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Research Paper

Simple Additive Weighting as Decision Support System for Determining Employees Salary

Nashrudin Setiawan[1], M D T P Nasution[1], Yossie Rossanty[1], Anna Riana Suryanti Tambunan[2], Martina Girsang[3], R T A Agus[4], Muhammad Yusuf[5], Rian Vebrianto[6], Oktaviana Nirmala Purba[7], Achmad Fauzi[8], Surya Perdana[9], Khairun Nisa[10]

[1]*Universitas Pembangunan Panca Budi, Medan, Indonesia*
[2]*Department Language Education and English Literature, Universitas Negeri Medan, Medan, Indonesia*
[3]*Universitas Methodist Indonesia, Medan, Indonesia*
[4]*Department of Information System, Sekolah Tinggi Manajemen Informatika dan Komputer Royal, Kisaran, Indonesia*
[5]*Sekolah Tinggi Keguruan dan Ilmu Pendidikan Pelita Bangsa, Binjai, Indonesia*
[6]*Faculty of Tarbiyah and Teaching, UIN Sulthan Syarif Kasim Riau, Riau, Indonesia*
[7]*Department of Mathematics Education, Universitas Asahan, Kisaran, Indonesia*
[8]*Department of Informatics Management, Sekolah Tinggi Manajemen Informatika dan Komputer Kaputama, Binjai, Indonesia*
[9]*Department of Law, Universitas Muhammadiyah Sumatera Utara, Medan, Indonesia*
[10]*Indonesian Language and Literature Education, Universitas Asahan, Kisaran, Indonesia*

Abstract

Employees are seen as one of the important company assets and need to be managed and developed to support the survival and achievement of corporate goals. One form of employee organization that can be done by the company is to provide the appropriate remuneration or salary payments for employees. Increase in salary greatly affects the motivation and productivity of employees in implementing and completing the work. To determine the magnitude of the salary increase, a system is needed that can support the decision making done by the manager. Utilization of decision support system using Simple Additive Weighting (SAW) method helps managers to make quicker and more accurate decision making. This method is chosen because it is able to select the best alternative from a number of alternatives that exist based on the criteria specified. The research is done by finding the weight value for each attribute then done ranking which will determine the optimal alternative.

Keywords: *Decision Support System, Employees, Simple Additive Weighting*

1. Introduction

Employees are seen as one of the important company assets and need to be managed and developed to support the survival and achievement of corporate goals [1]–[3]. If employees can be well organized, then the company can run all the business processes well too. Therefore, to facilitate the process, a computerized system is required so that in the implementation, from calculation to payment to employees can run faster and the results obtained will be more accurate.

The development of technology and information continuously progressed rapidly[4]–[7] can be utilized to facilitate all activities within the company. Decision Support Systems[8]–[14] are part of computer-based information systems that belong to knowledge-based or knowledge management systems that can be used to support decision-making [15]–[22] within an organization or company[23]. This system can assist decision makers who complement them with information from data that has been processed with relevance and is needed to make decisions about a problem more quickly and accurately[24]–[26].
The rate of salary increase is determined on the basis of performance that must have some problems so that there is a need for a method to solve it. One method that can be used is the method of Simple Additive Weighting (SAW)[27]–[30]. The basic concept of the SAW method is to find the weighted sum of performance ratings on each alternative and on all attributes that require the process of normalizing the decision matrix (X) to a scale comparable to all existing alternative ratings. This method is chosen because it is able to select the best alternative from a number of alternatives that exist based on the criteria specified. The research is done by finding the weight value for each attribute then done ranking which will determine the optimal alternative.

2. Methodology

Decision is an activity or activity or action of choosing one alternative from some alternatives taken as solution of a problem[1], [31], [32]. The type of decision taken to solve a problem can be seen from the type of structure, such as:

a. Structured Decision is a decision that is done repeatedly and is routine. The decision-making procedure is very clear.
b. Semi structured Decision it is a decision that has two traits. Some decisions can be handled by the computer and others still have to be done by decision makers.
c. Unstructured Decision, it is a handling decision that is complicated because it does not happen over and over or is not

always the case. The decision requires experience and external sources.

