Enhancing Employee Motivation: A TOPSIS-Based Decision Support System for Incentive Allocation through Performance Evaluation

Yuke Subaikah Sutyawati, Benny Daniawan

Abstract— **Information technology is developing rapidly and has a significant role in various aspects, one of which is making decisions to evaluate employee performance. Employee performance assessment is an important activity and is often carried out by companies to determine employee performance in a certain period. A company's progress is greatly influenced by the good and bad of the system that is running. The decision support system can improve and influence the assessment of existing performance in the company. If the decision support system is inadequate, it can lead to errors in decision-making. This research was conducted at PT. App Inti provides enthusiasm and motivation to employees, and the company performs performance assessments every six months, which will influence the adjustment of employee salary increases. However, the current assessment process still uses simple methods and often experiences difficulties assessing performance, making the assessments less effective. Because errors and inaccuracies often occur during assessments, to make it easier for companies to make decisions and help solve these problems, a decision support system was designed using the TOPSIS method. The TOPSIS is a multi-attribute decision-making method often used to complete practical decisions. Then, the results can be considered and help the company determine a decision based on the alternatives and criteria that the company has decided. Then, the results of this research can help companies determine which employees are more visible during the assessment. Then, the TOPSIS ranking results are used to adjust salary increases that have been selected by the company, thereby helping companies make decisions more quickly.**

Index Terms— **Performance Appraisal, Decision Support System, TOPSIS**

I. INTRODUCTION

Information technology is one example that is developing rapidly to help humans in the process of determining strategies for decision-making [1], Technology also has an essential role in companies, including the employee performance appraisal process [2]. Information technology makes it easier for someone to make a decision [3].

Performance appraisal is one of the essential activities for companies to evaluate the performance of their employees during work, as well as to determine employee skills and competencies to improve employee performance, motivation, and enthusiasm [4] [5]. Performance assessments are carried out to obtain valuable information in making decisions about the company's human resource management activities [6].

A decision support system is part of an information system that an organization uses to manage data into information as a reference in making semi-structured and unstructured decisions [7], so that it can increase effectiveness when making decisions and be more objective [8]. The best decisions can be obtained from an objective process and can be completed using a decision support system [9].

PT. App Inti is a company in Jakarta engaged in the IT field of Application and Website Development Services. To increase employee morale so that their performance continues to grow, the company gives awards to employees by conducting performance assessments. This assessment will influence the adjustment of employee salary increases. Rewards such as salary increases can have an essential role in improving performance because they are a form of positive assessment of employees for the performance they have achieved [10]. Having a performance appraisal will make employees feel motivated so that it can encourage employees to be more accomplished and make an excellent contribution to the company [11].

Management and leaders of each division carry out employee performance appraisals. Employees are assessed based on criteria determined by the company. These criteria include discipline, responsibility, tidiness, collaborative, commitment, integrity, motivation, and problem-solving. Currently, the assessment process is still carried out manually. The criteria and indicators used are less targeted, so assessors often need help giving grades because there are no benchmarks in the assessment. So, when processing data, management often finds employees with inappropriate values.

In light of the existing problems, a decision to support an information system was designed using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. TOPSIS method is one of

Manuscript received September 15, 2023. Yuke Subaikah, author is with the Information System Department of Buddhi Dharma University, Tangerang, Indonesia. (e-mail: yukesubaikahh@gmail.com)

Benny Daniawan, author is with Information System Department of Buddhi Dharma University, Tangerang, Indonesia. (e-mail: b3n2y.miracle@gmail.com)

the methods that are of interest to researchers in creating decision support systems because the concept is simple but complex in solving problems, characterized by solving problems in this method by selecting the best alternative not only from the shortest distance from the positive ideal solution but also from the longest distance from a negative ideal solution [12].

