

TOPSIS Method for Determining The Priority of Strategic Training Program

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Abstract— The voice of stakeholders is an important issue for government or public organizations. The issue becomes an input in designing strategic program. Decision maker should evaluate the priority to get the importance level. The decision making process is a complex problem because it is influenced by many criteria. The purpose of this study is to solve multi-criteria decision making problem using TOPSIS method. This method is proposed due to its easy and simple computation process. The case sample is determining the strategic training program in energy and mineral resources field. TOPSIS analysis may be able to assist decision maker in allocating resources for the preparation of strategic training program in accordance with the priorities

Keywords— TOPSIS, training, strategic issue, energy and mineral resources

I. INTRODUCTION

The performance of public or government organizations is much influenced by the strategic issues from the stakeholders. Generally, stakeholders have certain expectations and needs according to the field. The problem becomes the input for the government to find the best solutions through various proposed program and activities. Sometimes, there are several identified problems or issues. The challenge for managers of organizations is to select issues that have strategic value in accordance with the scope of its authority. To select this issue by using criteria parameter so that the results is to be accountable. The identified strategic issue is then determined for its urgency to make priority scale order based on expert's advice. Due to the amount and complexity of the criteria resulting in the complexity of the process for determining the alternatives and sometimes unexpected conflicts, it is important to have a proper method based on its problem's characteristics.

MCDM (multi-criteria decision making) is a method frequently used to solve a decision making problem with many criteria or attributes. MCDM has a lot of variants that each of them has weaknesses and strengths. Velasquez and Hester [1] reviewed MCDM-based articles and found that there are eleven methods for the system; among which include Multi-attribute Utility Theory, Analytical hierarchy

process (AHP), Fuzzy set theory, Technique for order of preference by similarity to ideal solution (TOPSIS), etc.

The purpose of this study is to demonstrate the application of TOPSIS for problem solving for choosing strategic issues. Case sample is analyzed with strategic issue formula for training program in energy and mineral resources field. TOPSIS in this paper is used to determine the priority scale of the issues, while defining the weight of each criterion using pairwise comparison method or analytical hierarchy process.

II. TOPSIS

TOPSIS was first developed by Hwang and Yoon in 1981. The basic idea of TOPSIS is that chosen alternative should have the closest relation to the positive ideal solution (the optimal solution) and the farthest to the negative ideal solution (non-optimal solution). TOPSIS is widely used by researchers and practitioners due to its easy, simple mathematical model, and simple computation process so that it can be solved with a computer spread sheet program [2], [3], [4]. Velasquez and Hester [1] observed the advantages and disadvantages of the method, as well as the areas of application for this method as shown in Table 1.

The application of TOPSIS method is combined with many other methods such as AHP. This trend has been analyzed by Behzadian et al. [5] and it was found that there have been researches and articles on the topic. Bhutia and

Phipon [4] use the AHP and TOPSIS methods to solve the selection problem for determining the suppliers priority in the supply chain cycle. Tavana and Hatami-Marbini [3] use the AHP-TOPSIS at the John Space Center on the Integrated Human Exploration Mission Simulation Facility (INTEGRITY) project to assess the priority of human spaceflight mission simulators. Onder and Dag [6] study the supplier selection of Electrolytic Cooper Cathode using AHP and TOPSIS approaches. Ghosh [7] evaluates faculty performance in engineering education. AHP and TOPSIS were used to determine teacher performance based on feedbacks from students.

TABLE I
SUMMARY OF TOPSIS

advantages	disadvantages	area application
Has a simple process; easy to use and program; the number of steps remains the same regardless of the number of attributes.	Its use of Euclidean Distance does not consider the correlation of attributes; difficult to weight and keep consistency of judgment.	Supply chain management and logistics, engineering, manufacturing systems, business and marketing, environmental, human resources, and water resources management.

III. METHOD

The proposed method for study on the strategic issues priority problem solving consists of four steps as shown in Figure 1, which include (a) literature review (articles and reports) related to the topic, (b) identifying the criteria and their weight by using pairwise comparison method, (c) identifying the strategic issue of training in energy and mineral resources field, and constructing the hierarchy. The hierarchy consists of three levels: goal, criteria, and issue alternatives, (d) constructing the decision matrix and evaluating the issue priority using TOPSIS, and (e) preparing the strategic training program as shown in Fig 1.