Decision-making includes four interconnected and consecutive stages, including:

a. Intelligence
This stage is the process of tracking and detecting the scope of problematic and problem recognition process. The input data is obtained, processed, and tested in order to identify the problem.

b. Design
This stage is the process of discovering, developing, and analyzing alternative actions that can be done. This stage includes a process for understanding the problem, lowering the solution and testing the feasibility of the solution.

c. Choice
At this stage a selection process is made between various possible action alternatives[33]–[36]. This stage includes the search, evaluation and recommendation of appropriate solutions for the model that has been made. The solution of the model is the specific value for the result variable on the selected alternative.

d. Implementation
Implementation stage is the implementation stage of the decision that has been taken. At this stage it is necessary to arrange a set of planned actions so that the results of the decisions can be monitored and adjusted as necessary.

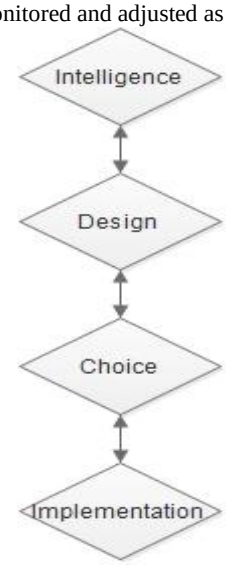

Fig. 1: Stages of Decision Maker

Simple Additive Weighting (SAW) method is often also known as the weighted summing method. 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 process of normalizing the decision matrix (X) to a scale comparable to all existing alternative ratings[37], [38].

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{Max\ x_{ij}} & if\ j\ are\ benefit\ attribute \\ \dfrac{i}{Min\ x_{ij}} & \\ \dfrac{i}{x_{ij}} & if\ j\ is\ cost\ attribute \end{cases}$$

Information:
r_{ij} = normalized performance rating value
x_{ij} = attribute value owned by each criterion
Max x_{ij} = the largest value of each criterion
Min x_{ij} = the smallest value of each criterion
Benefit = if the greatest value is best
Cost = if the smallest value is best
Where r_{ij} as the normalized performance rating of alternative Ai on attribute Cj; i = 1,2, ..., m and j = 1,2, ..., n. Preference value for each alternative (V_i), the function as equation below:

$$V_i = \sum_{j=1}^{n} W_j\ r_{ij}$$

Information:
V_i = ranking for each alternative
W_j = weighted value of each criterion
r_{ij} = normalized performance rating value
A larger value of Vi indicates that Ai's alternatives are preferred

3. Results and Discussion

The implementation of Simple Additive Weighting (SAW) method in decision support system requires criteria and weighting of value as well as some alternatives to be calculated in the ranking process and assessment in decision making to determine the level of salary increase, as an experiment there are 62 samples of data that will get a raise. The following is data from 62 samples of data used.

Table.1: Sample Data

ID	Alternative
A1	Alternative_1
A2	Alternative_2
A3	Alternative_3
A4	Alternative_4
A5	Alternative_5
A6	Alternative_6
A7	Alternative_7
A8	Alternative_8
A9	Alternative_9
A10	Alternative_10
A11	Alternative_11
A12	Alternative_12
A13	Alternative_13
A14	Alternative_14
A15	Alternative_15
A16	Alternative_16
A17	Alternative_17
A18	Alternative_18
A19	Alternative_19
A20	Alternative_20
A21	Alternative_21
A22	Alternative_22
A23	Alternative_23
A24	Alternative_24
A25	Alternative_25
A26	Alternative_26
A27	Alternative_27
A28	Alternative_28
A29	Alternative_29
A30	Alternative_30
A31	Alternative_31
A32	Alternative_32
A33	Alternative_33
A34	Alternative_34
A35	Alternative_35
A36	Alternative_36
A37	Alternative_37
A38	Alternative_38
A39	Alternative_39
A40	Alternative_40
A41	Alternative_41
A42	Alternative_42
A43	Alternative_43
A44	Alternative_44
A45	Alternative_45
A46	Alternative_46
A47	Alternative_47
A48	Alternative_48
A49	Alternative_49
A50	Alternative_50
A51	Alternative_51
A52	Alternative_52

A53	Alternative_53
A54	Alternative_54
A55	Alternative_55
A56	Alternative_56
A57	Alternative_57
A58	Alternative_58
A59	Alternative_59
A60	Alternative_60
A61	Alternative_61
A62	Alternative_62

As for the steps that must be done in the calculation of the salary increase rate in accordance with the above case using Simple Additive Weighting (SAW) method, that is:

a. Specifies performance-based criteria and fuzzy numbers on SAW for the weight of values to be used for assessment. These criteria can be seen in table 2, 3 and 4 below.

