Determines the Weight Criteria of Simple Additive Weighting Method Using Certainty Factor

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Determines the Weight Criteria of Simple Additive Weighting Method Using Certainty Factor

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***Abstract*— Simple Additive Weighting is a method of decision-making that is widely used because the calculation process using the simple steps in problem-solving. This method works by summing the weights of each criterion for selecting the best alternative from several alternatives based on criteria that have been determined. Where each criterion consists of several sub-criteria which has a weight of each in the form of crisp or fuzzy numbers. In this study, the weight of each decision-making criteria determined using the Certainty Factor method by combining the value of the measure of belief and measure of disbelief in numbers form. The value is derived from the assumption of the level of belief and disbelief on a hypothesis based on evidence. By using the Certainty Factor as a determinant the criteria weight for decision-making has produced in the value of preferences the more detailed and varied. The combination of these two methods can be used to perform the selection of the best alternative from the several alternatives that have almost similar values.**

Keywords—criteria, evidence, certainty factor, crisp, fuzzy, simple additive weighting

I. INTRODUCTION

Decision Support System (DSS) is a system used to help decision-makers in the face of the decision-making problem, whether that decision is structured or unstructured based on the data and particular model. DSS usually used to determine the decision that will be selected from the several alternatives that are available. This system designed to support each stage of decision-making starting from the stage of problem identification, selecting relevant data, determine the approach used in the decision-making process and also evaluate the decisions that are available so that decisions will be taken is expected to solve the problems encountered. To get the decision relevant to the problems faced of course such decisions need to be supported by the information and facts that quality [1], [2].

To get a good decision usually uses various criteria as benchmarks for problem solving. Decision making that involves many criteria is often called Multi-Criteria Decision Making (MCDM) [3], [4]. One method that is often used in cases involving multiple criteria or MCDM is the Simple Additive Weighting (SAW) method. This method is widely used because the calculation process and steps in solving problems using the ways of the easy and simple. SAW method works by summing the weights of each criterion to choose the best alternative from a number of alternatives based on the criteria used as benchmarks of problem-solving. In data processing, Simple additive weighting requires the assessment criteria, weight of criteria and the value of the fact of each alternative and further use the operations of multiplication and summation to get the value of the preference [1], [5]–[9].

The most important problem in the MCDM model is the data used such as criteria, criteria weights, and sub-criteria are not permanent and can change in certain conditions, because the criteria weights depend on the decision-maker and if the criteria or criteria weights undergo changes will be able to change the final decision [10]. The weight of criteria is very important in decision support systems. The selection of criteria that matches the problem and the selection of sub-criteria will also affect the outcome of the decision [11].

The determination of the weights of the criteria be an interesting thing to study. Various research has been carried out to obtain maximum results in decision making related to the determination of criteria weights as has been done by S. Niroomand, et al (2019) perform hybridization SAW method by modeling the mixed-integer linear formulation formula [12]. G. Popovic, et al (2019) applied a step-wise weight assessment ratio analysis to determine the criteria weights and Weighted Sum method in selecting hotel construction locations [13]. Whereas Y. Wu, et al (2019) combine the weights of the criteria and using the theory of prospects cumulative to selecting suppliers [14].

In this study, the authors use the Certainty Factor method to determine the value of the sub-criteria that fit with the alternative will be selected. The weighting of each criterion will be determined by finding the value of certainty factors by combining the value of measure of belief and the value of measure of disbelief in the numbers single. Certainty Factor using a value for the assumption of degrees of belief to each of the criteria by doing the hypothesis to any Evidence or facts.

II. METHODS

A. Data Research

The data for this study were obtained from the Deli Serdang Regency Housing and Settlements Department which has the Deli Serdang Building Movement program, one of which performed house renovation of not livable residents that became livable. The assessment criteria used to determine the families who will get a house renovation program consist of 4 criteria, namely family income, family dependents, the condition of the house is inhabited as well as assets owned. The four criteria are dispart into 22 sub-criteria. Data obtained by conducting literature studies and field studies on related agencies. The data that has been obtained will be analyzed using the SAW method to determine the decision to be taken and Certainty Factors is used to determine the weights of criteria for each alternative based on the facts they have.

B. Simple Additive Weighting Method

Simple Additive Weighting method is the method which is the most famous and most widely used by the Decision maker's in decision-making where the decisions taken have a lot of criteria or Multiple Criteria Decision Making. The steps of decision making with this method are very simple and this method is the basis of most of the techniques MCDM other. The basic concept is to perform the summation of the weights from performance ratings on each of the criteria that have been determined. In the SAW technique, the final result is a preference value which is used as an alternative ranking and used as a basis for decision making [10], [15].