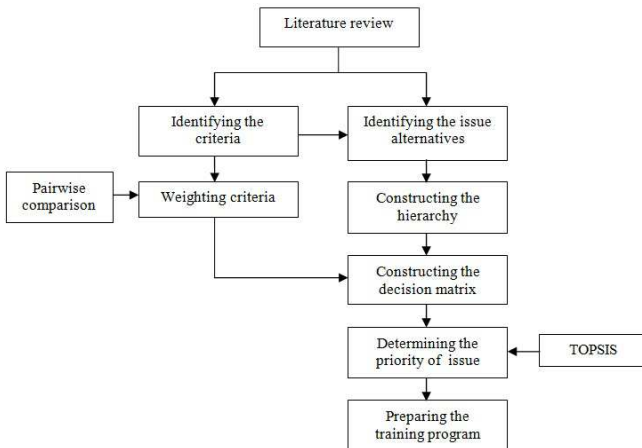


Fig. 1 Flowchart of the study

For instance, the decision matrix consists of n strategic issue alternatives, A_1, A_2, \dots, A_n and m criteria or attributes,

C_1, C_2, \dots, C_m . The decision makers evaluate every alternative related each other to the criteria, resulting in the formation of matrix structure $\mathbf{X} = (x_{ij})_{n \times m}$ as follows [8]:

$$\mathbf{X} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1j} & \dots & x_{1m} \\ x_{21} & x_{22} & \dots & x_{2j} & \dots & x_{2m} \\ \vdots & \vdots & \dots & \vdots & \dots & \vdots \\ x_{i1} & x_{i2} & \dots & x_{ij} & \dots & x_{im} \\ \vdots & \vdots & \dots & \vdots & \dots & \vdots \\ x_{n1} & x_{n2} & \dots & x_{nj} & \dots & x_{nm} \end{bmatrix} \quad (1)$$

The next phase is determining the issue priority using TOPSIS procedure consists of six steps, which are:

- a. Calculating the normalized decision matrix using the following equation.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^n x_{kj}^2}}, \quad i = 1, 2, \dots, n; \quad j = 1, 2, \dots, m. \quad (2)$$

- b. Calculating the weighted normalized decision matrix using the following equation.

$$v_{ij} = W_j n_{ij}, \quad i = 1, 2, \dots, n; \quad j = 1, 2, \dots, m. \quad (3)$$

where W_j is relative weight of each criterion or attribute, and added to 1 or $\sum_{j=1}^m W_j = 1$.

- c. Determining the Positive ideal solution (PIS) and Negative ideal solution (NIS) using the following equation.

$$PIS = A^+ = \{v_1^+, v_2^+, \dots, v_m^+\} = \{(max_i v_{ij} | j \in \Omega_b), (min_i v_{ij} | j \in \Omega_c)\}, \quad (4)$$

$$NIS = A^- = \{v_1^-, v_2^-, \dots, v_m^-\} = \{(min_i v_{ij} | j \in \Omega_b), (max_i v_{ij} | j \in \Omega_c)\}, \quad (5)$$

Where Ω_b and Ω_c are associated with benefit criteria and cost criteria.

- d. Calculating the separation measure by using Euclidean distance. The separation of each alternative from the PIS and NIS using the following equation.

$$D_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^+)^2}, \quad i = 1, 2, \dots, n. \quad (6)$$

$$D_i^- = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^-)^2}, \quad i = 1, 2, \dots, n. \quad (7)$$

- e. Calculating the Relative closeness (RC) of each alternative to the ideal solution using the following equation.

$$RC_i = \frac{D_i^-}{D_i^+ + D_i^-}, \quad i = 1, 2, \dots, n. \quad (8)$$

- f. Determining the rank of alternatives based on the RC value. The higher RC value indicates that the alternative is the best solution or the most preferred.

IV. CASE SAMPLE

Preparing the strategic training program must be related to the issues growing from the inputs suggested by the stakeholders. The identified issues require the management to evaluate each of them in order to determine the priority

scale for the issues. The application of TOPSIS method enables the analysis for every issue related to the criteria as the guidelines. The results of the analysis show that the training programs supported by significant resources include trainings for energy reduction and mining inspectors. Both programs are conducted to overcome national problems and to meet the needs of the stakeholders.

