Hybridization Fuzzy Simple Additive Weighting and Electre in Recipient Selection of Subsidized Rice

Putu Gede Pakusadewa
Department of Information Technology Management
Institut Teknologi Sepuluh Nopember
gede.pakusadewa@gmail.com

Riyanarto Sarno
Department of Informatics
Institut Teknologi Sepuluh Nopember
riyanarto@if.its.ac.id

Kelly Rossa Sungkono
Department of Informatics
Institut Teknologi Sepuluh Nopember
kelly@its.ac.id

***Abstract*— The subsidized rice is government assistance for families with low-income. But in its implementation, there are several problems such as the complexity of selecting data from low-income families and human error that make families with good income also get subsidized rice. This study uses fuzzy Simple Additive Weighting (F-SAW) combined with Elimination Et Choix Traduisant La Realite (ELECTRE) methods for selecting a low-income family. The first step is converting prospective recipient data into fuzzy values. Then, this study normalizes data by using the Simple Additive Weighting method. The normalized data processed using the ELECTRE method to sort out the prospective recipients of subsidized rice. The results showed that the first chosen subsidized recipient of rice with the value e_kl = 1 is CP3.**

Keywords—decision support systems; ELECTRE; fuzzy SAW; RASKIN

I. INTRODUCTION

Subsidized rice for low-income families or RASKIN is part of the government program in poverty reduction and social protection [1]. The RASKIN program began in 1998 to help the low-income families in the form of rice allowances. In distributing rice assistance, there are some difficulties in screening RTS (targeted households) due to varied RTS data [2]. Other problem is households that are classified as prosperous family even get the RASKIN [3].

Based on these problems, a decision support system (DSS) method is needed in selecting RASKIN recipients to be more effective. Research by Sagar (2013) discusses DSS with fuzzy Simple Additive Weighting (F-SAW) method for factory maintenance plan [4]. The conclusion of this research is F-SAW can be implemented for DSS in determining plant equipment maintenance strategies. Another DSS study was conducted by Mesran (2017). In this study, Mesran used the Elimination Et Choix Traduisant La Realite (ELECTRE) method for selection best lecturer at STMIK BUDI DARMA [5]. The conclusion of Mesran research is the ELECTRE method can selecting the list of prospective lecturers to become the best lecturers. The next DSS study was carried out by Kaya (2011) with research assessing environmental impacts in the industrial area of Istanbul, Republic of Turkey [6]. The research from Kaya uses the Fuzzy Analityc Hierarchy Process with ELECTRE method. This research ranks three industrial areas in Istanbul with the worst level of industrial environmental impact in accordance with regional rehabilitation plans in the design of the Istanbul metropolitan city in 2006.

From the explanation of the related research, method that is considered capable of overcoming the problem of decision making for the recipient of RASKIN assistance is fuzzy hybridization SAW and ELECTRE. The final results of this study are in the form of a decent rating to the ineligible candidates for the RASKIN program.

The study consisted of 7 sections where section 1 outlines the research background, sections 2 to 4 describe the basis of applied theory, section 5 describes the stages of completion of the research method, section 6 discusses the results of the test, and section 7 outlines the conclusions and suggestions.

II. FUZZY LOGIC

Fuzzy logic is a logic that can expand the value of truth and errors, not just true (1) or wrong (0). So that it can be considered fuzzy logic has an uncertain value between right or wrong. This means that a value can be true and false if using fuzzy logic [7]. Fuzzy logic can process qualitative and quantitative data in its calculations [8]–[13]. The level determination of truth or error of a value according to the weight of membership used. Values in membership degrees in intervals of 0 to 1.

III. SIMPLE ADDITIVE WEIGHTING

Simple Additive Weighting is a method to overcome problem that related with Multiple Attribute Decision Making (MADM) [14]. The stages completion of the SAW method according to Setyania (2016) are as follows [15]:

1. Define the criteria of alternatives and determine the alternative solutions sought.
2. Determine the value of the suitability rating between the alternative and the problem criteria.
3. Determine the weight value of the importance of all criteria according to the Equation (1).

$$W = \{w_1, w_2, w_3, \dots, w_j\} \quad (1)$$

where: W is weight value of the importance and j is number of criteria.

978-1-7281-3832-9/19/$31.00 ©2019 IEEE

4. Make a decision matrix according to the Equation (2).

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

where: X is decision matrix, x_{mn} is value on each matrix element, m is total amount of alternative, n is total amount of criteria.