The steps of decision making with the Simple Additive Weighting method are as follows [6], [10]:

- Determine the criteria and sub-criteria used as a benchmark assessment as well as the weight of each.
- Provide alternative values for each predetermined criterion based on the facts that owned alternatives.
- Determine the suitability rating of each alternative on each criterion in the form of an X matrix
- Normalize the X matrix by calculating the value of the performance rating (r_{ij}).

$$r_{ij} = \begin{cases} \frac{X_{ij}}{Max\, X_{ij}} & benefit \\ \frac{Min\, X_{ij}}{X_{ij}} & cost \end{cases} \quad (1)$$

Match rating values (r_{ij}) can be calculated using the benefit formula (Max x_{ij}) if the largest value is the best value or using the cost formula (Min x_{ij}) if the smallest value is the best value.

- Make the ranking process for each alternative by multiplying the weight value with the value of the performance rating which has been normalized.

$$Vi = \sum_{j=1}^{n} W_j r_{ij} \quad (2)$$

The ranking process (Vi) is done by multiplying the weight value of each criterion (w_j) with the normalized performance rating value (r_{ij}).

C. Certainty Factor Method

Certainty Factor method is a method to prove the uncertainty of an expert's thinking, were to accommodate this, a person usually uses Certainty Factor (CF) to describe the level of expert confidence in the problem will be solved. Certainty Factor combines the value of the measure of belief of hypothesis H which is influenced by Evidence E (MB [H, E]) with the value of the measure of disbelief of hypothesis H which is influenced by Evidence E (MD [H, E]) in the form of numbers a single by assuming the degree of confidence an expert on a fact with the following formula [16]–[18]:

$$CFcombine = CF[H,E]1+CF[H,E]2*(1-CF[H,E]1) \quad (3)$$

The next step is subtracting the value of MB [H, E] by MD [H, E] as in the following formula [16]–[18]:

$$CF[H.E] = MB[H,E] - MD[H,E] \quad (4)$$

Certainty Factor is used to provide a level of belief in the results of the calculation because a decision-maker often analyzes existing information by giving a factor of uncertainty. In this system to get the factors of certainty, each data given by the appraiser will have the weight to each [18]–[20].

D. Proposed Method

The method proposed by the authors to solve the problem of determining the weight of criteria in decision making is to combine the Certainty factor method the Simple Additive Weighting method illustrated as a flowchart in Figure 1 below:

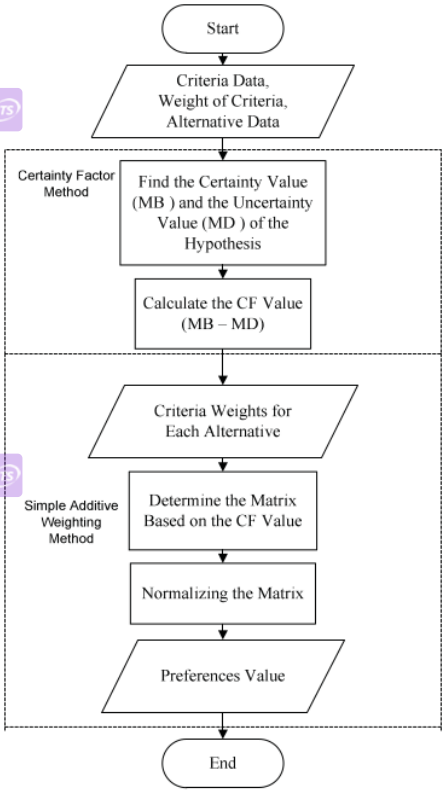

Fig. 1. Decision Making with CF and SAW

The steps of the proposed method as illustrated in the flowchart above can be described as follows:

- Determine the value of sub-criteria and the weight of each in the form of MB and MD values
- Calculate the value of CF (H.E) for each alternative based on criteria
- Determine the criteria weights by subtracting the value MB(H. E) with the value of MD (H, E)

- Determine the suitability rating in the form of an X matrix
- Normalized the X matrix by calculating the value of the performance rating (r_{ij})
- Make the ranking process for each alternative by multiplying the weight value with the value of the performance rating which has been normalized.