Developing human resources for energy and mineral resources field is an attempt which should be viewed in dynamics meaning that the notion should adapt with the development of strategic environmental issues and the needs demanded by the stakeholders. Thus, the policies stated in strategic planning documents should be evaluated in accordance with the dynamics in contemporary strategic environment. Based on the literature review, it is found that there are five criteria as guidelines for identifying strategic issues [9], which include:

- Straight relation to or cause of service problems in training institution (criterion 1)
- Cause of significant negative impact on the socio-economic conditions in the community (criterion 2)
- Solvability through competence, resources, and programs developed by the training institution (criterion 4)
- Solvability through the improvement of the training institution performance (criterion 4)
- Success in handling the improvement of the training institution's contribution to national development in general (criterion 5)

Based on the criteria above, strategic issues in energy and mineral resources and other sectors are related to human resources development in order to preparing training program in energy and mineral resources field, which include [10]:

- Improvement of local apparatus competence (issue 1).
- Preparation of one thousands mining inspectors (issue 2).
- National movement on reducing dependency on oil and electricity (issue 3).
- Preparation of the human resources in order to accelerate and expand Indonesia's economic development (issue 4).
- Gender responsive in energy and mineral resources field in order to support gender equality and women empowerment (issue 5).

Based on the identification the criteria and alternatives, the hierarchy structure of the strategic issues priority of training in energy and mineral field is modeled as shown in Figure 2.

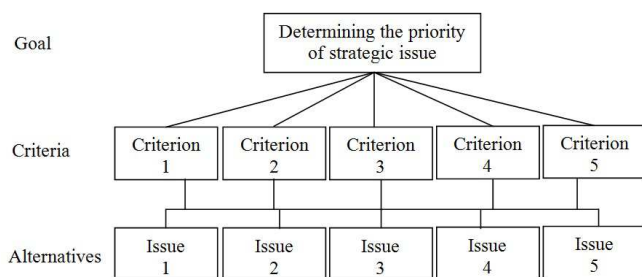


Fig 2 The hierarchy structure

The evaluation for the weight of the criteria is conducted using pairwise comparison. The evaluation matrix uses Saaty scale ranging from 1 to 9 reflecting the evaluating expression by an expert on the importance level of two criteria. For instance, the evaluation result among the criteria has been calculated and the matrix is shown as in Table 2. The weight value of the criteria then becomes the input data for TOPSIS computation.

TABLE III
THE EVALUATION OF THE PAIRWISE COMPARISON MATRIX AMONG CRITERIA

	C1	C2	C3	C4	C5	Weight
C1	1	5	1	7	9	0.384
C2	1/5	1	1/5	7	7	0.167
C3	1	5	1	9	5	0.365
C4	1/7	1/7	1/9	1	1	0.040
C5	1/9	1/7	1/5	1	1	0.044

The next phase is applying the TOPSIS method to determine the strategic issue priority related to the composition of the training program. For instance, the decision matrix evaluation for every issue in relation to each criterion as shown in table 3.

TABLE IIIII
THE DECISION MATRIX

Weight	0.384	0.167	0.365	0.040	0.044
Criterion 1 (1 = very less related; ... ; 5 = strongly related)					
Criterion 2 (1 = very less negative impact; ... ; 5 = strongly negative impact)					
Criterion 3 (1 = very unsolvable; ... ; 5 = strongly solvable)					
Criterion 4 (1 = very unsolvable; ... ; 5 = strongly solvable)					
Criterion 5 (1 = very less contribute; ... ; 5 = strongly contribute)					
Issue 1	4	3	3	3	4
Issue 2	5	5	5	4	5
Issue 3	5	5	5	5	5
Issue 5	4	4	4	4	3
Issue 6	2	2	3	3	3

Note: C1, C3-C5 are benefit criteria and C2 is cost criterion.

The result of the weight of normalized decision matrix, positive ideal and negative ideal solutions are as shown in Table 4.

TABLE IVV
THE WEIGHTED NORMALIZED DECISION MATRIX AND POSITIVE/NEGATIVE IDEAL SOLUTIONS

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
Issue 1	0.1656	0.0564	0.1195	0.0139	0.0192
Issue 2	0.2070	0.0939	0.1991	0.0185	0.0240
Issue 3	0.2070	0.0939	0.1991	0.0231	0.0240
Issue 4	0.1656	0.0752	0.1593	0.0185	0.0144
Issue 5	0.0828	0.0376	0.1195	0.0139	0.0144
A_i^+	0.2070	0.0376	0.1991	0.0231	0.0240
A_i^-	0.0828	0.0939	0.1195	0.0139	0.0144

Meanwhile, the result of the computation of distance between the value of each alternative and the ideal positive and negative solutions, and the rank of alternative priorities

(relative closeness) is shown in Table 5. Based on the TOPSIS analysis, it is found that the priority of issue 3 becomes the main priority in the preparing the training program in energy and mineral resources field. The second one and the next are issue 2, issue 4, issue 1, and issue 5 respectively.