5. Normalize the values of positive and negative criteria in the decision matrix. If the matrix criteria are positive (j) then normalization using the Equation (3). If the matrix criteria are negative (i) then normalization using the Equation (4).

$$R_{ij} = \frac{x_{ij}}{max\{x_{ij}\}} \quad (3)$$

$$R_{ij} = \frac{min\{x_{ij}\}}{x_{ij}} \quad (4)$$

where: R_{ij} is normalized element value, x_{ij} is matrix element value, $max\{x_{ij}\}$ is maximum value of the criteria element, $min\{x_{ij}\}$ is minimum value of the criteria element, i is total amount of alternative, j is total amount of criteria.

6. Sum the priority values or preferences of all alternatives according to the Equation (5).

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

where: V_i is alternative ranking value, w_j is the weight value of criteria importance, r_{ij} is normalized matrix element value, i is total amount of alternative, j is total amount of criteria.

IV. ELIMINATION ET CHOIX TRADUISANT LA REALITE

ELECTRE is an algorithm to find solutions to problems that involve the MADM. The concept of the ELECTRE method is eliminate alternatives that are not suitable so the best alternative or solution can be generated. The steps for completing the ELECTRE method are as follows [16]:

1. Normalizing the value of the decision matrix element. Completion of this stage uses the Equation (6). While the results of the normalization stage will be a matrix according to the Equation (7).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (6)$$

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1j} \\ r_{21} & r_{21} & \dots & r_{2j} \\ \vdots & \vdots & & \vdots \\ r_{i1} & r_{i2} & \dots & r_{ij} \end{bmatrix} \quad (7)$$

where: R is matrix with normalized elements r_{ij} is value on each matrix element, i is 1, 2, 3, …, n., j is 1, 2, 3, …, m., n is total amount of alternatives and m is total amount of criteria.

2. Make a V matrix. This step started with multiplying the R matrix with the weight of criteria (w_j) that have been predetermined. The V matrix calculations based on the Equation (8).

$$V = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \dots & w_j r_{1j} \\ w_1 r_{21} & w_2 r_{21} & \dots & w_j r_{2j} \\ \vdots & \vdots & & \vdots \\ w_j r_{i1} & w_j r_{i2} & \dots & w_j r_{ij} \end{bmatrix} \quad (8)$$

$$V = \begin{bmatrix} v_{11} & v_{12} & \dots & v_{1j} \\ v_{21} & v_{21} & \dots & v_{2j} \\ \vdots & \vdots & & \vdots \\ v_{i1} & v_{i2} & \dots & v_{ij} \end{bmatrix}$$

where: w_j is the weight of criteria.

3. Calculates the value of concordance and discordance. These stages begin by dividing the criteria group j from the alternative pairs k and l; $(k, l = 1, 2, 3, \dots, n$ and $k \neq l)$. These groups are changed into concordance and discordance. The criteria are categorized as concordance if:

$$c_{kl} = \{j, v_{kj} \geq v_{ij}\} \quad (9)$$

where: c_{kl} is the value in row k and row l.
While the criteria are categorized as discordance if:

$$d_{kl} = \{j, v_{kj} < v_{ij}\} \quad (10)$$

where: d_{kl} is the value in row k and row l.

4. Determining the concordance matrices and discordance. The step of determining the C matrix or concordance matrix begins by calculating the weights (w_j) in the concordance set according to the Equation (10).

$$C_{kl} = \sum_{j \in C_{kl}} w_j \quad (10)$$

where: C_{kl} is the value of concordance matrix element.

While the step of determining the D matrix or discordance matrix is based on Equation (11).

$$D_{kl} = \frac{max\{|v_{kj} - v_{ij}|\}\ j \in D_{kl}}{max\{|v_{kj} - v_{ij}|\}\ \forall_j} \quad (11)$$

where: D_{kl} is the value of discordance matrix element.

5. Calculates the value of dominant concordance and discordance matrices. Calculation of concordance dominant matrix or F matrix is done by comparing the threshold value with the matrix concordance element according to Equation (12). Equation (13) is used to find the threshold value.

$$c = \frac{\sum_{k=1}^{p}\sum_{k=1}^{p} c_{kl}}{p(p-1)} \quad (12)$$

where: c is the threshold value and p is number of altervative.

$$f_{kl} = \begin{matrix}1, jika\ c_{kl} \geq c\\ 0, jika\ c_{kl} < c\end{matrix} \quad (13)$$

where: f_{kl} is matrix element of dominant concordance.
While the calculation of dominant discordance matrix or G matrix is done by comparing the threshold value with the discordance matrix element according to the Equation (14). Equation (15) is used to find the threshold value.

$$d = \frac{\sum_{k=1}^{p}\sum_{k=1}^{p} d_{kl}}{p(p-1)} \quad (14)$$

where: d is the threshold value and p is number of altervative.

$$g_{kl} = \begin{matrix}0, jika\ d_{kl} \geq d\\ 1, jika\ d_{kl} < d\end{matrix} \quad (15)$$

where: g_{kl} is matrix element of dominant concordance.