III. Results and Discussion

In this section will be done the decision-making process about the citizens who are entitled to receive the help of house surgeon of the Deli Serdang Regency Housing and Settlements Department using the SAW method. Where the weight of each assessment criteria for each alternative (A_i) will be calculated using the CF method and the ranking will be calculated using the SAW method.

A. Criteria

The criterion (C_i) in selecting the best alternative that is suitable to receive house renovation assistance can be seen in Table 1 below:

TABLE I. CRITERIA

Code	Criteria	Attribute	Weight
C1	Income	Benefit	25 %
C2	Family dependent	Benefit	25 %
C3	House Conditions	Benefit	35 %
C4	Asset ownership	Benefit	15 %

B. Sub-Criteria

Each criterion has sub-criteria (HK_i) and has weight as the basis for determining the rank of each alternative. Weights of sub-criteria consist of the value of MB and the value of the MD that will be used as weighting criteria for alternative

TABLE II. SUB-CRITERIA

C_i	Sub-Criteria (HK_i)		Weight	
	Code	*Description*	*MB*	*MD*
C1	HK1	Have a permanent job and income less than Rp.1,000,000	0.9	0.02
	HK2	Do not have a permanent job and income is smaller than Rp.1,000,00	1	0.01
	HK3	Have a permanent job and income between Rp.1,000,000 to Rp.2,000,000	0.7	0.03
	HK4	Does not have a permanent job and income between Rp. 1,000,000 to Rp.2,000,000	0.8	0.02
	HK5	Have a permanent job and income greater than Rp. 2,000,000 up to Rp.3,000,000	0.5	0.02
	HK6	It does not have a permanent job and income is greater than Rp. 2,000,000 up to Rp. 3,000,000	0.6	0.03
	HK7	Have a permanent job and income greater than Rp.3,000,000	0.3	0.05
	HK8	Does not have a permanent job and income is greater than Rp.3,000,000	0.4	0.04
C2	HK9	Have dependents of children with college university status	0.9	0.01
	HK10	Have dependents of children who are in elementary school, junior high or high school	0.8	0.01
C3	HK11	Have dependents of children with disabilities	0.9	0.02
	HK12	Do not have dependents of school children	0.3	0.02
	HK13	Have a house other than the one occupied	0.3	0.01
	HK14	Do not have a house other than the one occupied	0.6	0.02
	HK15	The house occupied is privately owned and livable	0.5	0.03
	HK16	The house is privately owned and is quite livable	0.7	0.02
	HK17	The house is privately owned and is not livable	0.9	0.01
C4	HK18	Have assets in the form of houses other than occupied	0.3	0.05
	HK19	Own assets in the form of land with leased status	0.5	0.04
	HK20	Own land assets with idle land status	0.6	0.03
	HK21	Renting land for self-management	0.7	0.02
	HK22	Do not have land assets	0.9	0.01

C. Case Study

In a case of selection the citizens (acting as an alternative/ Ai) who are eligible to receive house renovation assistance from the government based on the following assessment:

TABLE III. CASE STUDY

Alternative	C_i→HK_i	MB	MD
A1	C1→HK1	0.9	0.02
	C2→HK9	0.9	0.01
	C2→HK10	0.8	0.01
	C3→HK14	0.6	0.02
	C3→HK17	0.9	0.01
	C4→HK22	0.7	0.02
A2	C1→HK1	0.9	0.02
	C2→HK10	0.8	0.01
	C2→HK11	0.9	0.02
	C3→HK16	0.7	0.02
	C4→HK21	0.6	0.03
A3	C1→HK4	0.8	0.02
	C2→HK11	0.9	0.02
	C3→HK15	0.5	0.03
	C4→HK21	0.7	0.02
A4	C1→HK6	0.6	0.03
	C2→HK9	0.9	0.01
	C2→HK11	0.9	0.02
	C2→HK12	0.3	0.02
	C3→HK17	0.9	0.01
	C4→HK21	0.7	0.02

Based on the facts about the alternatives above, the steps taken are to calculate the value of CF using formula 3 and then the final weight of each criterion for each alternative is determined using formula 4 with the following results:

1. CF Value for Alternatives 1 (A1)

TABLE IV. CF VALUE FOR ALTERNATIVE 1 (A1)

Alternative	Criteria			
	C1	*C2*	*C3*	*C4*
A1	0.88	0.9601	0.9302	0.68

2. CF Value for Alternatives 2 (A2)

TABLE V. CF VALUE FOR ALTERNATIVE 2 (A2)

