{\sqrt{6000}}$ = 0.25820

$X_{20,2} = \frac{20}{\sqrt{6000}}$ = 0.25820

Normalization matrix (1,3) of line 1, column 3 (C3)

$$X_{1,3} = \frac{X_{1,3}}{\sqrt{X_{1,3}^2+X_{2,3}^2+X_{3,3}^2+X_{4,3}^2+X_{5,3}^2+X_{6,3}^2+X_{7,3}^2+X_{8,3}^2+X_{9,3}^2+X_{10,3}^2+X_{11,3}^2+X_{12,3}^2+X_{13,3}^2+X_{14,3}^2+X_{15,3}^2+X_{16,3}^2+X_{17,3}^2+X_{18,3}^2+X_{19,3}^2+X_{20,3}^2}}$$

$$X_{1,3} = \frac{10}{\sqrt{10^2+10^2+10^2+10^2+10^2+10^2+10^2+10^2+10^2+20^2+20^2+20^2+10^2+10^2+10^2+20^2+10^2+10^2+20^2+10^2}}$$

$X_{1,3} = \frac{10}{\sqrt{3500}}$ = 0.16903

$X_{10,3} = \frac{20}{\sqrt{3500}}$ = 0.33806

$X_{20,3} = \frac{10}{\sqrt{3500}}$ = 0.16903

Continued until normalization of the matrix (20, 1) row 20 column 1. The same for normalization of column 2 (C2), starting from normalization of the matrix (1, 2) row 1 column 2. Until normalization of the matrix (20, 2) rows of 20 columns 2. Continue the same steps for normalization of column 5 (C5), starting from normalization matrix (1, 5) row 1 column 5. to normalization matrix (20, 5) row 20, column 5. From the normalized value calculation, a normalized value matrix (X*) will be obtained as in table 9.

Table 5. Normalized value

Alternative	C1	C2	C3	C4	C5
P1	0.30500	0.12910	0.16903	0.07454	0.18898
P2	0.15250	0.25820	0.16903	0.37268	0.28347
P3	0.22875	0.38730	0.16903	0.37268	0.09449
P4	0.22875	0.12910	0.16903	0.22361	0.18898
P5	0.15250	0.12910	0.16903	0.22361	0.09449
P6	0.22875	0.38730	0.16903	0.22361	0.18898
P7	0.15250	0.12910	0.16903	0.22361	0.28347
P8	0.15250	0.25820	0.16903	0.22361	0.28347
P9	0.07625	0.12910	0.16903	0.22361	0.18898
P10	0.15250	0.25820	0.33806	0.22361	0.28347
P11	0.15250	0.12910	0.33806	0.07454	0.09449
P12	0.22875	0.12910	0.33806	0.22361	0.28347
P13	0.30500	0.12910	0.16903	0.07454	0.28347
P14	0.30500	0.25820	0.16903	0.07454	0.28347
P15	0.22875	0.12910	0.16903	0.22361	0.28347
P16	0.22875	0.25820	0.33806	0.07454	0.28347
P17	0.22875	0.12910	0.16903	0.22361	0.09449
P18	0.15250	0.25820	0.16903	0.37268	0.09449
P19	0.30500	0.25820	0.33806	0.07454	0.28347
P20	0.30500	0.25820	0.16903	0.22361	0.09449

D. Specifies the type and weight of the criteria

Next is to determine the type of each criterion, there are two criteria, namely the benefit criteria or the cost criteria. This determination is based on the data that has been collected. The benefit is a type of criterion, if the value is greater then the result will be better if it is smaller then the value is not good. Cost is a type of criterion if the value is smaller then the results will be better, if it is bigger then the value is not good. The weight value of each criterion is as shown in Table 6.