Previous research about Employee Performance Assessment Decision Support systems using the TOPSIS Method with five criteria: presence, cooperation, work quality, initiative, and productivity. From this research, we obtained the results of ranking alternatives that have the potential to become the best employees [12]. Another research study is about the Application of the TOPSIS Method in decision-making with the selection of the best car based on four criteria: style, safety, fuel efficiency, and expansion. From this research, we get results from each alternative that can be used in recommendations for choosing the best car [13]. The study, Determining Employee Bonuses in Companies Using the TOPSIS Method, has four criteria: attendance, employee assessment, length of service, and loyalty. So, the results obtained are that employees with the most significant value weight are entitled to receive an annual bonus based on criteria determined by the company [14].

Based on previous research, the researcher designed a decision support system using the TOPSIS method to assess employee performance for salary increases to obtain results that could help PT. App Inti in making assessments and making decisions.

II. METHODS

A. Decision Support System (DSS)

It is a computer-based system that can collect and process information data to be helpful so that it can assist in making decisions by utilizing data and models to solve structured and unstructured problems [7].

DSS is used to help decision-making in structured to unstructured issues, where people need to learn how the decision should be made [15]. Then, DSS is a process of selecting the best alternative from several alternatives used to solve problems [16].

The decision-making process has several objectives [17], i.e.

1) Assist management in making decisions on structured and unstructured problems.

2) DSS can provide solutions, and the results are acceptable.

3) Increase productivity.

B. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

First introduced by Hwang and Yoon, TOPSIS is known for solving Multi-Criteria Decision Making problems, which has the concept that the alternative chosen must have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution [13].

The TOPSIS method can help complete a decision realistically because it has a simple concept and is easy to understand. It also can measure the relative performance of decision alternatives [12]

TOPSIS has several advantages i.e rationality, understandability, simple mathematics—allowing for the best alternatives for each criterion to be presented in a simple mathematical form, weights are included in the comparative procedures, reliability, effective implementation, intuitiveness of the procedure [18].

Determination of alternatives is obtained from several stages, and each stage is interconnected with the others until the final preference value can be obtained. The steps of the TOPSIS method, according to (Chen, Yoon and Hwang, 1992) [17] i.e.

1) Determine the attributes or criteria that will be used in forming a suitability rating to form a matrix called the decision matrix.

2) Normalize the decision matrix with the following formula :

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{1}$$

3) Calculating normalized matrix values :

$$y_{ij} = W_i \, r_{ij} \tag{2}$$

4) Looking for positive ideal and negative ideal solutions :

$$A^+ = (y_1^+, y_2^+, \dots y_n^+) \tag{3}$$

$$A^- = (y_1^-, y_2^-, \dots y_n^-) \tag{4}$$

5) Determine alternative distance values using positive and negative ideal solution matrix :

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (y_i^+ - y_{ij})^2} \tag{5}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} (y_i^- - y_{ij})^2} \tag{6}$$

6) Determine the preference value of each alternative:

$$V_j = \frac{D_i^-}{D_i^- + D_i^+} \tag{7}$$

7) Sort preferences

The final step is to sort from relative closeness (V_i), highest to lowest, the best decision alternative will be indicated with the highest relative value.

III. RESULT

This research data was taken from management, who had determined the criteria and indicators to be used, then discussed with each superior and chose the employees who would be assessed. The data obtained is then processed in a performance assessment decision support system using the TOPSIS method. This study has 10 Employees (alternatives: Ai, i=1, 2, 3…10), and eight criteria (criteria Cj, j=1, 2, 3…,8) for evaluation. The original matrix is set in Table 5. The stages of implementing the method are as follows:

A. Criteria and Value Weights

The manager determines assessment criteria with value weights, shown in Table 1 to Table 5.

