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COMPARISON OF MCDM METHOD FOR SELECT ORPHANAGE

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Abstract—Multiple Criteria Decision Making (MCDM) is a decision-making method that has various techniques for solving the problem of determining the best alternative. In this study, three methods will be compared, namely CoCoSo, ARAS, and VIKOR, for the selection of Orphanages, which are the priority recipients of APBD funds. Determination of orphanage recipients from APBD funds in the Pontianak City Social Service still does manually, by only comparing the facilities and conditions of the orphanage. The CoCoSo, ARAS, and VIKOR methods can provide recommendations in the form of the rating of orphanages that can be used as a reference to determine the priorities of APBD fund recipients. The ranking produced by each method will be compared and seen the correlation coefficient value using the Spearman rank correlation. The results of this study are the three methods provide different rankings, the Spearman correlation coefficient values are very weak and weak, and there is no significant relationship between one method with other methods.

Keywords: ARAS, CoCoSo, MCDM, VIKOR, Orphanage Selection

Abstrak—*Multiple Criteria Decision Making (MCDM) merupakan metode pengambilan keputusan yang memiliki banyak cara dalam penyelesaian masalah penetapan alternatif terbaik. Dalam penelitian ini, akan dibandingkan tiga metode yaitu CoCoSo, ARAS, dan VIKOR untuk pemilihan Panti Asuhan yang menjadi proritas penerima dana APBD. Penentuan panti asuhan penerima dana APBD di Dinas Sosial Kota Pontianak masih dilakukan secara manual, dengan hanya membandingkan fasilitas dan kondisi panti asuhan. Metode* CoCoSo*, ARAS, dan VIKOR dapat memberikan rekomendasi berupa perangkingan panti asuhan yang dapat dijadikan acuan untuk menentukan prioritas penerima dana APBD. Perangkingan yang yang dihasilkan setiap metode akan dibandingkan dan dilihat nilai koefisien korelasinya menggunakan korelasi rank Spearman. Hasil dari penelitian ini adalah ketiga metode tersebut menghasilkan rangking yang berbeda, nilai koefisien korelasi Spearman diantara sangat lemah dan lemah, dan tidak ada hubungan yang signifikan antara metode satu dengan metode lainnya.*

***Kata Kunci**: ARAS, CoCoSo, MCDM, VIKOR, Pemilihan Panti Asuhan.*

INTRODUCTION

Multiple-Criteria Decision Making (MCDM) is a method of decision making to determine the best alternative from some alternatives based on specific criteria [1]. According to Zimmermann in Kusumadewi et al. [1], MCDM, based on objectives, is consists of two models. The first one is *Multi-Attribute Decision Making* (MADM), which used to conduct an assessment or selection of alternatives with a limited amount. The other is *Multi-Objective Decision Making* (MODM), which used to solve problems in a continuous space.

Research on MADM continues to grow rapidly. It's can see from several methods that can use to make a selection. Stanujkic et al. [2] revealed several methods and developers at MADM including *COmplex Proportional ASsessment* (COPRAS) by Zavadskas et al. in 1994, *VIsekriterijumska optimizacijai KOmpromisno Resenje in Serbian* or *Multicriteria Optimization and Compromise Solution* (VIKOR) by Opricovic in 1998, *Additive Ratio Assessment* (ARAS) by Zavadskas and Turskis in 2010, and *Multi-Objective Optimization based on Ratio Analysis* (MOORA) by Brauers and Zavadskas in 2006. Besides, there are other MADM methods revealed by Zolfani et al. [3], among others are *Weighted Aggregated Sum Product Assessment* (WASPAS) by Zavadskas et al. in 2012, *Evaluation Based on Distance from Average Solution* (EDAS) by Keshavarz Ghorabaee et al. in 2015, *A New, Combinative Distance-Based Assessment* (CODAS) by Keshavarz Ghorabaee et al.

In 2016, and *Combined Compromise Solution* (CoCoSo) By Yazdani et al. in 2018.

In this study, CoCoSo and ARAS methods compare to the VIKOR method from previous studies. Yazdani et al.[4] have developed CoCoSo in 2018, with a case study of the selection of logistics and transportation companies in France from a supply chain project. CoCoSo had compared with other methods such as TOPSIS, VIKOR, COPRAS, WASPAS, MOORA, EDAS, and CODAS. The results of the study, CoCoSo, are stable and have very high similarities with COPRAS, MOORA, and VIKOR. But, the research of Yazdani et al. does not compare the results of the CoCoSo method with the ARAS method.