6. Calculate the aggregate value of the matrix dominance. The A matrix as an aggregate dominance matrix is determined by multiplying the F matrix with the G matrix according to Equation (16).

$$e_{kl} = f_{kl} \times g_{kl} \quad (16)$$

where: e_{kl} is matrix element of aggregate dominance.

V. METHOD

The stages in this study based on the flow diagram in Fig. 1. The first method in this study is Fuzzy SAW. First, determining the compatibility rating of each alternative. Then, converting fuzzy values to rating matches rated crips. The last step of Fuzzy SAW is normalizing the decision matrix. After that, ELECTRE is used. First, normalizing the matrix weighting. Then, calculating the set of the concordance and discordance. After that, calculating the dominant concordance and discordance and matrix. Then, calculating the aggregate dominance matrix. Finally, doing alternative elimination.

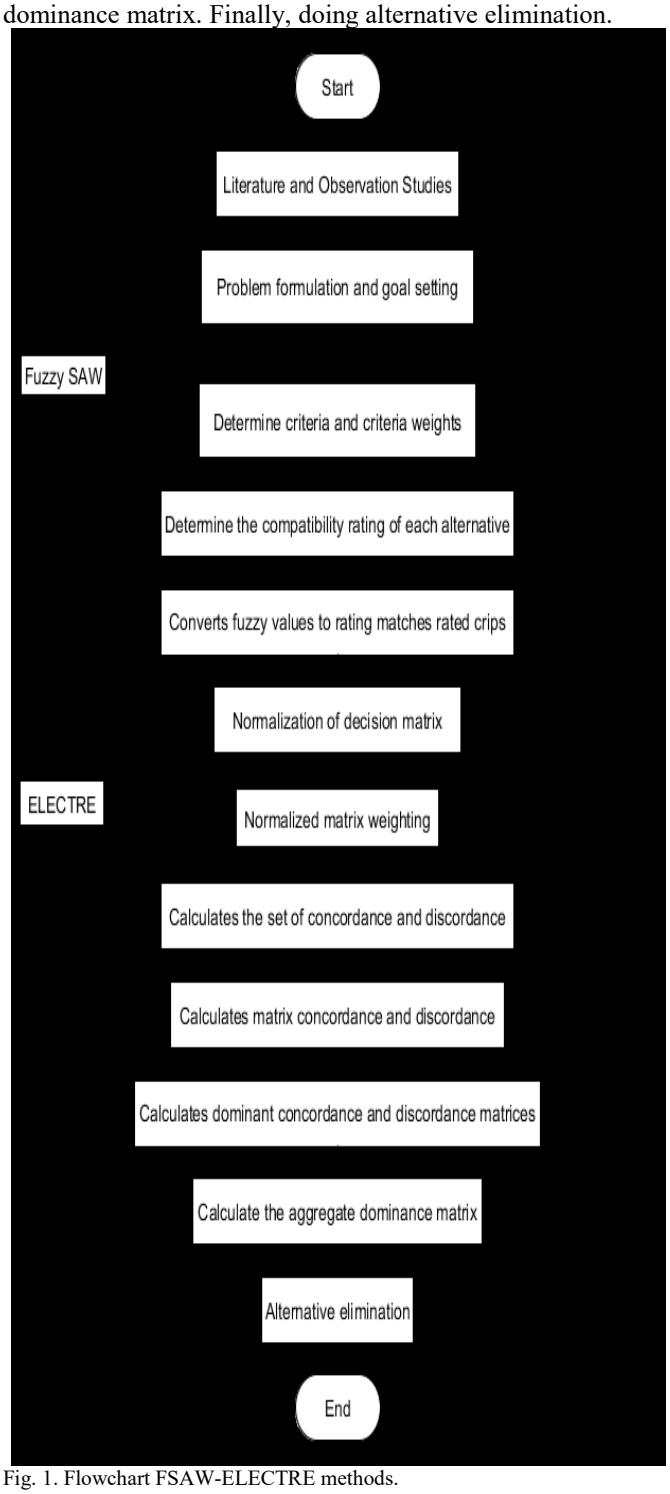

Fig. 1. Flowchart FSAW-ELECTRE methods.