Table 1. Criteria and Value Weights

No	Code Criteria	Criteria	Weight
1	C1	Discipline	10%
2	C2	Responsibility	25%
3	C3	Tidiness	5%
4	C4	Collaborative	20%
5	C5	Commitment	10%
6	C6	Integrity	5%
7	C7	Motivation	10%
8	C8	Problem Solving	15%

Table 2. Discipline Criteria Indicators

Weight	Indicators
5	Consistently always arrives on time, with an absenteeism score of 0
4	Always arrives on time with 3x absenteeism
3	Always present, but likes to be late, intolerable conditions, with 4-6x absences
2	Often late, and absent with an absentee rate of more than 6x
1	Often late and absent for no apparent reason

Table 3. Responsibility Criteria Indicators

Weight	Indicators
5	Can complete assigned tasks on time and follow instructions accurately.
4	Can complete assigned tasks on time, although occasional errors may occur.
3	Can complete assigned tasks but is occasionally late and less accurate.
2	Completes assigned tasks but often late and not accurate.
1	Unable to complete assigned tasks.

Table 4. Tidiness Criteria Indicator

Weight	Indicators
5	Dress neatly and professionally while at work and demonstrate self-awareness in maintaining an orderly work desk.
4	Dress neatly and professionally and frequently preserve the tidiness of the workspace.
3	Occasionally dress in a tidy manner and tidy up the work desk, but may require supervision
2	It doesn't prioritize the tidiness of clothing; the focus is on dressing, and the work desk often needs to be more tidy.
1	Refrain from adhering to company regulations regarding dress code

Table 5. Rating result

Alt	C1	C2	C3	C4	C5	C6	C7	C8
A1	5	4	4	5	4	4	4	4
A2	5	4	4	4	4	4	4	4
A3	5	4	4	5	5	5	4	5
A4	5	4	4	4	5	4	4	5
A5	5	4	5	5	5	4	5	5
A6	5	4	5	4	5	5	4	4
A7	3	4	5	5	5	4	4	4
A8	5	2	5	3	5	4	4	4
A9	5	4	5	4	4	3	4	4
A10	5	4	5	5	5	5	4	4

The assessment results obtained answers from the management of PT. App Inti is based on a scale of 1-5, as shown in Table 5. After getting the value, here is how to use the TOPSIS method:

B. TOPSIS Method

The following are the stages in using the TOPSIS method as follows:

1) Normalizing the alternative values and the weighted normalized matrix with the values contained in Table 5 above, and the normalized matrix results using formula (1) using eight assessment criteria as follows (data is shown in part):

$$C_1\sqrt{5^2 + 5^2 + 5^2 + 5^2 + 5^2 + 5^2 + 3^2 + 5^2 + 5^2 + 5^2}$$
$$= 15,2970$$

$$r_{1.1=}\frac{x1.1}{x1} = \frac{5}{15,2970} = 0,3269$$

The calculation to find the r_{ij} value shown in Table 6.

Table 6. Normalization Matrix

Alt	C1	C2	C3	C4	C5	C6	C7	C8
A1	0.3269	0.3288	0.2734	0.3553	0.2679	0.2981	0.3077	0.2925
A2	0.3269	0.3288	0.2734	0.2843	0.2679	0.2981	0.3077	0.2925
A3	0.3269	0.3288	0.2734	0.3553	0.3348	0.3727	0.3077	0.3656
A4	0.3269	0.3288	0.2734	0.2843	0.3348	0.2981	0.3077	0.3656
A5	0.3269	0.3288	0.3418	0.3553	0.3348	0.2981	0.3846	0.3656
A6	0.3269	0.3288	0.3418	0.2843	0.3348	0.3727	0.3077	0.2925
A7	0.1961	0.3288	0.3418	0.3553	0.3348	0.2981	0.3077	0.2925
A8	0.3269	0.1644	0.3418	0.2132	0.3348	0.2981	0.3077	0.2925
A9	0.3269	0.3288	0.3418	0.2843	0.2679	0.2236	0.3077	0.2925
A10	0.3269	0.3288	0.3418	0.3553	0.3348	0.3727	0.3077	0.2925

2) Determine the normalization matrix using formula (2) for criteria weights use Table 1:

$$y_{1.1} = 0,1 * 0,3268 = 0,0327$$

The calculation to find weighted normalization value shown in Table 7.

