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Developing Winning Tender Recommendation System: Fuzzy Moora Approach

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ABSTRACT

A Decision-Making in determining the project tender winner becomes a significant challenge in the procurement stage, thus it is very vulnerable to administrative errors, corruption, and nepotism. Therefore, a recommendation system becomes a new problem solving in order to increase the information transparency, the company's opportunity to win, the fraud minimization, and the community complaint on the project tender. The system is developed using the analysis of Fuzzy MOORA to calculate the significant consideration of six criteria, including the administration, the qualifications, the technical experience, the proposed price, the number of projects, and the size of the project based on the winning budget. Herein, 20 companies were acted as alternatives in applying and testing the recommendation tender system. As a result, Blackbox and User Acceptance Test (UAT) of this application from ten staffs of the Working Selection Group (POKJA) at the Bureau of Procurement of Goods and Services (PBJ) of Riau Province found that the entire modules and functions of the system run well. Meanwhile, UAT scores of 87.6% states that this application can assist the POKJA's staffs in objectively selecting the tender winner. In addition, the sensitivity test analyzes the possible increasing of the weighting criteria, viz., C3 (technical experience) and C4 (price) can improve the quality rankings of alternatives up to 79.16%. Thus, this result enhanced the efficacy of Fuzzy MOORA approach in providing a better recommendation analysis.

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1. INTRODUCTION

Procurement of goods and services is a mechanism for meeting the need for goods and services that occurs generally within the domain of government and within the scope of Limited Liability Enterprises/State Owned Enterprises (BUMN), BUMN subsidiaries, or companies linked with BUMN [1]. Following Presidential Regulation No. 16 of 2018 Chapter 3 part one article 4 concerning objectives procurement of goods/services defined that the procurement of goods/services aims to produce the right goods/services from every dollar spent, measured in terms of quality, quantity, time, cost, location, and provider.

The Decision Support System (DSS) approach can be used to streamline the process of acquiring goods/services as in this case study. DSS is a component of an information system that is used to support a company's or organization's decision-making [2]. Besides, DSS is potential approach that valuable in searching and analyzing the massive volumes of data as well as collect substantial data for issue problem solving and decision-making [3]. DSS system and development considers several issues in problem solving, including the complexity of the decision-making process, the need for fast solutions, the availability of expertise during the application, and the specificity of the problem [4].

Several studies have been undertaken to determine the tender holders using the DSS approach. Annas et al., (2021) used the Analytical Hierarchy Procedure (AHP) method to analyze and study the outcomes of priority criteria rank from highest to lowest that allowing the committee to choose the tender winner. Then, Abdullahi et al. (2019) employed the Fuzzy Multi-Attributes Group Decision Making (MAGDM) method in calculating and validating the evaluation module of tender systems as a new technology decision making improvement instead of manual paper-based tender systems. This DSS was successfully applied by the Nigerian public procurement agency [5].

Besides AHP and Fuzzy AHP, the common used of MAGDM approach is Multi-objective Optimization Based on Ratio Analysis (MOORA). This approach presented by Brauers and Zavadkas, as one of the newest Multi-Criteria Decision Making (MCDM) systems that is stable and requires relatively limited time in analyzing and calculating process [6]. This MOORA can identify the most desirable alternative by ranking its feasibility as a recommendation for decision-makers [7]. The MOORA approach uses simple mathematics, thus it is easy to grasp, and allowing it to address the numerous sorts of complex decision-making [7]. The MOORA approach is typically used to calculate the initial subjective weights before combining it with a more analytical and detailed method, such as Fuzzy approach. The Fuzzy in MOORA is capable in producing the more dependable and accurate calculations of decision making [8]. Therefore, this research tries to take the advantages of Fuzzy MOORA in weighting mechanism of the tender winners selections. Thus, the sound of group participants as decision makers are acknowledged and becomes the valuable variable analysis even thought it is far from the requirements.

2. RESEARCH METHOD

2.1. Tender

Previous reviews have been frequently investigated the evaluation of tender processes from various types of work, as well as the examination of the proposed criteria in recommending the tenders[9]. According to article 22 of law no. 5 Year of 1999, a tender is a price submission mechanism conducted by commercial units in order to carry out several government work projects, including the project contracting, procurement of goods or provision of services, and acquisition of goods or services. In the other word, tendering is the government's preferred way of acquiring goods, services, and projects by involving several commercial units [10].

Tenders in the Riau Province Bureau are divided into several types, namely procurement of goods, construction, consulting, and other services. The above process is conducted by following the several stages requirements, including administration, and qualification checked, technical and price proposed, and tender winner selection process. As bureaucracy, the winner tender determination is under responsibility of the Selection Working Group (POKJA) at PBJ Riau Province. By referring the Presidential Regulation No. 16 of 2018 article 1 number 12, POKJA is defined as human resources appointed by the head of the Goods/Services Procurement Work Unit (UKPBJ) to manage the provider selection process in government work projects. Therefore, POKJA must be ensured the entire process and selection following the government regulation.

