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An Alternative in Determining the Best Wood for Guitar Materials Using MOORA Method

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***Abstract*— This study aims to assist wood craftsmen in Dongkelan, Krapyak, Yogyakarta in determining the best wood to be used as guitar material, because there are frequent complaints from buyers that the materials used as guitar materials are rotten quickly and are dull in terms of color. Based on these problems, a solution is sought using the Multi Objective Optimization on the basis of Ratio Analysis (MOORA) decision support system method, and is assisted by experts in determining the right criteria related to determine the best wood used in making guitar materials. After a long discussion the correct criteria were found based on the problem. These criteria are wood strength, wood grain, texture, and wood weight. All of these criteria are then processed using the MOORA decision support system method. After processing, the best results are obtained. The more suitable wood for guitar making is Ebony with 23.6831 results occupying the first rank. To assess the results of our decision support system, a questionnaire was carried out directly to several guitar makers with a total of 14 people. The assessment to our system results an accuracy of 85.71% which means that our system could produce significant results. In this case, Ebony wood is the best used as a guitar-making material.**

Keywords-guitar; making guitar material; Decision Support System; MOORA; education.

1 INTRODUCTION

A guitar is a wooden instrument equipped with strings plucked using a finger or guitar pick [1]. When picked, the strings on this guitar will produce a sound. According to its type, guitars can be divided into two, namely electric guitars and acoustic guitars. The electric guitar combines its components with an electric mic or pick up (spool), while the acoustic guitar uses a saddle or a bridge where the strings fasten to stream sound into the sound chambers [2].

There are many types of wood used to build guitars including Ebony, Rosewood, Meranti, Merbau, and others. It makes guitar makers are difficult to determine the right type of wood used as material for making guitars. In overcoming this difficulty in selecting wood, an appropriate research is needed in using the best wood as guitar materials based on information from experts, which will then be implemented in the form of applications [3]. This assistance system is part of the information system used to make decisions when facing a case or problem [4]. In supporting decision making, the assistive system will calculate criteria by using a computer system to process information needed in making decision. Development of methods in aids system from the simplest to more specific directions are Weighted Sum Model, Technique For Order Preference by Similarity to Ideal Solution, Analytical Hierarchy Process, and others.

In this study the authors applied MOORA in determining the best wood as a guitar material with criteria of wood strength, wood fiber, texture, and wood weight. The use of MOORA [5][6] is because it is a framework for making effective decisions on complex problems by simplifying and accelerating the decision making process by solving the problem into its parts [7], and synthesizing which one has the highest priority and acts to influence the outcome of the situation.

Some similar studies that the authors took as material in making this study. Firstly it is according to [8] which the object is the selection of Yamaha motorcycle mechanics in Alfascorfii. Alternative data available are prospective mechanics, in the study giving examples of A1, A2, A3, A4, A5, and A6, which are suitable to be selected as mechanics in Alfascorfii by being influenced by criteria of trouble shooting, education, years of service, and discipline. From the results of using MOORA, it is obtained that A2 mechanics have the highest value, then A2 mechanics is a viable alternative to being chosen as a mechanic in Alfascorfii.

Secondly it is according to [9] which the object is the determination of recipients of the house renovation assistance. Alternative data available are local residents, in the study giving examples of A1, A2, A3, A4, A5, A6, A7, A8, A9, and A10. Criteria to be given home renovation assistance are work, income, floor type, wall type, MCK, and roof type. From the results of using MOORA, it was found that residents of A7 and A9 have the highest values in a row. Thus, residents of A7 and A9 were viable alternatives to receive housing renovation assistance.

Thirdly it is according to [10] which the object is choosing the best motorcycle mechanics. Alternative data available, namely, motorcycle mechanics, in the study gave examples of A1, A2, A3, A4, and A5, which if appropriate to be selected as the best motorcycle mechanic influenced by the criteria of trouble shooting, years of service, education, and letters of reprimand. From the results of using MOORA, it is found that A2 motorcycle mechanic has the highest value, then A2 motorcycle mechanic is a viable alternative to be used as the best motorcycle mechanic.

