Comparison of SMART and SAW Methods in Decision Making

Berti Sari Br Sembiring¹, Muhammad Zarlis¹, Sawaluddin¹, Alfian Agusnady¹, Titin Qowidho¹
¹ Department of Information Technology, Faculty of Computer Science and Information Technology, Universitas Sumatra Utara, Medan - Indonesia

* bertisari0@gmail.com

Abstract. In this study using a comparative analysis of SMART and SAW methods. The results of the SAW method calculation analysis have a faster processing time with a time of 0.40 s. While the SMART method calculation analysis has a longer processing time difference of 0.47 s. In this study the authors suggest using the SMART method. Where the process of calculating the SMART method has more varied results, because the criteria value between one candidate and another candidate influences each other. While the calculation of the SAW method results are less varied, because the criteria value between one candidate and another candidate does not affect each other. Weighting is done without an algorithm. In this study the authors suggest using the SMART method because there is a final value of <60 is not feasible given the provision of venture capital.

1. Introduction

Social carbuncle is an executive element of local government in the social sphere, granting free grants and venture capital to small business actors is very vulnerable to being misused and not given to people who really need it. To overcome this, a decision-making system is needed that can assist the Office of Social Affairs in providing business capital to the public to be right on target. Therefore a decision-making system is needed.

In this study the author tries to analyze the SMART method and SAW in a decision making. SAW (Simple Additive Weighting) technique is one of the most used Multi-Attribute Decision Making (MADM) techniques [1]. It is used to determine the best alternative from many alternatives. The stages used in this research were as follows [2]. Simple Multi Attribute Rating Technique (SMART) is a multi criteria decision making method based on theory that each alternative consists of a number of criteria that have values and each criterion has weight to illustrate how important the value is compared to other criteria [3]. Many branches of computer science can solve complex problems. This is evidenced by several studies in the field of datamining [4][5], field of artificial neural networks [6]–[8], etc.

2. Methodology

Applying the Simple Additive Weighting method in monitoring forest health, this study aims to be able to analyze and as an intelligent decision maker. The results of his research show that the model applied is able to help determine the level of health of urban forests [2].

Applying the AHP method and SAW in decision making. In his research the AHP method for the weighting process and the SAW method for the decision making process. Analysis finds consistent
results that are sufficient to determine the best based on all available alternatives [9]. Applying a simple additive weighting method using numeric to determine scholarship recipients. The results are obtained by looking for the weight value of each attribute, then ranking the optimal score for each alternative. Finally, this method can be used in this case study [10].

This study compared the AHP and SMART methods in decision making. The results showed that the SMART method is generally better than the AHP, particularly in an election in which a large number of alternatives and selection criteria [11].

a. SMART algorithm

SMART uses linear adaptive models to predict the value of each alternative. SMART is a flexible decision-making method. SMART is more widely used because of its simplicity in responding to the needs of decision makers and the way it analyzes responses [12].

Edwards defines there are several steps in solving the SMART method, namely:

1. Identifying decision problems. Definition of the problem must be done to find the root of the problem and the limitations that exist. The definition of a decision maker (decision maker) is done so that the value of the criteria can be in accordance with the interests of these criteria for alternatives.
2. Identify the criteria used in making decisions.
3. Identify alternatives to be evaluated. At this stage the data collection process will be carried out.
4. Identify relevant criteria for alternative assessment. Need to limit values. This can be achieved by eliminating less important goals.
5. Ranks the position of criteria interests. This needs to be done to be able to give weight to each criterion. Because the weight given to the criteria will depend on ranking criteria.
6. Give weight to each criterion. Giving weight is given with a value that can be determined by the user himself. In this case weighting will be carried out based on criteria that are considered the most important and based on criteria that are considered the least important.
7. Calculate normalization of criteria weight. The weight obtained will be normalized where the weight of each criterion obtained will be shared with the results of each criteria weight.

\[
\text{nw}_j = \frac{w_j}{\sum_{n=1}^{k} w_n} 
\]

Information:
- \(w_j\) = normalization of the jth criteria weight.
- \(w_j\) = the weight of the criteria to be calculated.
- \(k\) = number of criteria.
- \(w_n\) = weight of the nth criteria.