Table.2: Criteria and Weighting Value

Criteria	Weight
Achievement	35%
Discipline	25%
Attitude	25%
Years of service	15%

Table.3: Weight Fuzzy Numbers

Fuzzy Number	Value
Very Bad	1
Bad	2
Enough	3
Good	4
Very Good	5

Table.4: Years of service

Time (Month)	Value
3 – 11	1
12 – 23	2
24 – 35	3
36 – 47	4
48 – 59	5

b. Determine the match rating of each alternative on each of the criteria that can be seen in table 5 below.

Table.5: Rating of Matching Alternative with Criteria

Alternative	Rating result			
	Achievement	Discipline	Attitude	Years of service
A1	4	4	4	4
A2	4	3	4	4
A3	4	4	4	4
A4	3	3	3	4
A5	4	4	4	3
A6	4	2	4	2
A7	3	4	4	2
A8	3	3	3	4
A9	4	2	3	5
A10	4	4	3	5
A11	4	3	3	5
A12	3	4	4	4
A13	4	4	4	5
A14	4	4	4	4
A15	3	4	4	3
A16	4	4	4	3
A17	4	4	4	3
A18	3	3	3	3
A19	3	2	3	2
A20	4	3	3	3
A21	4	3	4	4
A22	4	4	4	4
A23	3	3	3	4
A24	3	3	4	2
A25	3	4	3	4
A26	3	4	4	4
A27	3	3	3	3
A28	4	4	3	3
A29	4	3	3	3
A30	4	4	4	3
A31	4	3	4	3
A32	3	3	3	3
A33	3	4	3	2
A34	3	3	4	2
A35	3	3	3	2
A36	3	3	4	2
A37	4	4	4	2
A38	3	4	3	2
A39	3	3	4	2
A40	3	4	4	2
A41	3	4	3	2
A42	3	3	3	2
A43	3	4	4	2
A44	4	4	4	2
A45	4	4	4	2
A46	4	5	4	2
A47	4	4	4	2
A48	3	3	3	2
A49	4	3	4	2
A50	3	3	3	2
A51	3	3	3	2
A52	4	5	4	2
A53	3	3	3	2
A54	3	4	3	1
A55	3	4	4	1
A56	3	3	3	1
A57	4	4	4	1
A58	4	4	4	1
A59	4	4	4	1
A60	3	4	4	1
A61	3	3	3	1
A62	3	3	3	1

c. Calculate the normalization value of each alternative by the formula:

$$r_{ij} = \frac{x_{ij}}{\underset{i}{Max}\ x_{ij}}$$

Implementation of formula:

$$r_{11} = \frac{4}{4} = 1 \qquad r_{12} = \frac{4}{5} = 0.8$$

$$r_{13} = \frac{4}{4} = 1 \qquad r_{14} = \frac{4}{5} = 0.8$$

$$r_{621} = \frac{3}{4} = 0.75 \qquad r_{622} = \frac{3}{5} = 0.6$$

$$r_{623} = \frac{3}{4} = 0.75 \qquad r_{624} = \frac{1}{5} = 0.2$$

The result of normalization is made in the form of a normalization matrix as below.