VI. RESULT AND DISCUSSION

In this testing phase, the criteria used in selecting RTS are frequency of daily meals (K1), frequency of eating meat or chicken or milk (K2), monthly income (K3), number of dependents (K4), house ownership status (K5) and health

facilities (K6), while the weights for fuzzy numbers are in accordance with TABLE I. Based on TABLE I, the weighting criteria are in accordance with Table II until TABLE VII.

TABLE I. FUZZY WEIGHTS

Status	Score
Very Good (SB)	0.2
Good (B)	0.4
Enough (C)	0.6
Less (K)	0.8
Very Less (SK)	1
Some (B1)	0.8
Too Much (SB1)	1

TABLE II. FUZZY WEIGHTING K1

Frequency of daily meals	Score	Status
>3	0.2	SB
3	0.6	B
2	0.8	C
1	1	K

TABLE III. FUZZY WEIGHTING K2

Frequency of eating meat chicken / milk	Score	Status
>3	0.2	SB
3	0.6	B
2	0.8	C
1	1	K

TABLE IV. FUZZY WEIGHTING K3

Monthly income	Score	Status
≥ 1.000.001	0.2	B
750.001 - 1.000.000	0.6	C
500.001 - 750.000	0.8	K
≤ 500.000	1	SK

TABLE V. FUZZY WEIGHTING K4

Number of dependents	Score	Status
0	0.2	SB
1	0.4	B
2	0.6	C
3	0.8	B1
>3	1	SB1

TABLE VI. FUZZY WEIGHTING K5

House ownership status	Score	Status
Own	0.2	B
Not Own	0.6	C
Lease	1	K

TABLE VII. FUZZY WEIGHTING K6

Health facilities	Score	Status
Hospital	0.2	B
Puskesmas	0.6	C
Self-medication	1	K

The next step is to convert a number of data from prospective RASKIN recipients to fuzzy values. The results can be seen in Table VIII. Besides, the criteria weight is shown in Table IX. Then normalized of data in Table VIII based on the SAW algorithm. The normalized data is in TABLE X.

TABLE VIII. DATA FOR PROSPECTIVE RASKIN RECIPIENTS IN FUZZY VALUES

NO	K1	K2	K3	K4	K5	K6
CP1	0.6	0.8	0.6	0.2	0.2	0.6
CP2	0.6	0.6	0.6	0.6	0.6	0.2
CP3	0.8	1	1	0.4	0.2	1
CP4	0.6	0.6	0.6	0.6	0.2	0.6
CP5	0.2	0.2	0.2	0.6	0.2	0.2

TABLE IX. THE CRITERIA WEIGHT

Criteria	Weight
Frequency of daily meals	0.25
Frequency of eating meat chicken / milk	0.25
Monthly income	0.2
Number of dependents	0.15
House ownership status	0.1
Health facilities	0.05

TABLE X. ALTERNATIVE MATRIX DATA NORMALIZED

NO	K1	K2	K3	K4	K5	K6
CP1	0.75	0.8	0.6	0.333	0.333	0.6
CP2	0.75	0.6	0.6	1	1	0.2
CP3	1	1	1	0.667	0.333	1
CP4	0.75	0.6	0.6	1	0.333	0.6
CP5	0.25	0.2	0.2	1	0.333	0.2

The next step is calculation using ELECTRE algorithm. The result of matrix multiplication is shown in Fig. 2.

$$\begin{bmatrix} 0.18750 & 0.2 & 0.12 & 0.05 & 0.0333 & 0.03 \\ 0.1875 & 0.15 & 0.12 & 0.15 & 0.1 & 0.01 \\ 0.25 & 0.25 & 0.2 & 0.1 & 0.0333 & 0.05 \\ 0.1875 & 0.15 & 0.12 & 0.15 & 0.0333 & 0.03 \\ 0.0625 & 0.05 & 0.04 & 0.15 & 0.0333 & 0.01 \end{bmatrix}$$

Fig. 2. ELECTRE matrix multiplication results.

$$\begin{bmatrix} 0 & 1 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Fig. 3. Concordance dominant or F matrix.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig. 4. Dominant discordanceor G matrix.

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Fig. 5. Aggregate dominance matrix.

TABLE XI. ALTERNATIVE MATRIX THAT HAVE BEEN SORTED

Alternative	$e_{kl} = 1$
CP3	4
CP2	3
CP4	2
CP1	1
CP5	0

The last step is to calculate the aggregate dominance matrix value based on Fig. 3 and Fig. 4. Based on Fig. 5, the sequence of RASKIN recipients use the ELECTRE algorithm according to TABLE XI. The process is calculating total number 1 per line then convert it into an alternative series. The alternative series are CP3 as the first candidate, CP2 as the second candidate, CP4 as the third candidate, CP1 as the fourth candidate, and CP5 as the fifth candidate.