The last is according to [11] which the object is student selection exemplary. The existing alternative data, namely, the students concerned, in the study gave examples of A1, A2, A3, A4, and A5 which were appropriate to be selected as model students by being influenced by the criteria of report cards, abscesses, assignments, and achievements. From the results of using MOORA, it is found that A5 students have the highest grades, then A5 students are the alternatives chosen to be model students in the school concerned.

Based on previous research that have been explained above, this research was carried out with the aim of helping wood craftsmen in Dongkelan, Krapyak, Yogyakarta in determining the best wood as material for making guitars, with the help of expert. MOORA method is used because this method whose a good level of selectivity; it can determine the objectives of conflicting criteria which can be beneficial (benefits) or unfavorable (costs).

2 METHOD

The method used in determining the best wood to make guitar material, can be seen in Figure 1. Following is the explanation of each stage of this research flow.

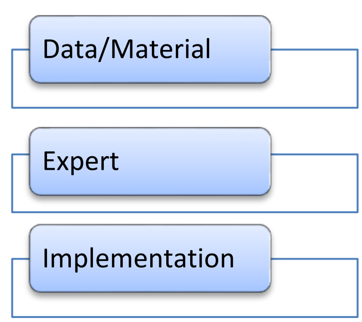
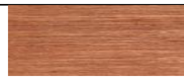
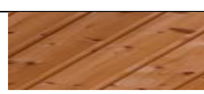


Figure 1. Research Flow

2.1 *Data/Material*

Data obtained is the wood which will be used to make guitar. Table 1 shows these data.

Table 1 Wood Data

Wood Name	Figure
Teak wood	
Mahogany	
Meranti	
Merbau	
Albasia	
Sandalwood	
Ulin	
Ebony	
Trembesi	
Bangkirai	
Camphor	
Sonokeling	
Sungkai	
Pine	
Fir	
Coconut	
Sugar palm	

Data collection procedures in this study were carried out in two methods, as follows:

2.1.1 *Observations*

Observations were made in Dongkelan, Krapyak Yogyakarta by making direct observations of what happened and directly felt the problems that occurred.

2.1.2 *Interview*

Interviews were conducted in Dongkelan, Krapyak Yogyakarta precisely with guitar craftsmen. The results of observations are in the form of data to make a recommendation system to determine the best wood for guitar material.

2.2 *Expert*

Experts here assist the author in determining the criteria commonly used in making guitar, as well as in determining the set of each criterion, along with their values. By referencing to the problems of the relevant agencies, it was agreed that the criteria used to determine the best wood in making guitar, consist of the strength of wood, wood fiber, texture, and wood weight.

2.3 *Implementation*

The implementation is intended as the application of MOORA in determining the best wood in the manufacture of guitar. According to [6], MOORA is applied to solve problems with complex mathematical calculations. MOORA has a level of flexibility and ease to understand in separating the subjective parts of an evaluation process into decision weight criteria with several attributes of decision making. This method has a good level of selectivity because it can determine the objectives of conflicting criteria. The superiority of MOORA is simpler, more stable and stronger, even this method does not require an expert in mathematics to use it and requires simple mathematical calculations. In addition, this method also has more accurate results and is well targeted in helping decision making [12]. When compared with other methods, MOORA is even simpler and easier to implement.

Following is stages of the implementation of Multi Objective Optimization on the basis of Ratio Analysis in determining the best wood in making guitar. Figure 2 shows these stages.