$$R = \begin{bmatrix} 1 & 0.8 & 1 & 0.8 \\ 1 & 0.6 & 1 & 0.8 \\ 1 & 0.8 & 1 & 0.8 \\ 0.75 & 0.6 & 0.75 & 0.8 \\ 1 & 0.8 & 1 & 0.6 \\ 1 & 0.4 & 1 & 0.4 \\ 0.75 & 0.8 & 1 & 0.4 \\ 0.75 & 0.6 & 0.75 & 0.8 \\ 1 & 0.4 & 0.75 & 1 \\ 1 & 0.8 & 0.75 & 1 \\ 1 & 0.6 & 0.75 & 1 \\ 0.75 & 0.8 & 1 & 0.8 \\ 1 & 0.8 & 1 & 1 \\ 1 & 0.8 & 1 & 0.8 \\ 0.75 & 0.8 & 1 & 0.6 \\ 1 & 0.8 & 1 & 0.6 \\ 1 & 0.8 & 1 & 0.6 \\ 0.75 & 0.6 & 0.75 & 0.6 \\ 0.75 & 0.4 & 0.75 & 0.4 \\ 1 & 0.6 & 0.75 & 0.6 \\ 1 & 0.6 & 1 & 0.8 \\ 1 & 0.8 & 1 & 0.8 \\ 0.75 & 0.6 & 0.75 & 0.8 \\ 0.75 & 0.6 & 1 & 0.6 \\ 0.75 & 0.8 & 0.75 & 0.8 \\ 0.75 & 0.8 & 1 & 0.8 \\ 0.75 & 0.6 & 0.75 & 0.6 \\ 1 & 0.8 & 1 & 0.6 \\ 1 & 0.6 & 0.75 & 0.6 \\ 1 & 0.8 & 1 & 0.6 \\ 1 & 0.6 & 1 & 0.6 \end{bmatrix} \begin{bmatrix} 0.75 & 0.6 & 0.75 & 0.6 \\ 0.75 & 0.8 & 0.75 & 0.4 \\ 0.75 & 0.6 & 1 & 0.4 \\ 0.75 & 0.6 & 0.75 & 0.4 \\ 0.75 & 0.6 & 1 & 0.4 \\ 1 & 0.8 & 1 & 0.4 \\ 0.75 & 0.8 & 0.75 & 0.4 \\ 0.75 & 0.6 & 1 & 0.4 \\ 0.75 & 0.8 & 1 & 0.4 \\ 0.75 & 0.8 & 0.75 & 0.4 \\ 0.75 & 0.6 & 0.75 & 0.4 \\ 0.75 & 0.8 & 1 & 0.4 \\ 1 & 0.8 & 1 & 0.4 \\ 1 & 0.8 & 1 & 0.4 \\ 1 & 1 & 1 & 0.4 \\ 1 & 0.8 & 1 & 0.4 \\ 0.75 & 0.6 & 0.75 & 0.4 \\ 1 & 0.6 & 1 & 0.4 \\ 0.75 & 0.6 & 0.75 & 0.4 \\ 0.75 & 0.6 & 0.75 & 0.4 \\ 1 & 1 & 1 & 0.4 \\ 0.75 & 0.6 & 0.75 & 0.4 \\ 0.75 & 0.8 & 0.75 & 0.2 \\ 0.75 & 0.8 & 0.75 & 0.2 \\ 0.75 & 0.6 & 0.75 & 0.2 \\ 1 & 0.8 & 1 & 0.2 \\ 1 & 0.8 & 1 & 0.2 \\ 1 & 0.8 & 1 & 0.2 \\ 0.75 & 0.8 & 1 & 0.2 \\ 0.75 & 0.6 & 0.75 & 0.2 \\ 0.75 & 0.6 & 0.75 & 0.2 \end{bmatrix}$$

d. Determine the preferences of each alternative by using the formula:

$$V_i = \sum_{j=1}^{n} W_j \; r_{ij}$$

W = [0.35 0.25 0.25 0.15]

The preference value for determining the ranking result is as follows:

V_1 = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.8) = 0.92 (15%)

V_2 = (0.35 x 1) + (0.25 x 0.6) + (0.25 x 1) + (0.15 x 0.8) = 0.87 (10%)

V_3 = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.8) = 0.92 (15%)

V_4 = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.8) = 0.72 (5%)

V_5 = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.6) = 0.89 (10%)

V_6 = (0.35 x 1) + (0.25 x 0.4) + (0.25 x 1) + (0.15 x 0.4) = 0.76 (5%)

V_7 = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.4) = 0.7725 (5%)

V_8 = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.8) = 0.72 (5%)

V_9 = (0.35 x 1) + (0.25 x 0.4) + (0.25 x 0.75) + (0.15 x 1) = 0.7875 (10%)

V_{10} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 0.75) + (0.15 x 1) = 0.8875 (10%)