Zavadskas and Turskis [5] introduced the ARAS method in 2010 by evaluation of microclimate in office rooms case study. The utility function value of ARAS methods determining the complex efficiency of a feasible alternative is directly proportional to the relative effect of values and weights of the main criteria considered in a project. ARAS convenient to evaluate and rank decision alternatives.

In this study, we use data from Autia et al. [6]. Autia et al. had used VIKOR method for the research. Opricovic [7] introduced VIKOR as one of the MCDM methods in 1998. VIKOR had used in the Autia et al. study for recommendations orphanages receiving APBD funds, a case study in Pontianak City Social Service. Previously, the determination of orphanages that received APBD funds at the Pontianak City Social Service was done manually, by only comparing the facilities and conditions of the orphanage.

In this study, the results of CoCoSo method ranking and ARAS method for ranking the orphanages compared with the final results of Autia et al. study. The ranking produced by the CoCoSo, ARAS, and VIKOR methods can be used as a reference to determine the priority of orphanages that receive APBD funds.

We will also look for correlation coefficients between methods using the Spearman rank correlation. Using the Spearman rank correlation, it will know the relationship between the ranking results using the CoCoSo, ARAS, and VIKOR methods.

MATERIALS AND METHODS

Materials

In this study, we use data from Autia et al. [6]. There are eight criteria with weight criteria that have been determined by the Pontianak City Social Service, and 27 alternative orphanages in Pontianak City.

There are 3 Benefits Criteria in this research:

C1: Number of children, with a criterion weight of 0.15
C2: Number of school children, with a criterion weight of 0.15
C3: Number of orphanage administrators, with a criterion weight of 0.05

For the cost criteria in this study consists of 5 criteria:

C4: Number of rooms, with a criterion weight of 0.1
C5: Number of toilets, with a criterion weight of 0.1
C6: Vehicle ownership, with a criterion weight of 0.05
C7: Condition of the building, with a criterion weight of 0.2
C8: Number of permanent donors, with a criterion weight of 0.2

Methods

The method used in this study is ARAS, CoCoSo, and VIKOR methods. VIKOR is a method used by Autia et al[6], In their research. Ranking conducted by CoCoSo and ARAS methods is sorted from the largest to the lowest value, while the VIKOR method ranks from the smallest to the largest value.

A. CoCoSo

CoCoSo have developed by Yazdani et al. in 2018. CoCoSo resolves the problem with the following steps [4] :

1) The initial decision-making matrix is determined [4] as shown below :

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

$i = 1, 2, ..., m; \quad j = 1, 2, ... n$

2) The normalisation of criteria values is accomplished based on compromise normalisation equation[4] (by Zeleny in 1973):

$$r_{ij} = \frac{x_{ij} - min_i x_{ij}}{max_i x_{ij} - min_i x_{ij}} \text{; for benefit criterion} \quad (2)$$

$$r_{ij} = \frac{max_i x_{ij} - x_{ij}}{max_i x_{ij} - min_i x_{ij}} \text{; for cost criterion} \quad (3)$$

3) The total of the weighted comparability sequence and the whole of the power weight of comparability sequences for each alternative sum of the weighted comparability sequence and also an amount of the power weight of comparability sequences for each alternative as Si and Pi respectively:

$$S_i = \sum_{j=1}^{n}(w_j r_{ij}) \quad (4)$$

Accredited Rank 3 (Sinta 3) based on the Decree of the Dirjen Penguatan RisBang Kemenristekdikti No. 28/E/KPT/2019, September 26, 2019. Published by PPPM STMIK Nusa Mandiri

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this Si value is achieved based on grey relational generation approach :

$$P_i = \sum_{j=1}^{n}(r_{ij})^{w_j} \quad (5)$$

this Pi value is also achieved according to the WASPAS multiplicative attitude [4].