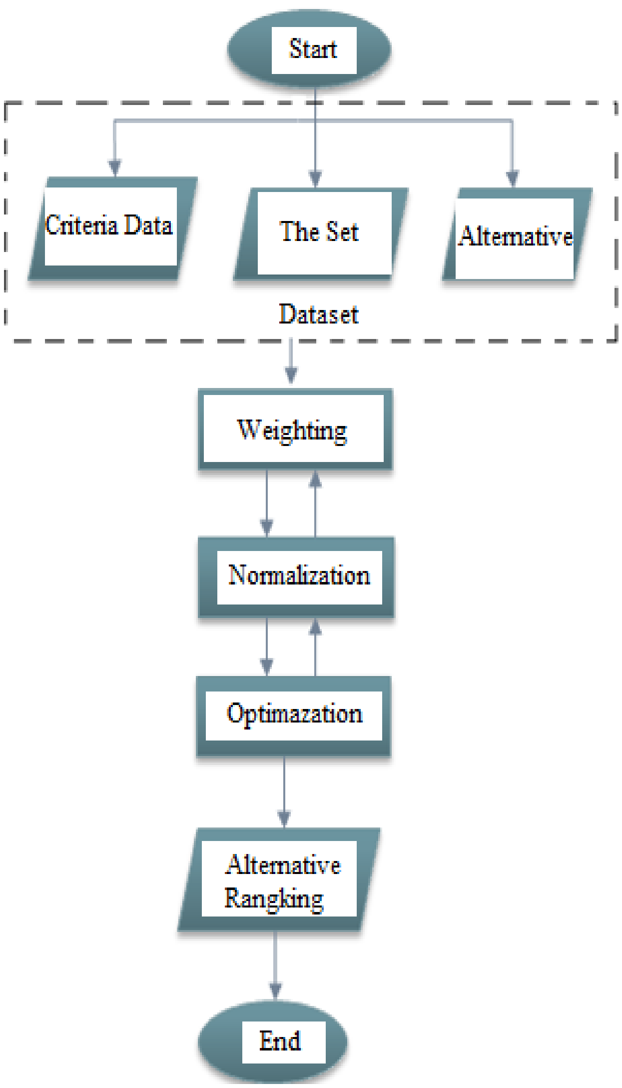


Figure 2. The flow of Multi Objective Optimization on the basis of Ratio Analysis (MOORA)

2.3.1 *Criteria Data*

Criteria data are obtained from experts based on the problems that occur. Table 2 shows these criteria consisting of criteria code, criteria names, attributes, and weights of each criterion [13].

Table 2 Criteria

Criteria Code	Criteria Name	Attribute	Weight
C01	Wood Strength	Benefit	20
C02	Wood Fiber	Benefit	35
C03	Texture	Benefit	30
C04	Wood Weight	Cost	15

2.3.2 *The Set*

The set is data obtained from the derived data criteria. Each criterion has a set that has been determined and agreed upon by experts and related agencies.

2.3.2.1 *Wood Strength Criteria Set*

The set of wood strength criteria is derived from the wood strength criteria data which contains the number, the name of the wood strength criteria, and the value of each set of wood strength criteria. The table of sets of wood strength criteria can be seen in Table 3.

Table 3 Wood Strength Criteria Set

Numbe	Name of the Wood Strength Criteria	Value
1	Very Strong	5
2	Strong	4
3	Medium	3
4	Broken Easy	2

2.3.2.2 *Wood Fiber Criteria Set*

The set of wood fiber criteria is derived from the wood fiber criteria data which contains the number, the name of the wood fiber criteria, and the value of each set of wood fiber criteria. Table of set of wood fiber criteria can be seen in Table 4.

Table 4 Wood Fiber Criteria Set

Number	Name of the Wood Fiber Criteria	Value
1	Very Solid	5
2	Solid	4
3	Be extensive	3
4	Glow	2

2.3.2.3 *Texture Criteria Set*

Texture criteria set is a derivative of texture criteria data that contains the number, texture criteria name, and value of each texture criteria set. Table set of texture criteria can be seen in Table 5.

Table 5 Texture Criteria Set

Number	Texture Criteria Name	Value
1	Very Smooth	5
2	Smooth	4
3	Medium	3
4	Rough	2

2.3.2.4 Wood Weight Criteria Set

The set of wood weight criteria is derived from the wood weight criteria data which contains the number, the name of the wood weight criteria, and the value of each set of wood weight criteria. Table of wood weight criteria set can be seen in Table.

Table 6 Wood Weight Criteria Set

Number	Name of the Wood Weight Criteria	Value
1	Greater than 30 Kg	5
2	25 Kg – 29 Kg	4
3	20 Kg – 24 Kg	3
4	15 Kg – 19 Kg	2
5	Less than 14 Kg	1

2.3.3 Alternative

The alternative table is a table that contain alternative data that will be used in the calculation process. The alternative table can be seen in Table 7.