2.2. *Fuzzy Multi-Objective Optimization by Ratio Analysis* (MOORA)

According to Zadeh, fuzzy set theory [11] is a foundation of fuzzy logic that can make reasonable conclusions in the presence of imprecision, uncertainty, and inadequate knowledge [12]. The phrase fuzzy refers to something confusion or unclear [13] information and data that utilized to make a decision based on an explanation of conditions expressed as 0 or 1 [11]. In separating the subjective component of decision-making criteria and features, the MOORA technique provides a high level of flexibility and ease of comprehension [7]. This MOORA can be used to handle a variety of complicated decision-making challenges in manufacturing settings [14]. This MOORA approach has a high level of selectivity in determining an alternative[15]. MOORA's technique is also defined as a concurrent process to optimize two or more conflicting requirements on numerous constraints [16]. The value of this aim is quantified for each decision alternative in decision-making difficulties, providing a basis of alternatives possibilities comparison, and particularly facilitating the selection of the most potential option. As a result, multi-purpose optimization approaches appear to be ideal tools for ranking or picking one or more alternatives from a viable set of options based on numerous features that are frequently contradictory. MOORA approach has various advantages over other accessible decision-making methods, including fewer mathematical computations, shorter computing time, and this approach is simpler and more stable than the others MADM techniques, including Analytical Hierarchy Process (AHP) [17],The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) [18], Elimination and Choice Translating Reality (ELECTRE) [19], Multicriteria Optimization and Compromise Solution (VIKOR) [20], and The Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) [21]. The MOORA technique is also adaptable and simple to use, separating the subjective component of the evaluation process into decision-weighting factors with a variety of decision-making qualities [16]. MOORA’s algorithm stages are as follows [13]:

1. Determining the value of the decision matrix by starting the determination of the identifying purpose of the relevant evaluation attributes.

$$\boldsymbol{X_{ij}} = \begin{bmatrix} \boldsymbol{x}_{11}\boldsymbol{x}_{12} \dots \boldsymbol{x}_{1n} \\ \boldsymbol{x}_{21}\boldsymbol{x}_{22} \dots \boldsymbol{x}_{2n} \\ \dots\dots\dots\dots \\ \boldsymbol{x}_{m1}\boldsymbol{x}_{m2} \dots \boldsymbol{x}_{mn} \end{bmatrix} \tag{1}$$

Where $x_{ij} =$ as the formation of decision matrix; *x* defines as value of each criterion; *i* as the value of criteria; *j* as alternatives values; *m* as criteria value for *m*, and *n* as alternative value for *n*.

2. Normalizing the matrix

Normalization attempts to combine each element of the matrix. Therefore, the entire elements provides the similar value. This ratio is expressed as follows.

$$\boldsymbol{X^{*}ij} = \frac{\boldsymbol{x_{ij}}}{\sqrt{[\sum_{i=1}^{m} \boldsymbol{x^2 ij}]}} (j = 1,2,\dots,n) \tag{2}$$

where X^*ij defines as the normalization matrix of *j* on criterion *i;* Xij as the formation matrix calculation; *i* as the attribute or criterion sequence number ranges in 1,2,3,…, *n* ; *j* denotes as an alternative sequence number that defines within 1,2,3…, m.

3. Performing the attribute optimization

The normalized measurements are added in the maximizing case (for favorable attributes) and eliminated in the minimizing case for multi-objective optimization (for unfavorable attributes).

$$\boldsymbol{y_i} = \sum_{j=1}^{m} \boldsymbol{x_{ij}^{*}} - \sum_{j=g+1}^{n} \boldsymbol{x_{ij}^{*}} \tag{3}$$

Where *g* represents as the maximum attribute, *(n-g)* is the number of attributes with the minimum value, and y_i represents the *i* numbers alternative normalized value for the entire attributes. It is possible to improve the accuracy of attribute values by multiplying the appropriate weights as calculated in the formula below.

$$\boldsymbol{y_i} = \sum_{j=1}^{m} \boldsymbol{W_j x_{ij}^*} - \sum_{j=g+1}^{n} \boldsymbol{w_j x_{ij}^*} \tag{4}$$

Where W_j is the attribute determined by the decision maker.

4. Ranking the value of y_i

The value of y_i can be positive or negative depending on the maximum and minimum totals in the decision matrix. The best alternative has the highest y_i value, while the worst alternative has the lowest value.

2. 3. Sensitivity Analysis

The study on how the uncertainty of output model (numeric or otherwise) can be adjusted into the uncertainty of input model is known as sensitivity analysis [22]. The Sensitivity analysis assist researchers in understanding the relative importance of each factors and parameters within a given problem setting [23]. This analysis is effective in determining the most significant factor of a proposed model [24]. Sensitivity tests are used to determine, and compare the outcomes of evaluation criteria in order to define which criteria are the most critical or sensitive and highly contributes the alternative ranking changes. Sensitivity analysis also provide the fundamental information about which input variables that should be prioritized in the following design process [25]. This method is also extensively used to discover and rank models with the greatest influence on output model parameters [26].