8. Develop single-attribute utilities

This stage is to give a value to all criteria for each alternative. In this field an expert estimates alternative values on a scale of 0-100. Where 0 is the minimum value and 100 is the maximum value.

\[
u_{ij} = 100 \left( \frac{c_{\text{max}} - c_{\text{out}}} {c_{\text{max}} - c_{\text{min}}} \right) \]

- \(u_{ij}\) = alternative utility value i in criterion j.
- \(c_{\text{max}}\) = maximum sub criteria value.
- \(c_{\text{min}}\) = minimum sub criteria value.
- \(c_{\text{out}}\) = value of criteria i.

9. Calculate the appraisal / utility for each alternative Calculation is done using SMART.
10. Decide

The utility value of each alternative will be obtained from step 9. If a single alternative is to be selected, then choose the alternative with the highest utility value [12].
b. Algorithm SAW

SAW (Simple Additive Weighting) technique is one of the most used Multi-Attribute Decision Making (MADM) techniques [1]. Simple Additive Weighting (SAW) is one method that can be used to solve the problem of MADM (Multi Attribute Decision Making). The basic concept of the SAW method is to find the weighted sum of performance ratings on each alternative on all attributes. The SAW method requires the decision matrix normalization process (X) to a scale that can be compared with all available alternative ratings.

\[
    r_{ij} = \begin{cases} 
    \frac{x_{ij}}{\max x_{ij}} & \text{if } J \text{ is the attribute of profit (benefit)} \\
    \frac{\min x_{ij}}{x_{ij}} & \text{if } j \text{ is attribute cost (cost)}
    \end{cases}
\]

Where \( r_{ij} \) is a normalized performance rating from alternative \( A_i \) in attribute \( C_j; i = 1,2,3, ..., m \) and \( j = 1,2,3, ..., n \). The preference value for each alternative \( V_i \) is given as:

\[
    V_i = \sum_{j=1}^{n} w_j r_{ij}
\]

Steps for completing the SAW method:
1. Determine the criteria that will be used as a reference in decision making.
2. Determine the suitability rating of each alternative on each criterion.
3. Make a decision matrix based on criteria, then normalize the matrix based on the equation adjusted for the type of attribute (profit attribute or cost attribute) so that a normalized matrix is obtained. The final result is obtained from the ranking process which is the sum of normalized matrix \( R \) multiplication with the weight vector so that the greatest value is chosen as the best alternative as a solution [13]

3. Results and Discussion

In this study the author will analyze the SMART method and SAW in the decision-making process, especially in the provision of business capital of the North Sumatra social service office. In making decisions using the SMART method and SAW, criteria, sub criteria and weights have been determined by the North Sumatra social service. The following are criteria, sub criteria and weights variables for each assessment.

2 – 4 Million (75)
> 4 Million (50)

Criteria
NPWP (60)

Complete (100)
Incomplete (50)

Type of Business (50)

Small (100)
Large (75)
Macro (50)

Saving Account (45)

Complete (100)
Incomplete (50)

Business Licensse (30)

Complete (100)
Incomplete (50)

explanation:
C1 = Document Legality
C2 = NPWP
C3 = Type of Business
C4 = Income
C5 = Saving Account
C6 = Business Licensse

In the next step, the process of calculating the SMART method is shown in table 1. As for the calculation table, it displays the ID, Name, and criteria, the final value, results, and processing time of the SMART method calculation.
Table 1. SMART Method Results