Table 7 Alternative

Alternative Code	Wood Name
A0001	Teak wood
A0002	Mahogany
A0003	Meranti
A0004	Merbau
A0005	Albasia
A0006	Sandalwood
A0007	Ulin
A0008	Ebony
A0009	Trembesi
A0010	Bangkirai
A0011	Camphor
A0012	Sonokeling
A0013	Sungkai
A0014	Pine
A0015	Fir
A0016	Coconut
A0017	Sugar palm

2.3.4 Weighting

Changing the dataset matrix into weighting data means that all datasets are changed in the form of weight values according to the value of the set of criteria [14].

2.3.5 Normalization

Normalization is intended to unite each matrix element so that the elements in the matrix have a uniform value. Each element is divided by the square root of the sum of the squares of each alternative per criterion/ attribute [15]. This ratio can be stated as shown in Formula 1 as follows:

$$X^*_{ij} = \frac{xij}{\sqrt{[\sum_{j=1}^{m} xij^2]}} \qquad (1)$$

2.3.6 Optimization

Provisions for granting weights are if maximum criteria specific gravity values are greater than the minimum criteria specific gravity values [16]. To indicate that an attribute is more important, multiply this attribute by an appropriate weight (coefficient of significance) [17]. The formula is shown in Formula 2:

$$\mathrm{Yi} = \sum_{i=1}^{g} wjX_ij - \sum_{j=g+1}^{n} wjX_ij \qquad (2)$$

2.3.7 Alternative Ranking

The value of **Yi** can be positive or negative depending on the maximum total (beneficial attribute) in the decision matrix. A ranking order from **Yi** indicates the last choice. Thus the best alternative has the highest value of **Yi** while the worst alternative has the lowest value of **Yi** [18].

3 RESULT AND DISCUSSION

3.1 Manual Calculation

The initial step is to form a matrix between alternative data and criteria data, the results of the formation are in the form of initial data that contains the value of each alternative and criteria. Preliminary data can be seen in Table 8.

Table 8 Dataset

Code_Alternative	Wood Strength	Wood Fiber	Texture	Wood Weight/Kg
A0001	Very Strong	Very Solid	Medium	35
A0002	Strong	Very Solid	Rough	25
A0003	Medium	Solid	Smooth	30

A0004	Very Strong	Solid	Medium	30
A0005	Broken Easy	Be extensive	Rough	24
A0006	Medium	Glow	Medium	14
A0007	Very Strong	Solid	Smooth	36
A0008	Strong	Very Solid	Very Smooth	32
A0009	Medium	Solid	Smooth	28
A0010	Medium	Solid	Medium	20
A0011	Strong	Solid	Rough	25
A0012	Strong	Solid	Medium	29
A0013	Medium	Be extensive	Medium	24
A0014	Broken Easy	Glow	Medium	12
A0015	Broken Easy	Be extensive	Medium	12
A0016	Broken Easy	Be extensive	Rough	15
A0017	Broken Easy	Glow	Rough	14

Then, we change the initial data matrix into weighting data, meaning that all initial data is changed in the form of weight values. Weighting data can be seen in Table 9.

Table 9 Weighting Data

Cod_Alternative	C01	C02	C03	C04
A0001	5	5	3	5
A0002	4	5	2	4
A0003	3	4	4	5
A0004	5	4	3	5
A0005	2	3	2	3
A0006	3	2	3	1
A0007	5	4	4	5
A0008	4	5	5	5
A0009	3	4	4	4
A0010	3	4	3	3
A0011	4	4	2	4
A0012	4	4	3	4
A0013	3	3	3	3
A0014	2	2	3	1
A0015	2	3	3	1
A0016	2	3	2	2
A0017	2	2	2	1

Weighting data are changed into normalized data by applying Formula 1. An example of calculating the normalization process on the wood strength criteria (C01) is given as follows:

$$C01= \sqrt{5^2+4^2+3^2+5^2+\cdots+2^2} = 14.28286$$

$$\text{A0001 } X_{11} = \frac{x_{11}}{14,28286} = \frac{5}{14,28286} = 0.35007$$

....

$$\text{A0017 } X_{171} = \frac{x_{151}}{14,28286} = \frac{2}{14,28286} = 0.14003$$

Following the above calculation on all criteria, a normalized matrix is produced. It can be seen in Table 10.