4) Relative weights of the alternatives using the following aggregation strategies are computed [4]. In this step, three appraisal score strategies are used to generate relative weights of other options, which are derived using Formulas (6)–(8):

$$k_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m}(P_i + S_i)} \quad (6)$$

$$k_{ib} = \frac{S_i}{min_i S_i} + \frac{P_i}{min_i P_i} \quad (7)$$

$$k_{ic} = \frac{\lambda(S_i) + (1-\lambda)P_i}{(\lambda max_i S_i + (1-\lambda)\, max_i P_i)}\ ; \quad 0 \le \lambda \le 1 \quad (8)$$

It is interpreted that Equation (6) expresses the arithmetic mean of sums of WSM and WPM scores, while Equation (7) expresses a sum of relative scores of WSM and WPM compared to the best [4]. Equation (8) releases the balanced compromise of WSM and WPM model scores. In Equation (8), λ (usually λ = 0.5) is chosen by decision-makers. However, the flexibility and stability of the proposed CoCoSo can rely on other values.

5) The final ranking of the alternatives is determined based on ki, values (as more significant as better) [4]:

$$k_i = (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}} + \frac{1}{3}(k_{ia} + k_{ib} + k_{ic}) \quad (9)$$

B. ARAS

ARAS was introduced by Zavadskas and Turskis in 2010. ARAS resolves the problem with the following steps [5]:

1) The form of the decision-making matrix (DMM), as in equation 10.

$$X = \begin{bmatrix} x_{01} \dots & x_{0j} & \dots & x_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} \dots & x_{ij} & \dots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} \dots & x_{mj} & \dots & x_{mn} \end{bmatrix}; i = \overline{0,m}; j = \overline{1,n} \quad (10)$$

where m – number of alternatives, n – number of criteria describing each alternative, x_{ij} – a value representing the performance value of the i alternative in terms of the j criterion, x_{0j} – optimal value of j criterion. If the optimal value of j criterion is unknown, then :

$$x_{0j} = \max_i x_{ij}, if\ \max_i x_{ij}\ is\ preferable;$$
$$x_{0j} = \min_i x_{ij}^{*}, if\ \min_i x_{ij}^{*}\ is\ preferable \quad (11)$$

2) The criteria, whose preferable values are maxima, are normalized as follows:

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \quad (12)$$

The criteria, whose preferable values are minima, are normalized by applying two-stage procedure:

$$x_{ij} = \frac{1}{x_{ij}^{*}}\ ; \bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \quad (13)$$

3) Defining normalized-weighted matrix – $\hat{X}$.
It is possible to evaluate the criteria with weights 0<w_j < 1. The sum of weights w_j would be limited as follows:

$$\sum_{j=1}^{n} w_j = 1 \quad (14)$$

$$\hat{X} = \begin{bmatrix} \hat{x}_{01} \dots & \hat{x}_{0j} & \dots & \hat{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{i1} \dots & \hat{x}_{ij} & \dots & \hat{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \hat{x}_{m1} \dots & \hat{x}_{mj} & \dots & \hat{x}_{mn} \end{bmatrix}; i = \overline{0,m}; j = \overline{1,n} \quad (15)$$

Normalized-weighted values of all the criteria are calculated as follows:

$$\hat{x}_{ij} = \bar{x}_{ij} w_j\ ; i = \overline{0,m}, \quad (16)$$

4) Determine the optimization value of S_i with equation (17).

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij}\ ; i = \overline{0,m}, \quad (17)$$

5) Determine the utility level Ki of each alternative with equation (18).

$$K_i = \frac{S_i}{S_0};\ i = \overline{0,m}, \quad (18)$$

where *Si* and *S*0 are the optimality criterion values, obtained from equation (17).
The calculated values Ki are in the interval [0, 1] and can be ordered in an increasing sequence, which is the wanted order of precedence.

C. Spearman's rank correlation

According to Kurniawan and Yuniarto [8], Spearman's rank correlation was first introduced in 1904 by Charles Spearman. Spearman's rank

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correlation used to examine the correlation hypothesis from data with a minimum scale of ordinal scale (ranking). The first step in calculating the Spearman correlation is to sort the smallest starting data, the data can be from the largest too, on the dependent variable. The formula for calculating the Spearman correlation is with equation 19

$$r_s = 1 - \frac{6\sum_{i=1}^{N} d_i^2}{N^3 - N} \quad \text{......(19)}$$

where :
d is the difference in rank, and N is the number of observations.

In this study, we will look at the correlation value between the methods to compare. According to Yazdani et al. [4], Spearman's rank correlation coefficient used to compare the ranking results obtained from various techniques. If the correlation coefficient is more than 0.8, the relationship between variables is considered high.

RESULTS AND DISCUSSION

The data used in this study shown in table 1.