Table 7. Weighted Normalization Matrix

Alt	C1	C2	C3	C4	C5	C6	C7	C8

A1	0.0327	0.0822	0.0137	0.0711	0.0268	0.0149	0.0308	0.0439
A2	0.0327	0.0822	0.0137	0.0569	0.0268	0.0149	0.0308	0.0439
A3	0.0327	0.0822	0.0137	0.0711	0.0335	0.0186	0.0308	0.0548
A4	0.0327	0.0822	0.0137	0.0569	0.0335	0.0149	0.0308	0.0548
A5	0.0327	0.0822	0.0171	0.0711	0.0335	0.0149	0.0385	0.0548
A6	0.0327	0.0822	0.0171	0.0569	0.0335	0.0186	0.0308	0.0439
A7	0.0196	0.0822	0.0171	0.0711	0.0335	0.0149	0.0308	0.0439
A8	0.0327	0.0411	0.0171	0.0426	0.0335	0.0149	0.0308	0.0439
A9	0.0327	0.0822	0.0171	0.0569	0.0268	0.0112	0.0308	0.0439
A10	0.0327	0.0822	0.0171	0.0711	0.0335	0.0186	0.0308	0.0439

3) Calculate the positive ideal solution and negative ideal solution matrix using formulas (3) and (4):

$$C1 = \frac{MAX}{0,0327 + 0,0327 + 0,0327 + 0,0327 + 0,0327 + 0,0327 + 0,0196 + 0,0327 + 0,0327 + 0,0327} = 0,0327$$

$$C1 = \frac{MIN}{0,0327 + 0,0327 + 0,0327 + 0,0327 + 0,0327 + 0,0327 + 0,0196 + 0,0327 + 0,0327 + 0,0327} = 0,0196$$

The results of the max and min normalization matrix for each criterion and alternative are shown in Table 8.

Table 8. Max and Min Normalization Matrix

Criteria	Max	Min
C1	0,0327	0,0196
C2	0,0822	0,0411
C3	0,0711	0,0137
C4	0,0711	0,0426
C5	0,0335	0,0268
C6	0,0186	0,0112
C7	0,0385	0,0308
C8	0,0548	0,0439

4) Calculate positive and negative ideal matrix using formulas (5) and (6).

$$D_1^+ = \sqrt{(0,0327 - 0,0327)^2 + (0,0822 - 0,0822)^2 + (0,0711 - 0,0137)^2 + (0,0711 - 0,0711)^2 + (0,0335 - 0,0268)^2 + (0,0186 - 0,0149)^2 + (0,0385 - 0,0308)^2 + (0,0548 - 0,0439)^2}$$
$$= 0,0158$$

$$D_1^- = \sqrt{(0,0196 - 0,0327)^2 + (0,0411 - 0,0822)^2 + (0,0137 - 0,0137)^2 + (0,0426 - 0,0711)^2 + (0,0268 - 0,0268)^2 + (0,0112 - 0,0149)^2 + (0,0308 - 0,0308)^2 + (0,0439 - 0,0439)^2}$$
$$= 0,0158$$

The results are obtained as in the Table 9.

Table 9. Positive and Negative Ideal Solution

Alternatives	D_l^+	D_l^-
A1	0.0158	0.0518
A2	0.0213	0.0456
A3	0.0084	0.0537
A4	0.0169	0.0473
A5	0.0037	0.0540
A6	0.0195	0.0466
A7	0.0191	0.0507
A8	0.0519	0.0155
A9	0.0220	0.0455
A10	0.0134	0.0527

5) Calculate the preference value of each alternative using formula (7).

$$A_1 = \sqrt{\frac{0,0518}{0,0518 + 0,0158}} = 0,7661$$

The results of the preference values will be sorted based on the largest value and displayed in Table 10.