Table 10 Normalization Data

Cod_Alternative	C01	C02	C03	C04
A0001	0.35007	0.32616	0.23355	0.33408
A0002	0.28006	0.32616	0.1557	0.26726
A0003	0.21004	0.26093	0.26261	0.33408
A0004	0.35007	0.26093	0.23355	0.33408
A0005	0.14003	0.1957	0.1557	0.20045
A0006	0.21004	0.13047	0.23355	0.06682
A0007	0.35007	0.26093	0.3114	0.33408
A0008	0.28006	0.32616	0.38925	0.33408
A0009	0.21004	0.26093	0.3114	0.26726
A0010	0.21004	0.26093	0.23355	0.20045
A0011	0.28006	0.26093	0.1557	0.26726
A0012	0.28006	0.26093	0.23355	0.26726
A0013	0.21004	0.1957	0.23355	0.20045
A0014	0.14003	0.13047	0.23355	0.06682
A0015	0.14003	0.1957	0.23355	0.06682
A0016	0.14003	0.1957	0.1557	0.13363
A0017	0.14003	0.13047	0.1557	0.06682

The next process, namely, ranking or optimizing. In this process, importance values of criteria that represent weight of each criterion are set up. These weights are decided by the decision maker, which in this case means the expert, namely as follows:

W= {20, 35, 30, 15}

The next process is to produce the final value using Formula 2. The calculation processes to get this value are as follows:

A0001
$Y1 = \sum (0.35007 \times 20) + (0.32616 \times 35) + (0.23355 \times 30) - \sum (0.33408 \times 15)$
$= 25.4235 - 5.0112$
$= 20.4123$

....
....

A0017
$Y17 = \sum (0.14003 \times 20) + (0.13047 \times 35) + (0.1557 \times 30) - \sum (0.06682 \times 15)$
$= 12.03805 - 1.0023$
$= 11.03575$

We only give two calculations for the sake of the number of page limit. Overall data from the ranking calculation are shown in Table 11 Ranking Data follows.

Table 11 Ranking Data

Code	Cod_Alternative	Wood_Name	Value	Rank
Y8	A0008	Ebony	23.6831	1
Y7	A0007	Ulin	20.46475	2
Y1	A0001	Teak Wood	20.4123	3
Y9	A0009	Trembesi	18.66645	4
Y4	A0004	Merbau	18.12925	5
Y12	A0012	Sonokeling	17.73135	6
Y2	A0002	Mahogany	17.6789	7
Y3	A0003	Meranti	17.66415	8
Y10	A0010	Bangkirai	17.3331	9
Y15	A0015	Pine	15.6543	10
Y11	A0011	Camphor	15.39585	11
Y13	A0013	Sungkai	15.05005	12
Y6	A0006	SandalWood	14.77145	13
Y14	A0014	Fir	13.37125	14
Y16	A0016	Coconut	12.31665	15
Y5	A0005	Albasia	11.31435	16
Y17	A0017	Sugar Palm	11.03575	17

3.2 Accuracy

The accuracy of results are assessed by conducting a questionnaire directly to several guitar makers. We provide the questionnaire with a list of wood types, then the guitar maker gives a ranking order of the provided list of wood types. The assessment of the guitar maker will only be taken into consideration on the best wood with a rating of 1, which will then be calculated using the following Formula 3.

$$\text{Accuracy} = \frac{N}{N+Ni} \times 100\% \quad (3)$$

With value N is total appropriate, Ni is the total is not appropriate.

Number of guitar makers who gave a rating = 14
Number of suitable judgments = 12
Number of unsuitable judgments = 2

$$\text{Accuracy} = \frac{12}{12+2} \times 100\% = 85.71\%$$

The accuracy in this study is 85.71% which means it has a significant verification value. This accuracy is obtained from 14 guitar makers, whom 12 out of them gave the same assessment as researchers.

4 CONCLUSION

After conducting research and implementation of the Multi Objective Optimization on the basis of Ratio Analysis (MOORA) method in determining the best wood which will then be made as material for making guitars, it can be concluded that, MOORA method can be used as one of the methods to determine the best wood recommendations, based on existing criteria.

The results of the study conclude that Ebony is the best wood that is suitable for making guitars with a value of 23.683. To prove the results of the implementation of MOORA method, a questionnaire was carried out directly to several guitar makers to be precise with 14 people with an accuracy of 85.71%, which means that it has significant verification.

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