The sensitivity test can be carried out using the calculation of sensitivity degree (*Sj)* on the attribute assessment, as following these steps [27]:

1. Determining the total value of the initial attribute weight, namely *Wj = 1*, with j = 1,2....n (number of attributes). The Fuzzy MOORA method determines the weight value in *Wj = 1.*
2. Changing the total value of the attribute or criterion weights with a value range of 0 – 1. Then, the activity changes the weight values by increasing the weight values, starting from 0.5 and 1 with the other attribute weights remaining according to the initial weight.
3. Changing in weight values are then used in calculating the final value of alternative rankings. Calculating the percentage the alternative ranking changes using the following formulas.

$$\frac{T}{i \times A} \times 100\% \tag{5}$$

Where *T* defines as the total final ranking changes; *i* as the total numbers of iterations; *A* as the number of attributes used.

Preliminary activity, the proposed criteria and alternatives in model development were gathered through several interviews with the Head of the Section at the Riau Province Bureau of Procurement of Goods and Services, including the administration, the qualifications, the technical experience, the price, the number of projects, and the project size. Furthermore, the defined criteria then verified through the systematic literature reviews from papers and journal indexed. Meanwhile, the alternatives were defined from the 20 registered participants in the Riau Province Procurement Bureau's Year 2021.

Herein, the decision-making model system is analyzed using the DSS Fuzzy MOORA approach that stages defined in Equation [1-4]. The DSS Fuzzy MOORA is calculated to analyze the recommended tender winners by applying the Prototyping technique in conjunction with the PHP programming language and the MySQL database. Administrators, working groups POKJA, and tender participants are acted as the DSS's actors. The administrator serves as a stand-in for and controls the DSS-Tender Recommendation application. The Working Group POKJA is responsible for assessing the user input criteria through the calculation of Fuzzy MOORA analysis. Lastly, Tender participants provide the application services as a user who submit the application documents as well as tenders participation. Furthermore, the DSS-Tender Recommendation application is Blackbox and User Acceptance Test (UAT) tested methods. Blackbox is functionality tested the system functions and modules in DSS-Tender Recommendation system development. Meanwhile, UAT was distributed to 10 users from working groups POKJA and tender participants to identify the user interface acceptance. The 10 questions on the UAT were responded to and assessed by the respondents to ensure the acceptance of the DSS-Tender Recommendation application, both in terms of appearance and utilization. Furthermore, a sensitivity analysis test was also carried out to determine the level of sensitivity of the criteria and its effect on the ranking results.

The activity flow in this study is resumed in Figure 1.

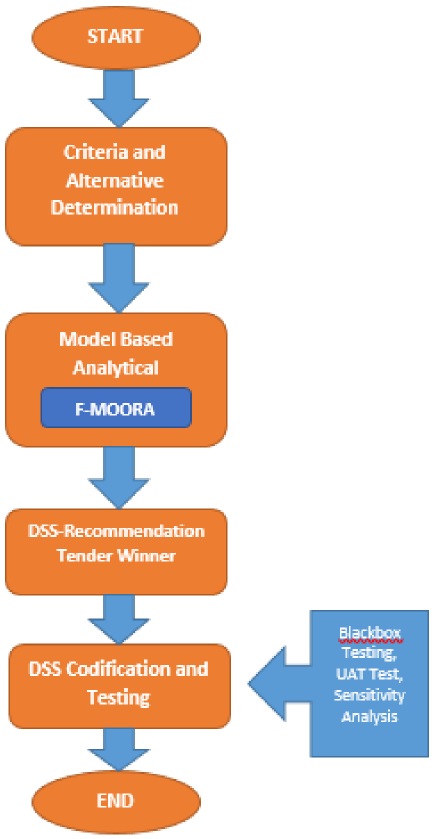


Figure 1. Research Activity

1. RESULTS AND ANALYSIS

3.1. Criteria and Weighting Criteria Determination

The proposed indicated criteria were defined as in Tables 1 and 2. As mention before, the finding were derived from the interviews and literature justification restricted to the scope of government tender construction in Indonesia. Indah et al., [29] observed that the most common problem in construction tender is the bidding system's inability to provide a complete database of contractors with their personnel, past works and experiences, and performance evaluation. The limited human resources in both number and competency is another important issue to consider. Therefore, these above become a main concern in determining the qualification of construction tender. Naik et al., [30] strength this by explaining that the identification of contractors' ability, before assigning projects to companies provide the successful projects. Moreover, the tender documents, government regulation and Riau Province policies collected to completely the recommendation process.