Table 10. Ranking

Alternatives	Value	Ranking
A5	0.9355	1
A3	0.8646	2
A10	0.7974	3
A1	0.7661	4
A4	0.7365	5
A7	0.7264	6
A6	0.7048	7
A2	0.6819	8
A9	0.6747	9
A8	0.2305	10

In this table the highest value comes from alternative 5 with a value of 0.9355 and the other alternatives results will be presented in the following chart.
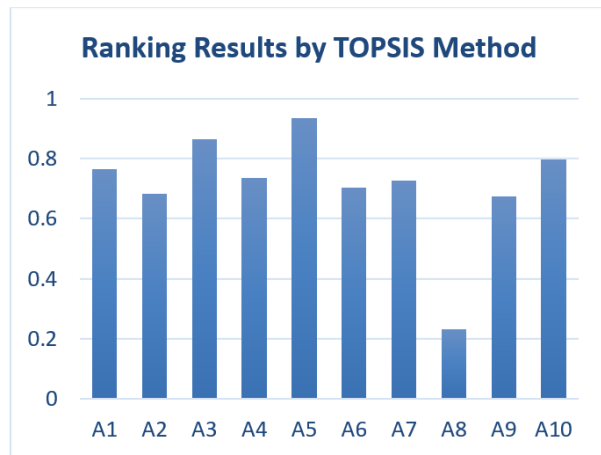

Fig. 1. TOPSIS Ranking Chart

With the results above, the company can see the best and worst employees performance.

IV. DISCUSSION

The TOPSIS method is the method most widely used by researchers in MCDM [19]. This method has the advantage of being a ranking method; TOPSIS focuses on selecting alternatives with the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution [20], [21]. This method fully utilizes attribute information to provide primary

rankings for existing alternatives [22]. Apart from that, this method has a reasonable logic that embodies rational human choices [19]. Unlike other MCDM methods, namely AHP, this method can produce accuracy values [23][24]. In contrast to TOPSIS, where this method does not have accurate calculations [25], a combination with other MCDM methods is required to produce accuracy values.

In this section, we compare the results of the TOPSIS Method calculations with the general calculations used by companies using the data in Table 5 previously and then add them up. The results are shown in Table 11 below:

Table 11. General Calculations

Alternatives	Total	Ranking
A5	38	1
A3	37	2
A10	37	2
A6	36	3
A4	35	4
A1	34	5
A7	34	5
A2	33	6
A9	33	6
A8	32	7

Based on the results of Table 11, it can be seen that the calculation in general will produce a biased ranking, where there are several alternatives with the same ranking, such as alternatives A3 and A10 occupying position 2, then alternatives A1 and A7 occupying position 5, as well as alternatives A2 and A9 occupying position 6. This is the problem that the company wants to avoid, so using the proposed TOPSIS method will produce more detailed value data and keep management clear about providing rewards in the form of salary increases and appropriate evaluation to employees.

V. CONCLUSIONS

TOPSIS is a suitable decision-making or performance assessment method in companies because the resulting values do not produce biased values, as shown in Table 11. Based on the results of data processing using a decision support system that has been developed, the highest-ranking results were obtained, namely Alternative 5 with a value of 0.9355, then Alternative 3 with a value of 0.8646, Alternative 10 with a value of 0.7974, and followed by other alternatives. The results of this assessment will be used by management to provide incentives for salary increases to the three best alternatives and deliver evaluation for the worst alternatives[P1][YS2].

REFERENCES

[1] A. Ikhwan and R. Hendri, "ANALISIS PERENCANAAN STRATEGS SISTEM INFORMASI DAN TEKNOLOGI INFORMASI MENGGUNAKAN FRAMEWORK WARD DAN PEPPARD STUDI KASUS: FAKULTAS KOMPUTER UMITRA INDONESIA," *Jurnal Teknologi dan Informatika (JEDA)*, vol. 1, no. 1, Nov. 2022, doi: 10.57084/jeda.v1i1.950.

[2] M. Kadafi, I. Effendy, and I. Effendy, "PERANCANGAN SISTEM PENILAIAN KINERJA KARYAWAN DENGAN METODE 360-DEGREE PADA PT ASTRA INTERNATIONAL DAIHATSU PALEMBANG," *Bina Darma Conference on Computer Science*, 2020.