Alternative	Criteria			
	C1	*C2*	*C3*	*C4*
A2	0.88	0.9502	0.68	0.57

3. CF Value for Alternatives 3 (A3)

TABLE VI. CF VALUE FOR ALTERNATIVE 3 (A3)

Alternatif	Criteria			
	C1	*C2*	*C3*	*C4*
A3	0.78	0.88	0.47	0.68

4. CF Value for Alternatives 4 (A4)

TABLE VII. CF VALUE FOR ALTERNATIVE 4 (A4)

Alternative	Criteria			
	C1	*C2*	*C3*	*C4*
A4	0.57	0.943796	0.89	0.68

Based on the calculations have been done above, then the next step is to perform ranking using SAW method with the following steps:

1. Criteria Value Of Each Alternative

TABLE VIII. VALUE OF ALL CRITERIA

Alternative	Criteria			
	C1	*C2*	*C3*	*C4*
A1	0.88	0.9601	0.9302	0.68
A2	0.88	0.9502	0.68	0.57
A3	0.78	0.88	0.47	0.68
A4	0.57	0.943796	0.89	0.68

2. The Suitability Rating Matrix X

$$X = \begin{Bmatrix} 0.88 & 0.9601 & 0.9302 & 0.68 \\ 0.88 & 0.9502 & 0.68 & 0.57 \\ 0.78 & 0.88 & 0.47 & 0.68 \\ 0.57 & 0.943796 & 0.89 & 0.68 \end{Bmatrix}$$

3. Normalization of Matrix X

$$X = \begin{Bmatrix} 1 & 1 & 1 & 1 \\ 1 & 0.989 & 0.731 & 0.838 \end{Bmatrix}$$

0.886 0.916 0.505 1
0.647 0.983 0.956 1

4. Ranking

The next step will be made by the matrix W * R multiplication and addition of the product to get the best alternative. W value is a percentage value of the weight of each specified assessment criteria (C1 = 25%, C2 = 25%, C3 = 35%, C4 = 15%) then the value of W = (0.25; 0.25; 0.35; 0.15) and the calculation is as follows:

TABLE IX. PREFERENCES VALUE

Rank	Alternative	Value
1	A1	1
2	A4	0.8921
3	A2	0.8788
4	A3	0.7772

Preference values that have been obtained as in the table above can be explained that A1 has the highest value i.e. 1 followed by A4, A2, and A3 with each value of 0.8921, 0.8788 and 0.7772. Then the citizens have the right to receive house renovation assistance is dependent on the amount of budget allocated by the government of Deli Serdang Regency at home surgery program. If the budget is sufficient, then do not close the possibility of all alternatives to get such assistance.

From the results of the experimental above can be drawn some important points about decision-making by Simple Additive Weighting method where the weights of criteria are determined using Certainty Factor method, have resulted in the value of the preferences which is more detailed and varied so that it will simplify the decision making. Weights of sub-criteria which is to be the value of MB and MD will depend heavily on the value given. Criteria, sub-criteria, and weights MB and MD are not the same for each case. Because it relies on the type of decisions taken and regulations made by the decision-makers.

IV. CONCLUSION

The results of the above research can be concluded that the combination method CF and SAW managed to get the best alternative from several alternatives where an alternative A1 has the value of preference is 1, A4 has a value of 0.8921, A2 has a value of 0.8788 and A3 has a value of 0.7772. The value of each alternative depends on the sub-criteria that have been set and also relies on the fact-the fact owned such an alternative. The utilization of the method of Certainty Factor in determining the weight of criteria in the case of decision-making has managed to get the value of preferences is detailed and varied so that decision making becomes more easy to do. This is very helpful to decision-makers if there is an alternative that has almost the same value and the number of alternatives that a lot. The determination of the weights of the subcriteria is dependent on the parties who make the rules of assessment so that each case or each time could these values change depending on the conditions of the problem at hand.

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Missing "," You may need to place a comma after this word.

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Article Error You may need to use an article before this word.

Prep. You may be using the wrong preposition.

P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.

Article Error You may need to use an article before this word.

Article Error You may need to use an article before this word.

Article Error You may need to remove this article.

Frag. This sentence may be a fragment or may have incorrect punctuation. Proofread the sentence to be sure that it has correct punctuation and that it has an independent clause with a complete subject and predicate.

Article Error You may need to use an article before this word. Consider using the article **the**.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

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S/V This subject and verb may not agree. Proofread the sentence to make sure the subject agrees with the verb.