Table 1. Definition of Criteria and Sub-criteria

Criteria	Sub Criteria
Administration	Is the completeness and fulfillment of tender documents, including business entities, integrity pact statements, and valid taxpayer information status [28-30]
Qualification	Is the fulfillment of the provider's qualification requirements, including a construction service business license, a business entity certificate (SBU), never being the blacklisted participant, at least 1 construction working experience for the latest 4 years, the Remaining Capability Package (SKP) range from 5 to P (Working Package) [28-30]
Technical Experience	Is the participant's experience scaling level as a provider, such as less than <2 years, 2-4 years, and more than >4 years [28-30]
Price	Is the amount of the offering price that is defined on a scale of less than <120,000,000, 120,000,000-130,000,000, and more than >130,000,000 [28-30]
Number of Projects (per year)	Is the number of projects obtained within one year with a scale of less than <2, 2-4, and more than >4 [28-30]
Project Price (Per year)	Is the amount of the project price obtained within one year with a scale of less than <500,000,000, 500,000,000-1,000,000,000, and more than > 1,000,000,000 [28-30]

Table 2. Weighting Criteria

Initialization	Criteria	Weight	Description
C1	Administration	0.2	Benefit
C2	Qualification	0.2	Benefit
C3	Technical Experience	0.15	Benefit
C4	Price	0.15	Cost

C5	Total Project (Per Year)	0.15	Benefit
C6	Size of Project Price (Per Year)	0.15	Benefit

The Weighting criteria and sub criteria were conducted based on the level of importance of each criterion which is defined on a scale of 0-1 and a total weight equal to 1 [30].

3.2. Fuzzification

Furthermore, the fuzzification procedure is carried out based on the weighting of set criteria (weighted range 0 to 50). This is done to prevent bias in the selection and specification of criteria. Table 3 shows the fuzzification results based on the list of formula in Equation 1-4.

Table 3. Fuzzification

Criteria	Sub-criteria	Fuzzy Set	Weight
Administration	Incomplete	Bad	10
	Complete	Good	30
	Strongly Complete	Excellent	50
Qualification	Incomplete	Bad	10
	Less Complete	Fair	20
	Complete	Good	30
	Sufficiently Complete	Quite Good	40
	Strongly Complete	Excellent	50
	<2 Years	Bad	10
	2-4 Years	Good	30

Technical Experience	>4 Years	Excellent	50
Price	<= 120.000.000	Excellent	50
	120.000.000-130.000.000	Good	30
	>=130.000.000	Bad	10
Total Project (Per Year)	<2	Bad	10
	2-4	Good	30
	>4	Excellent	50
Size of Project Price (Per Year)	<500.000.000	Bad	10
	500.000.000-1.000.000.000	Good	30
	>1.000.000.000	Excellent	50

3.3. MOORA Analysis

By following the Fuzzy MOORA analysis at Equation [1] and Equation [2], Table 4 and 5 are determined for calculating the decision matrix and Normalization, respectively.

Table 4. Decision Matrix Formation

Alternative	Criteria					
	C1	C2	C3	C4	C5	C6
A1	250	250	30	10	30	10
A2	250	250	50	50	50	30
A3	250	240	30	50	10	10
A4	250	240	30	30	30	10
A5	250	250	30	10	30	10
A6	250	250	50	50	30	30
A7	250	250	50	50	30	30
A8	250	250	50	30	50	30
A9	250	250	50	30	30	30
…						
A20	250	240	50	30	10	10

Table 5. Matrix Normalization

Alternative	Criteria					
	C1	C2	C3	C4	C5	C6

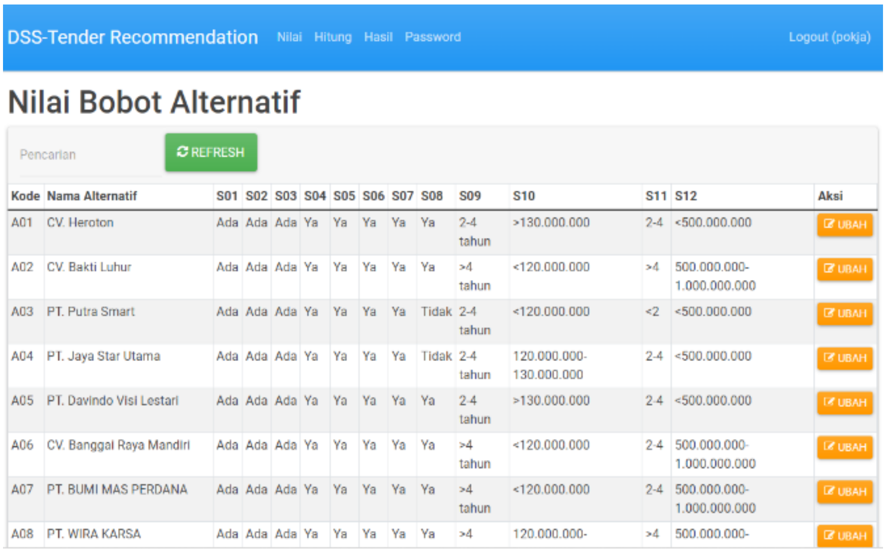
A1	0.2293	0.2332	0.1608	0.0602	0.2142	0.0846
A2	0.2293	0.2332	0.2680	0.3011	0.3571	0.2359
A3	0.2293	0.2239	0.1608	0.3011	0.0714	0.0846
A4	0.2293	0.2239	0.1608	0.1807	0.2142	0.0846
A5	0.2293	0.2332	0.1608	0.0602	0.2142	0.0846
A6	0.2293	0.2332	0.2680	0.3011	0.2142	0.2359
A7	0.2293	0.2332	0.2680	0.3011	0.2142	0.2359
A8	0.2293	0.2332	0.2680	0.1807	0.3571	0.2359
A9	0.2293	0.2332	0.2680	0.1807	0.2142	0.2359
…						
A20	0.2293	0.2239	0.2680	0.1807	0.0714	0.0846