Table 6. Type and weight of each criterion

Criteria	Type	weight (W)
C1	benefit	2.4
C2	benefit	1.8
C3	benefit	1.8
C4	cost	1.7
C5	benefit	2.3

E. Calculate the optimization value

The calculation of the MOORA Multiobjective Optimization Value (max-min) in this case refers to the equation (3) because each criterion has its weight (W). This optimization value is calculated for each given alternative. This value is the sum of the multiplication of the criterion weight with the maximum attribute value (max), namely the value of the benefit type attribute minus the number of multiplication of the criterion weight with the minimum attribute value (min), namely the attribute value of the cost type. The manual calculation is shown as in the following calculation:

Optimization value for P1 (y^*_1)

$y_1^* = (X^*_{1,1(\max)}.W_1 + X^*_{1,2(\max)}.W_2 + X^*_{1,3(\max)}.W_3 - X^*_{1,4(\min)}.W_4 + X^*_{1,5(\max)}.W_5$

$y_1^* = (0.30500 * 2.4) + (0.12910 * 1.8) + (0.16903 * 1.8) - (0.07454 * 1.7) + (0.18898 * 2.3)$

$y_1^* = 1.57658$

Optimization value for P2 (y^*_2)

$y_2^* = (X^*_{2,1(\max)}.W_1 + X^*_{2,2(\max)}.W_2 + X^*_{2,3(\max)}.W_3 - X^*_{2,4(\min)}.W_4 + X^*_{2,5(\max)}.W_5$

$y_2^* = (0.15250 * 2.4) + (0.25820 * 1.8) + (0.16903 * 1.8) - (0.37268 * 1.7) + (0.28347 * 2.3)$

$y_2^* = 1.15345$

Optimization value for P10 (y^*_{10})

$y_{10}^* = (X^*_{10,1(\max)}.W_1 + X^*_{10,2(\max)}.W_2 + X^*_{10,3(\max)}.W_3 - X^*_{10,4(\min)}.W_4 + X^*_{10,5(\max)}.W_5$

$y_{10}^* = (0.15250 * 2.4) + (0.25820 * 1.8) + (0.33806 * 1.8) - (0.22361 * 1.7) + (0.28347 * 2.3)$

$y_{10}^* = 1.71112$

Optimization value for P20 (y^*_{20})

$y_{20}^* = (X^*_{20,1(\max)}.W_1 + X^*_{20,2(\max)}.W_2 + X^*_{20,3(\max)}.W_3 - X^*_{20,4(\min)}.W_4 + X^*_{20,5(\max)}.W_5$

$y_{20}^* = (0.30500 * 2.4) + (0.25820 * 1.8) + (0.16903 * 1.8) - (0.22361 * 1.7) + (0.09449 * 2.3)$

$y_{20}^* = 1.33820$

F. Determine ranking

The results of the calculation of the Optimization Value are sorted from largest to smallest. The optimization value of the largest alternative is the best alternative from existing data. While the alternative with the lowest optimization value is the worst from existing data. The data are sorted from the largest data to the smallest data, as in Table 7.

Table 7. Results after being sorted

Alternative	Result
P19	2.33054
P16	2.14754
P14	2.02628
P13	1.79391
P10	1.71112
P12	1.66174
P6	1.60491
P1	1.57658
P8	1.40687
P15	1.35749
P20	1.33820
P11	1.29751
P7	1.17449
P2	1.15345
P4	1.14016
P3	1.13416
P17	0.92283
P9	0.77416
P5	0.73983
P18	0.71879

Final result using the MOORA method shows that the highest score is Participant 19 with a score of 2,33054.

4. CONCLUSION

In this study, DSS MOORA was able to solve problems in selecting participants who were entitled to KIP. The calculations in MOORA are relatively easy, also easy to understand. Determination of criteria is something very important because the criteria will determine the value of benefit or cost. Care is needed in determining the weight value of the criteria. Because this weight value will affect the final result. The multi-criteria determination of KIP recipient participants was very confusing. The data collected were also very similar. So it is very confusing in determining the right participants. With the implementation of MOORA, it will greatly simplify long work. MOORA was also proven to prevent personal interference in determining KIP participants. MOORA calculation is relatively fast, so it is suitable for large amounts of data.

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