Table 1 Input Data

A	C1	C2	C3	C4	C5	C6	C7	C8
A1	38	37	4	3	7	3	3	2
A2	43	43	8	4	7	2	3	0
A3	43	43	7	3	9	0	3	0
A4	15	15	3	2	3	1	3	1
A5	20	20	5	4	3	1	2	1
A6	54	54	12	10	8	0	3	0
A7	45	42	5	1	6	3	4	0
A8	31	28	3	2	19	4	4	0
A9	40	40	5	2	10	3	4	5
A10	42	42	10	5	8	3	4	2
A11	37	36	4	6	6	0	3	0
A12	22	22	3	4	8	0	1	0
A13	20	20	5	3	2	3	4	1
A14	37	37	6	13	7	3	4	3
A15	34	34	7	4	6	0	3	0
A16	35	33	7	9	4	0	4	10
A17	38	38	12	7	6	5	4	10
A18	35	23	4	6	3	5	4	8
A19	44	44	8	7	7	3	3	4
A20	31	31	5	4	7	3	3	2
A21	79	78	7	6	6	4	3	1
A22	40	40	4	12	8	0	3	0
A23	32	30	7	3	6	3	3	0
A24	180	175	15	10	10	5	3	5
A25	30	30	5	2	6	3	3	2
A26	120	77	5	6	7	3	4	0
A27	81	81	12	8	7	3	3	0

Source: Autia et al. [6]

A is an alternative.

Using the CoCoSo Method, work through steps (1)-(9). Table 2 is the result of equation (6) - (9) using the CoCoSo method. R in table 2 is ranking for each alternative. Based on table 2, the best alternative is the 27th alternative with the highest ki value of 2.39.

Table 2. Values of kia, kib, kic, ki, and rank.

A	kia	kib	kic	ki	R
A1	0.04	3.80	0.94	2.12	14
A2	0.04	4.17	0.97	2.28	7
A3	0.04	4.23	0.97	2.30	3
A4	0.03	3.39	0.66	1.76	21
A5	0.04	4.23	0.94	2.28	6
A6	0.04	4.18	0.97	2.29	5
A7	0.04	3.70	0.86	2.02	18
A8	0.03	2.59	0.58	1.40	24
A9	0.04	2.98	0.81	1.72	22
A10	0.04	3.36	0.84	1.88	19
A11	0.04	4.04	0.95	2.22	10
A12	0.04	4.35	0.85	2.26	9
A13	0.03	3.34	0.80	1.85	20
A14	0.03	2.60	0.70	1.49	23
A15	0.04	4.18	0.96	2.28	8
A16	0.03	2.31	0.69	1.37	25
A17	0.02	2.02	0.58	1.18	27
A18	0.03	2.22	0.64	1.31	26
A19	0.04	3.59	0.94	2.03	17
A20	0.04	3.70	0.93	2.07	16
A21	0.04	4.24	0.98	2.32	2
A22	0.04	3.74	0.92	2.09	15
A23	0.04	4.03	0.95	2.21	11
A24	0.04	4.39	0.89	2.30	4
A25	0.04	3.81	0.93	2.12	13
A26	0.04	4.00	0.89	2.16	12
A27	0.04	4.42	0.99	2.39	1

For the ARAS method, do steps (10)-(18).

Table 3. Value od S, Ki, and rank

A	S	Ki	R
A1	0.0383	0.4600	7
A2	0.0269	0.3234	17
A3	0.0238	0.2855	22
A4	0.0569	0.6838	4
A5	0.0588	0.7068	2
A6	0.0249	0.2988	20
A7	0.0329	0.3956	12
A8	0.0207	0.2488	25
A9	0.0304	0.3652	15
A10	0.0372	0.4470	8
A11	0.0206	0.2481	26
A12	0.0308	0.3706	14
A13	0.0536	0.6440	5
A14	0.0294	0.3532	16
A15	0.0219	0.2631	24
A16	0.0229	0.2748	23
A17	0.0251	0.3021	19
A18	0.0252	0.3033	18
A19	0.0316	0.3795	13
A20	0.0362	0.4345	9
A21	0.0594	0.7137	1
A22	0.0196	0.2356	27
A23	0.0244	0.2937	21
A24	0.0583	0.7005	3
A25	0.0394	0.4734	6

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A	S	Ki	R
A26	0.0341	0.4096	10
A27	0.0335	0.4021	11

R in table 3 is ranking for each alternative. Based on table 3, the best alternative is the 21st alternative with the highest ki value of 0,7137.