Next, Equation [3] is operated to calculate the attribute optimization value with the final ranking (Equation [4]) as shown in Table 6.

Table 6. Preference Calculation

Rank	Alternative	Weight
1	A19	0.2046
2	A12	0.1974
3	A8	0.1973
4	A2	0.1792
5	A9	0.1758
…	…	…
16	A11	0.1363
17	A4	0.1325
18	A14	0.1325
19	A20	0.1272
20	A3	0.093

Figures 2 show the use case diagram and DSS Fuzzy MOORA system development.



Kode	Nama Alternatif	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	Aksi
A01	CV. Heroton	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Ya	2-4 tahun	>130.000.000	2-4	<500.000.000	UBAH
A02	CV. Bakti Luhur	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Ya	>4 tahun	<120.000.000	>4	500.000.000-1.000.000.000	UBAH
A03	PT. Putra Smart	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Tidak	2-4 tahun	<120.000.000	<2	<500.000.000	UBAH
A04	PT. Jaya Star Utama	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Tidak	2-4 tahun	120.000.000-130.000.000	2-4	<500.000.000	UBAH
A05	PT. Davindo Visi Lestari	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Ya	2-4 tahun	>130.000.000	2-4	<500.000.000	UBAH
A06	CV. Banggai Raya Mandiri	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Ya	>4 tahun	<120.000.000	2-4	500.000.000-1.000.000.000	UBAH
A07	PT. BUMI MAS PERDANA	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Ya	>4 tahun	<120.000.000	2-4	500.000.000-1.000.000.000	UBAH
A08	PT. WIRA KARSA	Ada	Ada	Ada	Ya	Ya	Ya	Ya	Ya	>4	120.000.000-	>4	500.000.000-	UBAH

Figure 2. One of Interface DSS-Tender Recommendation system for Assessment Module

As the final result, the ranking of tender participants is explained in Table 6. On the table 6 informed that A19 as the optimum rank of tender participant with the value of 0.1968, followed by A12 with an optimization value of 0.1903, A8 with the value of 0.1899, and A3 with 0.0930 as the lowest rank. The resume of participant ranking can be depicted at Figure 3.

The Blackbox testing evaluate several modules, viz., login, criterion menu, crips menu, alternative menu, alternative values, print menu, and password menu. As general, the findings found that the system is running well. Meanwhile, UAT reveals that 87.6% respondents indicated the user friendliness of the system interface. Furthermore, the application's functionality is sufficient in aiding the decision-makers at the Goods and Services Procurement Bureau at Riau Province towards the optimum tender winner recommendation.

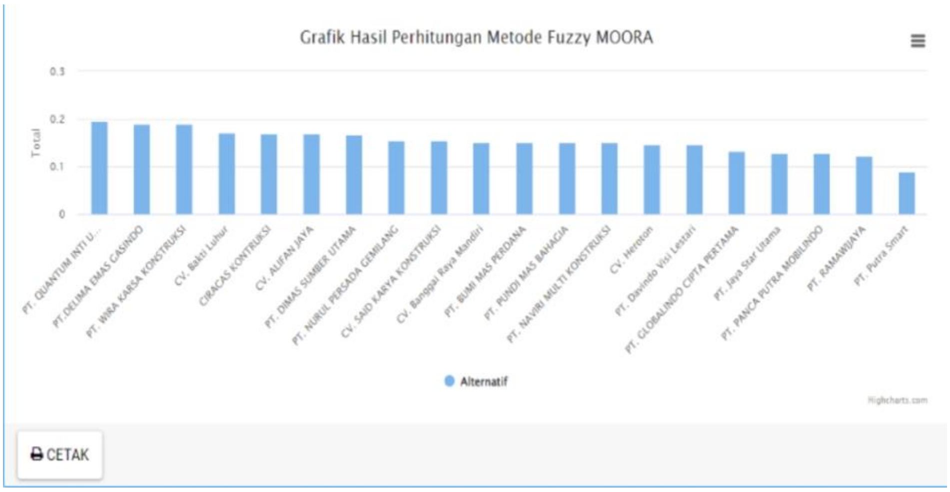


Figure 3. Tender Participants Ranking

3.4. Sensitivity Analysis

Referring to the final analysis of Fuzzy MOORA as depicted at Table 6, the sensitivity calculation tries to reanalysis the changes of the maximum value, initial conditions, and changing conditions in order to investigate the new optimum ranking. As a result, a new optimum ranking are defined as shown at Table 7.