[3] S. Shodiq, "Peran Sistem Informasi dan Teknologi Informasi terhadap Proses Pembelajaran di Masa Pandemi Covid-19," *Jurnal Edukasi*, vol. 8, no. 1, p. 17, Mar. 2021, doi: 10.19184/jukasi.v8i1.23968.

[4] O. Arifudin, R. Tanjung, H. Hendar, and H. Hanafiah, "Analisis Pengaruh Penilaian Kinerja Dan Kompensasi Terhadap Produktivitas Kerja Pada PDAM Kabupaten Karawang," *Jurnal Ilmu Manajemen*, vol. 10, no. 1, p. 71, Dec. 2020, doi: 10.32502/jimn.v10i1.2719.

[5] G. Maharani, S. Ali, and Z. Rialmi, "Pengaruh Pelatihan Kerja dan Penilaian Kinerja Terhadap Kinerja Karyawan Direktorat Umum dan SDM BPJS Ketenagakerjaan Pusat," *JMK (Jurnal Manajemen dan Kewirausahaan)*, vol. 6, no. 2, p. 59, May 2021, doi: 10.32503/jmk.v6i2.1516.

[6] S. I. Adam and O. Lengkong, "Sistem Pendukung Keputusan Penilaian Kinerja Pegawai Universitas Klabat Menggunakan Metode Analytic Network Process," *CogITo Smart Journal*, vol. 5, no. 2, pp. 227–238, Dec. 2019, doi: 10.31154/cogito.v5i2.199.227-238.

[7] M. I. Nasution, A. Fadlil, and S. Sunardi, "Perbandingan Metode AHP dan TOPSIS untuk Pemilihan Karyawan Berprestasi," *JURNAL MEDIA INFORMATIKA BUDIDARMA*, vol. 6, no. 3, p. 1712, Jul. 2022, doi: 10.30865/mib.v6i3.4194.

[8] H. Nalatissifa and Y. Ramdhani, "Sistem Penunjang Keputusan Menggunakan Metode Topsis Untuk Menentukan Kelayakan Bantuan Rumah Tidak Layak Huni (RTLH)," *MATRIK : Jurnal Manajemen, Teknik Informatika dan Rekayasa Komputer*, vol. 19, no. 2, pp. 246–256, May 2020, doi: 10.30812/matrik.v19i2.638.

[9] M. Badaruddin, "Sistem Pendukung Keputusan Penilaian Kinerja Karyawan Menerapkan Kombinasi Metode Simple Additive Weighting (SAW) dengan Rank Order Centroid (ROC)," *JURNAL MEDIA INFORMATIKA BUDIDARMA*, vol. 3, no. 4, p. 366, Oct. 2019, doi: 10.30865/mib.v3i4.1508.

[10] I. W. Pratama and G. Sukarno, "Analisis Penilaian Kinerja, Reward, dan Punishment terhadap Kinerja Pegawai pada Badan Kepegawaian Daerah Provinsi Jawa Timur," *Jurnal STEI Ekonomi*, vol. 30, no. 02, pp. 20–32, Nov. 2021, doi: 10.36406/jemi.v30i02.460.

[11] U. A. Saefullah, "Dampak Penilaian Kinerja dan Pengembangan Karir terhadap Kepuasan Kerja Karyawan Perbankan," *Technomedia*

Journal, vol. 6, no. 2, pp. 223–235, Nov. 2021, doi: 10.33050/tmj.v6i2.1761.

[12] S. N. Amida and T. Kristiana, "SISTEM PENDUKUNG KEPUTUSAN PENILAIAN KINERJA PEGAWAI DENGAN MENGGUNAKAN METODE TOPSIS," *JSAI (Journal Scientific and Applied Informatics)*, vol. 2, no. 3, Nov. 2019, doi: 10.36085/jsai.v2i3.415.