The Ranking result from the CoCoSo method and the ARAS method have compared with rank from studies using the VIKOR method. Table 4 shows the Qi values and rankings obtained from the VIKOR method.

Table 4. Value of Qi and rank

A	Qi	R
A1	0.197	12
A2	0.111	8
A3	0.095	4
A4	0.289	17
A5	0.17	11
A6	0.109	7
A7	0.683	19
A8	0.846	22
A9	0.858	23
A10	0.768	21
A11	0.135	9
A12	0.077	3
A13	0.755	20
A14	0.902	24
A15	0.104	6
A16	0.979	25
A17	1	27
A18	0.98	26
A19	0.254	16
A20	0.234	15
A21	0.097	5
A22	0.205	13
A23	0.158	10
A24	0.01	1
A25	0.214	14
A26	0.616	18
A27	0.056	2

Source: Autia et al. [6]

Table 5. Ranking of alternatives had based on the VIKOR, CoCoSo, and ARAS methods.

A	VIKOR	CoCoSo	ARAS
1	A24	A27	A21
2	A27	A21	A5
3	A12	A3	A24
4	A3	A24	A4
5	A21	A6	A13
6	A15	A5	A25
7	A6	A2	A1
8	A2	A15	A10
9	A11	A12	A20
10	A23	A11	A26
11	A5	A23	A27
12	A1	A26	A7
13	A22	A25	A19
14	A25	A1	A12
15	A20	A22	A9
16	A19	A20	A14
17	A4	A19	A2
18	A26	A7	A18
19	A7	A10	A17
20	A13	A13	A6
21	A10	A4	A23
22	A8	A9	A3
23	A9	A14	A16
24	A14	A8	A15
25	A16	A16	A8
26	A18	A18	A11
27	A17	A17	A22

Table 5 is the result of alternative ranking based on the VIKOR, CoCoSo, and ARAS methods. The orphanage ranking results based on VIKOR, CoCoSo, and ARAS methods can also see in Figure 1.

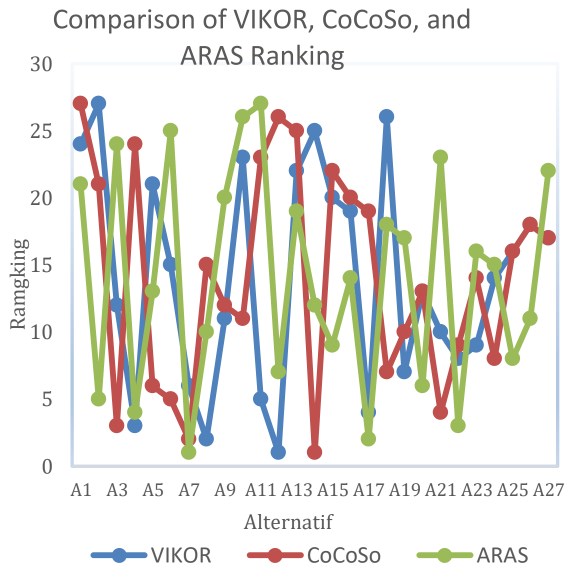

Figure 1 Comparison of VIKOR, CoCoSo, and ARAS Ranking

Spearman's correlation coefficient for VIKOR-CoCoSo is -0.05433, which means there is no significant relationship between VIKOR and CoCoSo, and the correlation value is very weak. The Spearman correlation coefficient for VIKOR-ARAS is 0.26, the correlation coefficient is weak, and there is no significant relationship between VIKOR-ARAS. For CoCoSo-ARAS, the correlation coefficient value is -0.13919, which means CoCoSo-ARAS is not related, and the correlation coefficient value is very weak.

From the ranking of each method, it can see that each method has a different rank. For the best choice for each method, A27 uses the CoCoSo method, A21 uses the ARAS method, and A24 uses the VIKOR method.

CONCLUSION

This study compares VIKOR, CoCoSo, and ARAS on 27 APBD orphanage recipient data in Pontianak City, inspects the ranking of each method, and examines the correlation value with the Spearman rank correlation. VIKOR, CoCoSo, and ARAS produce different rank. Spearman correlation coefficient values indicate that VIKOR-CoCoSo has a very weak correlation, VIKOR-ARAS has a weak correlation, and CoCoSo-ARAS has a very weak correlation. There is no significant relationship between one method with another method.

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