Table 7. Sensitivity Test Ranking Calculation

Rank	Initial Weight	Criteria 1		Criteria 2		…	Criteria 6	
		W_{C1}+(0.5)	W_{C1}+(1)	W_{C2}+(0.5)	W_{C2}+(1)	…	W_{C6}+(0.5)	W_{C6}+(1)
1	0.2046	0.3192	0.4339	0.3212	0.4378	…	0.2258	0.6278
2	0.1974	0.3120	0.4267	0.3138	0.4305	…	0.2101	0.4513
3	0.1973	0.3119	0.4266	0.3093	0.4213	…	0.21	0.4512
4	0.1792	0.2938	0.4085	0.2958	0.4124	…	0.1919	0.4331
5	0.1758	0.2905	0.4051	0.2924	0.4090	…	0.1885	0.4298
…	…	…	…	…	…	…	…	…
20	0.093	0.2076	0.3223	0.2049	0.3169	…	0.0972	0.1776
Max	0.2046	0.3192	0.4339	0.3212	0.4378	…	0.2258	0.6278

The sensitivity test on Criteria number 1 found the list alternative ranking analysis are defined as below

A19>A12>A8>A2>A9>A13>A18>A15>A17>A6>A7>A10>A16>A1>A5>A11>A4>A14 >A20 >A3.

For Criteria number 2 are ranked as

A19>**A8>A12**>A2>A9>A13>A18>A15>A17>A6>A7>A10>A16>A1>A5>A11>A4>A14 >A20>A3.

The overall calculation and analysis of alternatives ranking are presented in table 8. This table shows the total of 57 changes where the greatest changes of alternatives occur for Criteria C3 with 14 changes calculation and Criteria C4 (Wc4 + 1) with 15 changes. As following the Equation [5], the sensitivity analysis of Fuzzy MOORA for this case study reveals at 79.16% to indicate the potential and effective execution of this approach in recommending the tender winner rank.

Table 8. Results of Alternative Ranking Changes

Simulation to-	Criteria (C)	Criteria Weight Value W+n	Alternate Ranking Change	Number of Alternative Rank Changes
0	-	-	A19>A12> A8> A2> A9> A13> A18> A15> A17> A6> A7> A10> A16>A1>A5>A11>A4>A14>A20>A3.	-
…	…	…	…	…

5	C3	W_{C3}+(0.5)	A19>A8> A812>A2> A9> A13> A18> A6> A7> A10> A16> A11> A20>A15> A17> A1>A5> A4>A14> A3.	14
6		W_{C3}+(1)	A19>A8> A812>A2> A9> A13> A18> A6> A7> A10> A16> A11> A20>A15> A17> A1>A5> A4>A14> A3.	14
7	C4	W_{C4}+(0.5)	A19>A8>A12>A9>A13>A2>A18>A15>A17>A1>A5>A6>A7>A10>A16>A11>A4>A14>A20>A3	10
8		W_{C4}+(1)	A12> A1>A5>A19> A8> A2> A9> A13> A18> A15> A17> A6> A7> A10> A16> A11>A4>A14>A20>A3.	15
…	…	…	**…**	…
11	C6	W_{C6}+(0.5)	A19>A12> A8> A2> A9> A13> A18> A15> A17> A6> A7> A10> A16>A1>A5>A11>A4>A14>A20>A3.	0(no change)
12		W_{C6}+(1)	A19>A12> A8> A2> A9> A13> A18> A15> A17> A6> A7> A10> A16>A1>A5>A11>A4>A14>A20>A3.	0(no change)
			Number of Changes	57

4. CONCLUSION

The development of winning tender recommendation system based on Fuzzy MOORA has been successfully deployed. Based on the results of the user acceptance testing (UAT) and black box testing, an respondent agreement value of 87.6% was obtained, indicating that this tender recommendation system could perform well and meet user needs in delivering the best suggestion for tender winners at the Bureau of PBJ Riau Province. The sensitivity analysis test reveals that adding criteria weight for the criteria C3 and C4 induces a change in alternative ranking with a sensitivity percentage of 79.16%. This demonstrates effectiveness and optimality of Fuzzy MOORA in assessing and ranking alternatives. As a result, the analysis of the recommendations provided becomes more accurate and optimum.