VII. CONCLUSION

Based on the results, the FSAW-ELECTRE method can be used to selecting the best candidates for RASKIN. This study uses 6 criteria in the selection process. Based on the experiment, the alternative series are CP3 as the first candidate, CP2 as the second candidate, CP4 as the third candidate, CP1 as the fourth candidate, and CP5 as the fifth candidate. Suggestions for further research can use more criteria so that the selection results are better.

REFERENCES

[1] S. Arif, M. Syukri, R. Holmes, and V. Febriany, *Gendered risks, poverty, and vulnerability: Case study of the Raskin food subsidy program in Indonesia*. SMERU Research Institute, 2012.

[2] S. M. Hastuti, B. Sulaksono, S. D. Akhmadi, and R. P. Artha, *The effectiveness of the Raskin program*. SMERU Research Institute Jakarta, 2008.

[3] N. McCulloch*, "Rice prices and poverty in Indonesia," *Bulletin of Indonesian Economic Studies*, vol. 44, no. 1, pp. 45–64, 2008.

[4] M. K. Sagar, P. Jayaswal, and K. Kushwah, "Exploring fuzzy SAW method for maintenance strategy selection problem of material handling equipment," *International Journal of Current Engineering and Technology*, vol. 3, no. 2, pp. 600–605, 2013.

[5] G. G. Mesran, R. R. Suginam, M. Aan, and R. Rahim, "Implementation of Elimination and Choice Expressing Reality (ELECTRE) Method in Selecting the Best... Implementation of Elimination and Choice Expressing Reality (ELECTRE) Method in Selecting the Best Lecturer (Case Study STMIK BUDI DARMA)," *Int. J. Eng. Res. Technol*, vol. 6, pp. 141–144, 2017.

[6] T. Kaya and C. Kahraman, "An integrated fuzzy AHP--ELECTRE methodology for environmental impact assessment," *Expert Systems with Applications*, vol. 38, no. 7, pp. 8553–8562, 2011.

[7] A. Baykaso\uglu and K. Subulan, "Constrained fuzzy arithmetic approach to fuzzy transportation problems with fuzzy decision variables," *Expert Systems with Applications*, vol. 81, pp. 193–222, 2017.

[8] K. Langsari, R. Sarno, and others, "Optimizing Time and Effort Parameters of COCOMO II Using Fuzzy Multi-objective Particle Swarm Optimization.," *Telkomnika*, vol. 16, no. 5, 2018.

[9] D. Rahmawati and R. Sarno, "Anomaly Detection using Control Flow Pattern and Fuzzy Regression in Port Container Handling," *Journal of King Saud University - Computer and Information Sciences*, Jan. 2019.

[10] S. Huda, R. Sarno, and T. Ahmad, "Fuzzy MADM Approach for Rating of Process-Based Fraud," *Journal of ICT Research and Applications*, vol. 9, no. 2, pp. 111–128, 2015. http://doi.org/10.5614/itbj.ict.res.appl.2015.9.2.1.

[11] R. R. Putri, R. Sarno, D. Siahaan, A. S. Ahmadiyah, and S. Rochimah, "Accuracy improvement of the estimations effort in Constructive Cost Model II based on logic model of fuzzy," *Advanced Science Letters*, vol. 23, no. 3, pp. 2478–2480, 2017.

[12] A. Y. Ardiansyah, R. Sarno, and O. Giandi, "Rain detection system for estimate weather level using Mamdani fuzzy inference system," in *2018 International Conference on Information and Communications Technology (ICOIACT)*, 2018, pp. 848–854.

[13] A. C. Pratama and R. Sarno, "Android Application for Controlling Air Conditioner Using Fuzzy Logic," in *2018 6th International Conference on Information and Communication Technology (ICoICT)*, 2018, pp. 199–204.

[14] A. Cahyapratama and R. Sarno, "Application of Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) Methods In Singer Selection Process," in *International Conference on Information and Communications Technology (ICOIACT) Application*, 2018, no. Mcdm, pp. 234–239.

[15] R. E. Setyani and R. Saputra, "Flood-prone Areas Mapping at Semarang City By Using Simple Additive Weighting Method," *Procedia-Social and Behavioral Sciences*, vol. 227, pp. 378–386, 2016.

[16] P. Kumar, R. K. Singh, and K. Kharab, "A comparative analysis of operational performance of Cellular Mobile Telephone Service Providers in the Delhi working area using an approach of fuzzy ELECTRE," *Applied Soft Computing*, vol. 59, pp. 438–447, 2017.