TABLE V
THE SEPARATION FROM THE IDEAL ALTERNATIVE AND RELATIVE CLOSENESS

Alternatives	D_i^+	D_i^-	RC_i	Rank
Issue 1	0.0923	0.0911	0.4966	4
Issue 2	0.0566	0.1479	0.7235	2
Issue 3	0.0564	0.1482	0.7244	1
Issue 4	0.0695	0.0939	0.5748	3
Issue 5	0.1482	0.0564	0.2756	5

The following is an example of preparing the training program in energy and mineral resources field in 2012 which is proved to support every strategic issue as shown in Table 6. The program is supported by significant resources as it is considered to be the solution for national issue and to meet the needs demanded by the stakeholders.

TABLE VI
THE STRATEGIC TRAINING PROGRAM [10]

Priority	Issue	Training Program
1	Issue 3: Reducing dependency on oil and efficiency electricity	<ul style="list-style-type: none"> - Field consultants for 3 kg LPG - Field consultants for oil using control - Technical training for the maintenance and management of solar-based power plant - Technical training for biogas consultants - Technical training for electricity permits - Technical training for operational test of diesel-based power plant - Technical training for local energy planning - Technical training for energy conservation in buildings and constructions
2	Issue 2: One thousands mining inspectors.	<ul style="list-style-type: none"> - Training for prospective mining inspectors - Training for the improvement of mining inspectors' competence (master trainer) - Training for mining permit management
3	Issue 4: Acceleration and expansion of Indonesia's economic development	Trainings are distributed all over the regions and in accordance with each region's potential
4	Issue 1: Improvement local apparatus' competence	There are 303 training classes for local apparatus
5	Issue 5: Gender equality and women empowerment	There six gender-responsive trainings, such as Training for Fields Consultation of Volcanic Disasters, Training for the Promotion of Mining for Local Non-technical Apparatus, etc.

V. CONCLUSIONS

Preparing the strategic training program must be related to the issues growing from the inputs suggested by the stakeholders. The identified issues require the management to evaluate each of them in order to determine the priority scale for the issues. The application of TOPSIS method enables the analysis for every issue related to the criteria as the guidelines. The results of the analysis show that the training programs supported by significant resources include trainings for energy reduction and mining inspectors. Both programs are conducted to overcome national problems and to meet the needs of the stakeholders.

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REFERENCES

- [1] M. Velasquez, P. T. Hester, "An Analysis of Multi-Criteria Decision Making Methods," *International Journal of Operations Research*, vol. 10, no. 2, pp. 56-66, 2013.
- [2] Z. Pavić, V. Novoselac, "Notes on TOPSIS Method," *International Journal of Research in Engineering and Science*, vol. 1, issue 2, pp. 5-12, June 2013.
- [3] M. Tavana, A. Hatami-Marbini, "A Group AHP-TOPSIS Framework for Human Spaceflight Mission Planning at NASA," *Expert System with Applications*, 38, pp. 13588-13603, 2011.
- [4] P. W. Bhutia, R. Phipon, "Application of AHP and TOPSIS Method for Supplier Selection Problem," *IOSR Journal of Engineering*, vol. 2, issue 10, pp. 43-50, October 2012.
- [5] M. Behzadian, S. K. Otaghara, M. Yazdani, J. Ignatius "A State-of-the-art Survey of TOPSIS Applications," *Expert System with Applications*, 39, pp. 13051-13069, 2012.
- [6] E. Onder, S. Dag, "Combining Analytical Hierarchy Process and TOPSIS Approaches for Supplier Selection in a Cable Company," *Journal of Business, Economics & Finance*, vol. 2, issue 2, pp. 56-74, 2013.
- [7] D. N. Ghosh, "Analytic Hierarchy Process & TOPSIS Method to Evaluate Faculty Performance in Engineering Education," *UNIASCIT*, vol. 1 (2), pp. 63-70, 2011.
- [8] R-C. Tsaor, "Decision Risk Analysis for an Interval TOPSIS Method," *Applied Mathematics and Computation*, 218, pp. 4295-4304, 2011.
- [9] Pusat Informasi dan Pembangunan Wilayah (PIPW)-USAID, *Tata Cara Penyelenggaraan Klinik Konsultasi Penyusunan Renstra-Renja SKPD*, Surakarta: LPPM Universitas Sebelas Maret, 2008.
- [10] Badan Pendidikan dan Pelatihan Energi dan Sumber Daya Mineral (Badiklat ESDM), *Laporan Akuntabilitas Kinerja Instansi Pemerintah Tahun 2012*, Jakarta: Badan Diklat ESDM, 2013.