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REFERENCES

[1] A. E. J. Prakoso and C. N. Setyaningati, “Law Protection for Procurement Officers: Legal Protection against the Procurement Instrument of Goods and Services,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 175, no. 1, 2018, doi: 10.1088/1755-1315/175/1/012128.

[2] F. Annas, D. Ediana, A. Kurniawan, R. Wandira, and S. Zakir, “Decision Support System in Detrmination of Project Tender Winner Using the Analytical Hierarchy Process (AHP)

Method," *J. Phys. Conf. Ser.*, vol. 1779, no. 1, 2021, doi: 10.1088/1742-6596/1779/1/012006.

[3] K. Zong, Y. Yuan, C. E. Montenegro-Marin, and S. N. Kadry, "Or-based intelligent decision support system for e-commerce," *J. Theor. Appl. Electron. Commer. Res.*, vol. 16, no. 4, pp. 1150–1164, 2021, doi: 10.3390/JTAER16040065.

[4] A. Ullah, S. Hussain, A. Wasim, and M. Jahanzaib, "Development of a decision support system for the selection of wastewater treatment technologies," *Sci. Total Environ.*, vol. 731, p. 139158, 2020, doi: 10.1016/j.scitotenv.2020.139158.

[5] B. Abdullahi, Y. M. Ibrahim, A. D. Ibrahim, and K. Bala, "Developing a Web-Based Tender Evaluation System Based on Fuzzy Multi-Attributes Group Decision Making for Nigerian Public Sector Tendering," *Int. J. Comput. Inf. Eng.*, vol. 13, no. 7, pp. 349–357, 2019.

[6] A. Arabsheybani, M. M. Paydar, and A. S. Safaei, "An integrated fuzzy MOORA method and FMEA technique for sustainable supplier selection considering quantity discounts and supplier's risk," *J. Clean. Prod.*, vol. 190, pp. 577–591, 2018, doi: 10.1016/j.jclepro.2018.04.167.

[7] T. Limbong, J. Simarmata, S. Sriadhi, A. R. S. Tambunan, and E. K. Sinaga, "The Implementation of Multi-Objective Optimization on the Basis of Ratio Analysis Method to Select the Lecturer Assistant Working at Computer Laboratorium," vol. 7, pp. 352–356, 2018.

[8] F. Gurbuz and G. Erdinc, "Selecting the Best Hotel Using the Fuzzy-Moora Method with a New Combined Weight Approach," *ISMSIT 2018 - 2nd Int. Symp. Multidiscip. Stud. Innov. Technol. Proc.*, pp. 1–8, 2018, doi: 10.1109/ISMSIT.2018.8566688.

[9] R. Kozik, "The Process of the Tender Evaluation in Public Procurement for Implementation of Design Documentation," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 222, no. 1, 2019, doi: 10.1088/1755-1315/222/1/012019.

[10] M. C. Matto, A. M. Ame, and P. M. Nsimbila, "Tender process and value for money in Tanzania public procurement," *Int. J. Logist. Econ. Glob.*, vol. 9, no. 1, p. 1, 2021, doi: 10.1504/ijleg.2021.116218.

[11] M. Gallab, H. Bouloiz, Y. L. Alaoui, and M. Tkiouat, "Risk Assessment of Maintenance activities using Fuzzy Logic," *Procedia Comput. Sci.*, vol. 148, no. Icds 2018, pp. 226–235, 2019, doi: 10.1016/j.procs.2019.01.065.

[12] A. H. Hamamoto, L. F. Carvalho, L. D. H. Sampaio, T. Abrão, and M. L. Proença, "Network Anomaly Detection System using Genetic Algorithm and Fuzzy Logic," *Expert Syst. Appl.*, vol. 92, pp. 390–402, 2018, doi: 10.1016/j.eswa.2017.09.013.

[13] H. Ahmadi, M. Gholamzadeh, L. Shahmoradi, M. Nilashi, and P. Rashvand, "Diseases diagnosis using fuzzy logic methods: A systematic and meta-analysis review," *Comput. Methods Programs Biomed.*, vol. 161, pp. 145–172, 2018, doi: 10.1016/j.cmpb.2018.04.013.

[14] S. Sutarno, M. Mesran, S. Supriyanto, Y. Yuliana, and A. Dewi, "Implementation of Multi-Objective Optimazation on the Base of Ratio Analysis (MOORA) in Improving Support for Decision on Sales Location Determination," *J. Phys. Conf. Ser.*, vol. 1424, no. 1, 2019, doi: 10.1088/1742-6596/1424/1/012019.

[15] O. Okfalisa, R. Hafsari, G. Nawanir, S. Toto, and N. Yanti, "Optimizing placement of field experience program: An integration of moora and rule-based decision making," *Pertanika J. Sci. Technol.*, vol. 29, no. 2, pp. 895–918, 2021, doi: 10.47836/pjst.29.2.11.