| ID    | Name  | C1  | C2  | C3  | C4  | C5  | C6  | Final Score | Result | Time  |
|-------|-------|-----|-----|-----|-----|-----|-----|-------------|--------|-------|
| AL-0001 | Ahmad | 0.21 | 0.19 | 0.09 | 0.09 | 0.00 | 0.00 | 0.58        | N      |       |
| AL-0002 | Budiman | 0.21 | 0.00 | 0.09 | 0.17 | 0.16 | 0.10 | 0.73        | Y      |       |
| AL-0003 | Charlie | 0.21 | 0.19 | 0.00 | 0.09 | 0.16 | 0.10 | 0.75        | Y      |       |
| AL-0004 | Dedy | 0.21 | 0.00 | 0.17 | 0.17 | 0.00 | 0.00 | 0.55        | N      |       |
| AL-0005 | Erlangga | 0.21 | 0.19 | 0.09 | 0.09 | 0.16 | 0.10 | 0.84        | Y      | 0.47 s |
| AL-0006 | Febry | 0.00 | 0.00 | 0.17 | 0.17 | 0.00 | 0.00 | 0.34        | N      |       |
| AL-0007 | Gilang | 0.21 | 0.00 | 0.09 | 0.00 | 0.16 | 0.10 | 0.56        | N      |       |
| AL-0008 | Hany | 0.00 | 0.00 | 0.17 | 0.09 | 0.16 | 0.10 | 0.52        | N      |       |
| AL-0009 | Indra | 0.21 | 0.19 | 0.17 | 0.17 | 0.00 | 0.00 | 0.90        | Y      |       |
| AL-0010 | Jeriko | 0.21 | 0.00 | 0.09 | 0.17 | 0.16 | 0.10 | 0.73        | Y      |       |

N = Not Worthy of Providing Business Capital
Y = Eligible for Business Capital

Advantages:
The results are more varied, because the criteria between one candidate and another candidate influence each other.

Deficiencies:
- Execution time is longer.
- Weighting is done without algorithms.

In Table 1 the results are shown by the calculation of the SMART method using 10 data, based on assessment with pre determined criteria, where the final value varies with the processing time of 0.47 s.

Table 2. SAW Method Results

| ID    | Name  | C1  | C2  | C3  | C4  | C5  | C6  | Final Score | Result | Time  |
|-------|-------|-----|-----|-----|-----|-----|-----|-------------|--------|-------|
| AL-0001 | Ahmad | 0.21 | 0.19 | 0.13 | 0.13 | 0.08 | 0.05 | 0.79        | Y      |       |
| AL-0002 | Budiman | 0.21 | 0.10 | 0.13 | 0.17 | 0.16 | 0.10 | 0.87        | Y      |       |
| AL-0003 | Charlie | 0.21 | 0.19 | 0.09 | 0.13 | 0.16 | 0.10 | 0.88        | Y      |       |
| AL-0004 | Dedy | 0.21 | 0.10 | 0.17 | 0.17 | 0.08 | 0.05 | 0.78        | Y      |       |
| AL-0005 | Erlangga | 0.21 | 0.19 | 0.13 | 0.13 | 0.16 | 0.10 | 0.92        | Y      |       |
| AL-0006 | Febry | 0.11 | 0.10 | 0.17 | 0.17 | 0.08 | 0.05 | 0.68        | Y      | 0.40 s |
| AL-0007 | Gilang | 0.21 | 0.10 | 0.13 | 0.09 | 0.16 | 0.10 | 0.79        | Y      |       |
| AL-0008 | Hany | 0.11 | 0.10 | 0.17 | 0.13 | 0.16 | 0.10 | 0.77        | Y      |       |
| AL-0009 | Indra | 0.21 | 0.19 | 0.17 | 0.17 | 0.16 | 0.05 | 0.95        | Y      |       |
| AL-0010 | Jeriko | 0.21 | 0.10 | 0.13 | 0.17 | 0.16 | 0.10 | 0.87        | Y      |       |

N = Not Worthy of Providing Business Capital
Y = Eligible for Business Capital

Advantages: Faster execution time.

Shortcomings:
- The results are less varied, because the criteria value between one candidate and another candidate does not affect each other.
- Weighting is done without an algorithm.

Furthermore, in Table 2 the results are shown by the calculation of the SAW method using 10 data, based on the assessment with predetermined criteria, where the final value varies with the processing time of 0.40 s.

Explanation:
IF FINAL SCORE <0.60 THEN "N"
ELSE "Y"

Next is a graph of the final results from the comparison of the SMART and SAW methods, as shown in figure 1.

Explanation:
IF FINAL SCORE < 0.60 THEN "N"
ELSE "Y"

Next is the graph of the final results from the comparison of SMART and SAW methods, as shown in figure 1.