V_{11} = (0.35 x 1) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 1) = 0.8375 (10%)

V_{12} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.8) = 0.8325 (10%)

V_{13} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 1) = 0.95 (15%)

V_{14} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.8) = 0.92 (15%)

V_{15} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.6) = 0.8025 (10%)

V_{16} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.6) = 0.89 (10%)

V_{17} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.6) = 0.89 (10%)

V_{18} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.6) = 0.69 (0%)

V_{19} = (0.35 x 0.75) + (0.25 x 0.4) + (0.25 x 0.75) + (0.15 x 0.4) = 0.61 (0%)

V_{20} = (0.35 x 1) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.6) = 0.7775 (5%)

V_{21} = (0.35 x 1) + (0.25 x 0.6) + (0.25 x 1) + (0.15 x 0.8) = 0.87 (10%)

V_{22} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.8) = 0.92 (15%)

V_{23} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.8) = 0.72 (5%)

V_{24} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 1) + (0.15 x 0.6) = 0.7525 (5%)

V_{25} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 0.75) + (0.15 x 0.8) = 0.77 (5%)

V_{26} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.8) = 0.8325 (10%)

V_{27} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.6) = 0.69 (0%)

V_{28} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.6) = 0.8275 (10%)

V_{29} = (0.35 x 1) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.6) = 0.7775 (5%)

V_{30} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.6) = 0.89 (10%)

V_{31} = (0.35 x 1) + (0.25 x 0.6) + (0.25 x 0.1) + (0.15 x 0.6) = 0.84 (10%)

V_{32} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.6) = 0.69 (0%)

V_{33} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 0.75) + (0.15 x 0.4) = 0.71 (5%)

V_{34} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 1) + (0.15 x 0.4) = 0.7225 (5%)

V_{35} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.4) = 0.66 (0%)

V_{36} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 1) + (0.15 x 0.4) = 0.7225 (5%)

V_{37} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.4) = 0.86 (10%)

V_{38} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 0.75) + (0.15 x 0.4) = 0.71 (5%)

V_{39} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 1) + (0.15 x 0.4) = 0.7225 (5%)

V_{40} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.4) = 0.7725 (5%)

V_{41} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 0.75) + (0.15 x 0.4) = 0.71 (5%)

V_{42} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.4) = 0.66 (0%)

V_{43} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.4) = 0.7725 (5%)

V_{44} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.4) = 0.86 (10%)

V_{45} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.4) = 0.86 (10%)

V_{46} = (0.35 x 1) + (0.25 x 1) + (0.25 x 1) + (0.15 x 0.4) = 0.91 (15%)

V_{47} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.4) = 0.86 (10%)

V_{48} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.4) = 0.66 (0%)

V_{49} = (0.35 x 1) + (0.25 x 0.6) + (0.25 x 1) + (0.15 x 0.4) = 0.81 (10%)

V_{50} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.4) = 0.66 (0%)

V_{51} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.4) = 0.66 (0%)

V_{52} = (0.35 x 1) + (0.25 x 1) + (0.25 x 1) + (0.15 x 0.4) = 0.91 (15%)

V_{53} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.4) = 0.66 (0%)

V_{54} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 0.75) + (0.15 x 0.2) = 0.68 (5%)

V_{55} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 0.75) + (0.15 x 0.2) = 0.68 (5%)

V_{56} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.2) = 0.63 (0%)

V_{57} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.2) = 0.83 (10%)

V_{58} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.2) = 0.83 (10%)

V_{59} = (0.35 x 1) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.2) = 0.83 (10%)

V_{60} = (0.35 x 0.75) + (0.25 x 0.8) + (0.25 x 1) + (0.15 x 0.2) = 0.7425 (5%)

V_{61} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.2) = 0.63 (0%)

V_{62} = (0.35 x 0.75) + (0.25 x 0.6) + (0.25 x 0.75) + (0.15 x 0.2) = 0.63 (0%)

4. Conclusion

The application of Simple Additive Weighting (SAW) method in decision making of salary increasing level is done by finding weighted sum of criteria at each alternative and at attribute which need normalization decision matrix, then doing the process of ranking up to value of preference to determine alternative which get increase salary between 5% - 15% or not at all get a raise.

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