[16] S. Fadli and K. Imtihan, "Implementation of MOORA Method in Evaluating Work Performance of Honorary Teachers," *SinkrOn*, vol. 4, no. 1, p. 128, 2019, doi: 10.33395/sinkron.v4i1.10192.

[17] O. Okfalisa, H. Rusnedy, D. U. Iswavigra, B. Pranggono, E. H. Haerani, and S. Saktioto, "Decision Support System for Smartphone Recommendation: the Comparison of Fuzzy Ahp and Fuzzy Anp in Multi-Attribute Decision Making," *Sinergi*, vol. 25, no. 1, p. 101, 2020, doi: 10.22441/sinergi.2021.1.013.

[18] O. Okfalisa, T. Fernando, D. U. Iswavigra, and K. Rajab, "Integrated Fuzzy-Analytical Hierarchy Process (F-AHP) and Technique for Preference by Similarity to the Ideal Solution (TOPSIS) in Recommending Extracurricular Program Selection," vol. 5, no. 3, pp. 1–7, 2022.

[19] C. Sathiyaraj, M. Ramachandran, R. Kurinjimalar, and P. Anusuya, “Study on Fuzzy ELECTRE Method with Various Methodologies,” *REST J. Emerg. trends Model. Manuf.*, vol. 7, no. 4, pp. 108–115, 2021, doi: 10.46632/7/4/2.

[20] C. N. Wang, N. A. T. Nguyen, T. T. Dang, and C. M. Lu, “A compromised decision-making approach to third-party logistics selection in sustainable supply chain using fuzzy ahp and fuzzy vikor methods,” *Mathematics*, vol. 9, no. 8, 2021, doi: 10.3390/math9080886.

[21] R. Dabbagh and S. Yousefi, “A hybrid decision-making approach based on FCM and MOORA for occupational health and safety risk analysis,” *J. Safety Res.*, vol. 71, no. November, pp. 111–123, 2019, doi: 10.1016/j.jsr.2019.09.021.

[22] A. Saltelli *et al.*, “Why so many published sensitivity analyses are false: A systematic review of sensitivity analysis practices,” *Environ. Model. Softw.*, vol. 114, no. January, pp. 29–39, 2019, doi: 10.1016/j.envsoft.2019.01.012.

[23] S. Moradi, H. Yousefi, Y. Noorollahi, and D. Rosso, “Multi-criteria decision support system for wind farm site selection and sensitivity analysis: Case study of Alborz Province, Iran,” *Energy Strateg. Rev.*, vol. 29, no. April 2017, p. 100478, 2020, doi: 10.1016/j.esr.2020.100478.

[24] M. L. Pannier, P. Schalbart, and B. Peuportier, “Comprehensive assessment of sensitivity analysis methods for the identification of influential factors in building life cycle assessment,” *J. Clean. Prod.*, vol. 199, pp. 466–480, 2018, doi: 10.1016/j.jclepro.2018.07.070.

[25] N. Delgarm, B. Sajadi, K. Azarbad, and S. Delgarm, “Sensitivity analysis of building energy performance: A simulation-based approach using OFAT and variance-based sensitivity analysis methods,” *J. Build. Eng.*, vol. 15, no. July 2017, pp. 181–193, 2018, doi: 10.1016/j.jobe.2017.11.020.

[26] D. Liu, L. Li, A. Rostami-Hodjegan, F. Y. Bois, and M. Jamei, “Considerations and Caveats when Applying Global Sensitivity Analysis Methods to Physiologically Based Pharmacokinetic Models,” *AAPS J.*, vol. 22, no. 5, pp. 1–13, 2020, doi: 10.1208/s12248-020-00480-x.

[27] C. Su, J. Xian, and H. Huang, “An iterative equivalent linearization approach for stochastic sensitivity analysis of hysteretic systems under seismic excitations based on explicit time-domain method,” *Comput. Struct.*, vol. 242, p. 106396, 2021, doi: 10.1016/j.compstruc.2020.106396.

[28] Lembaga Kebijakan Pengadaan Barang/Jasa Pemerintah, “Peraturan LKPP Nomor 12 Tahun 2021,” *Jar. Dokumentasi dan Inf. Huk. BPK RI*, vol. 1, p. 36, 2021.

[29] Indah Kusumarukmi, Eryana; Joko Wahyu Adi, Tri; Awaludin, A.; Matsumoto, T.; Pessiki, S.; Jonkers, H.; Siswosukarto, S.; Fajar Setiawan, A.; Nur Rahma Putri, K. (2019). *Public tendering process for construction projects: problem identifications, analysis, and proposed solutions. MATEC Web of Conferences, 258(), 02013–.*

[30] Naik, M. G., Kishore, R., & Mousavi Dehmourdi, S. A. (2021). Modeling A Multi-Criteria Decision Support System for Prequalification Assessment of Construction Contractors Using CRITIC and EDAS Models. *Operational Research in Engineering Sciences: Theory and Applications*, *4*(2), 79-101.