[13] M. Saeed *et al.*, "Application of TOPSIS Method for Decision Making," *International Journal of Scientific Research in _____ Research Paper. Mathematical and Statistical Sciences*, no. 7, pp. 76–81, 2020, [Online]. Available: https://www.researchgate.net/publication/342347772

[14] J. Chandra, S. Sipahutar, and O. Sihombing, "PENENTUAN PEMBERIAN BONUS KARYAWAN PADA PERUSAHAAN DENGAN MENGGUNAKAN METODE TOPSIS," *Jurnal Sistem Informasi dan Ilmu Komputer Prima(JUSIKOM PRIMA)*, vol. 2, no. 2, pp. 31–38, Mar. 2019, doi: 10.34012/jusikom.v2i2.380.

[15] D. O. Wibowo and A. Thyo Priandika, "SISTEM PENDUKUNG KEPUTUSAN PEMILIHAN GEDUNG PERNIKAHAN PADA WILAYAH BANDAR LAMPUNG MENGGUNAKAN METODE TOPSIS," *Jurnal Informatika dan Rekayasa Perangkat Lunak (JATIKA)*, vol. 2, no. 1, p. page-page. xx~xx, 2021, [Online]. Available: http://jim.teknokrat.ac.id/index.php/informatika

[16] N. Rahmansyah, S. Kom, M. Kom, and S. A. Lusinia, *Buku Ajar SISTEM PENDUKUNG KEPUTUSAN*. 2021. [Online]. Available: http://jurnal.pustakagalerimandiri.co.id

[17] T. Limbong *et al.*, *Sistem Pendukung Keputusan: Metode & Implementasi*, Ke-1. Yayasan Kita Menulis, 2020.

[18] A. Galik, M. Bąk, K. Bałandynowicz-Panfil, and G. T. Cirella, "Evaluating Labour Market Flexibility Using the TOPSIS Method: Sustainable Industrial Relations," *Sustainability (Switzerland)*, vol. 14, no. 1, Jan. 2022, doi: 10.3390/su14010526.

[19] E. K. Zavadskas, A. Mardani, Z. Turskis, A. Jusoh, and K. M. Nor, *Development of TOPSIS Method to Solve Complicated Decision-Making Problems - An Overview on Developments from 2000 to 2015*, vol. 15, no. 3. 2016. doi: 10.1142/S0219622016300019.

[20] N. Mao, M. Song, and S. Deng, "Application of TOPSIS method in evaluating the effects of supply vane angle of a task/ambient air conditioning system on energy utilization and thermal comfort," *Appl Energy*, vol. 180, pp. 536–545, 2016, doi: 10.1016/j.apenergy.2016.08.011.

[21] F. Ciardiello and A. Genovese, "A comparison between TOPSIS and SAW methods," *Ann Oper Res*, vol. 325, no. 2, pp. 967–994, 2023, doi: 10.1007/s10479-023-05339-w.

[22] T. C. Wang, T. T. Thu Nguyen, and B. N. Phan, "Analyzing higher education performance by entropy - TOPSIS method: A case study in Viet Nam private universities," *Measurement and Control (United Kingdom)*, no. 415, 2022, doi: 10.1177/00202940221089504.

[23] T. L. Saaty, "Decision-making with the AHP: Why is the principal eigenvector necessary," *Eur J Oper Res*, vol. 145, no. 1, pp. 85–91, 2003, doi: 10.1016/S0377-2217(02)00227-8.

[24] J. Franek and A. Kresta, "Judgment Scales and Consistency Measure in AHP," *Procedia Economics and Finance*, vol. 12, no. March, pp. 164–173, 2014, doi: 10.1016/s2212-5671(14)00332-3.

[25] Y. Çelikbilek and F. Tüysüz, "An in-depth review of theory of the TOPSIS method: An experimental analysis," *Journal of Management Analytics*, vol. 7, no. 2, pp. 281–300, Apr. 2020, doi: 10.1080/23270012.2020.1748528.