![Figure 1. The results of the comparison between SMART and SAW methods](image)

In figure 1 it can be seen that the comparison of SMART and SAW methods uses 10 data where the final result as the same value as the highest value of 0.90, and the lowest value produces the same value with the lowest value of 0,60. From the calculation of the SMART and SAW method with the provision of <60 is not feasible shown in table 1, and table 2. In this study the authors suggest using the SMART method because there is a final value of <60 is not feasible given the provision of venture capital.

4. Conclusion
In this study using a comparative analysis of SMART and SAW methods. The results of the SAW method calculation analysis have a faster processing time (see table 2). While the SMART method calculation analysis has a longer processing time difference (see table 2). In this study the authors suggest using the SMART method. Where process calculation method SMART has more varied, because the value of criteria between one candidate with another candidate mutually influential. While the calculation of the SAW method is less varied, because the criteria value between one candidate and another candidate does not affect each other. Weighting is done without an algorithm. In this study the authors suggest using the SMART method because there is a final value of <60 is not feasible given the provision of venture capital.

References
[1] Muhammad Sam’an, et al, 2018, A Modified Algorithm For Full Fuzzy Transportation Problem With Simple Additive Weighting, International Conference On Information and Comunications Technology (ICOIACT).
[2] Andri Pranolo, et al, 2014, Simple Additive Weighting Method on Intelligent Agent for Urban Forest Health Monitoring, International Conference on Computer, Control, Informatics and Its Application.
[3] Tiga Magrisa, et al 2018, Implementasi Metode SMART Pada Sistem Pendukung Keputusan Pemilihan Kegiatan Ekstrakurikuler Untuk Siswa SMA, Informatika Mulawarman : Jurnal Ilmiah Ilmu Komputer.
[4] S. Sudirman, A. P. Windarto, and A. Wanto, “Data Mining Tools | RapidMiner: K-Means Method on Clustering of Rice Crops by Province as Efforts to Stabilize Food Crops In Indonesia,” *IOP Conference Series: Materials Science and Engineering*, vol. 420, no. 12089, pp. 1–8, 2018.

[5] H. Siahaan, H. Mawengkang, S. Efendi, A. Wanto, and A. P. Windarto, “Application of Classification Method C4.5 on Selection of Exemplary Teachers,” in *IOP Conference Series*, 2018, pp. 1–6.

[6] B. Febriadi, Z. Zamzami, Y. Yunefri, and A. Wanto, “Bipolar function in backpropagation algorithm in predicting Indonesia’s coal exports by major destination countries,” *IOP Conference Series: Materials Science and Engineering*, vol. 420, no. 12089, pp. 1–9, 2018.

[7] N. Nasution, A. Zamsuri, L. Lisnawita, and A. Wanto, “Polak-Ribiere updates analysis with binary and linear function in determining coffee exports in Indonesia,” *IOP Conference Series: Materials Science and Engineering*, vol. 420, no. 12089, pp. 1–9, 2018.

[8] A. Wanto, M. Zarlis, Sawaluddin, and D. Hartama, “Analysis of Artificial Neural Network Backpropagation Using Conjugate Gradient Fletcher Reeves in the Predicting Process,” *Journal of Physics: Conference Series*, vol. 930, no. 1, pp. 1–7, 2017.

[9] Afrianda Cahyapratama, at al, 2018, Application of Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) Methods In Singer Selection Process. International Conference on Information and Communications Technology (ICOIACT).

[10] Irvanizam, 2017, Multiple Attribute Decision Making With Simple Additive Weighting Approach for Selecting the Scholarship Recipients at Syiah Kuala University. International Conference on Electrical Engineering and Informatics (ICELTICs).

[11] C. S. Yap, et al, Methods for Information System Project Selection: An Experimtal Study of AHP and SMART.

[12] Faizal, et al., 2017, “Implementasi Sistem Pendukung Keputusan dengan Metode SMART untuk Meranking Kemiskinan dalam Proses Penentuan Penerima Bantuan PKH”, Jurnal Coding Sistem Komputer Untan, Volume 05, No.2 2017.

[13] Dhani Ratna Sari, et al., 2014, “Sistem Pendukung Keputusan Kelompok Untuk Menentukan Dosen Berprestasi Menggunakan Metode Simple Additive Weighting (SAW) dan Copeland Score (Studi Kasus : Universitas Muhammadiyah Purwokerto)”, Techno, Volume 15 No 1 April 2014.