Utilization of the PROMETHEE algorithm to determine the suitability of the atmospheric environment in traditional buildings

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Received 25 October 2022; accepted 20 December 2022; published 10 January 2023

ABSTRACT

The village house is an example of a traditional building. The village house is currently used as a community residence. The life of the village house still protects and maintains ancestral customs, including in the form of house architecture. In the process of building a village house, there is one aspect that is used, such as an appropriate environmental atmosphere. Where the building must maintain the beauty of the environment. The importance of paying attention to the atmospheric environment is because the characteristics of these traditional buildings are not lost, especially in the atmospheric environment as historical evidence. Thus, to develop village house buildings, there is a lack of information related to the traditional buildings themselves, such as the past environmental conditions around traditional buildings, road conditions around buildings, beauty and distance between buildings, and building models around conventional houses, to achieve the goal, documentation of the necessary knowledge related to the atmospheric environment for traditional buildings that still maintains or provides an atmosphere like the old days. The research will be conducted using the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) algorithm. The research method is by conducting a literature study, observation, and documentation. Observations and documentation were carried out to collect data in the form of 300 photos of Kampung Rumah in Borobudur, from the data in the form of 300 photos, 9 (nine) were collected. System testing using System Usability Scale (SUS), Black-box, and Expert Judgment. The result of the research is a system for determining the suitability of the environmental atmosphere for village houses in Borobudur using the PROMETHEE algorithm. This research is expected to help determine the village house environment in Borobudur by displaying the final results in the form of outranking and the system test value of 85%.

KEYWORDS
Environmental atmosphere
Culture
Promethee
Decission support system

1. Introduction

The State of Indonesia has various forms of ethnic settlements which are widespread in various regions. One of the wealth of architectural knowledge that must be explored and understood for his knowledge is culture. Culture is a subject in customs that has become a hereditary habit and is closely related to the citizens of each country [1]. According to Ki Hajar Dewantara, culture is the fruit of human ingenuity which is the result of human struggle against two strong influences, namely time and nature which are evidence of the glory of human life to overcome various obstacles and difficulties in life and livelihood in order to achieve safety and happiness which is outwardly orderly and peace.

In addition, culture is a way of life that develops and is shared by a group of people and passed down from generation to generation. Indonesia is an archipelagic country with interesting and unique cultural diversity. In the current era of modernization, many Indonesian people embrace foreign cultures and forget their own. As a result of the very rapid

development of technology and the influx of Western culture in Indonesia, original culture is slowly disappearing.

An example of regional culture that still exists today is the village house at Borobudur. The village house is located in the Magelang area, Central Java Province. Village houses are traditional buildings used for community residences. The daily life of village houses still maintains and maintains ancestral customs, including in the architectural design of the house. In the process of building village houses there are several aspects to consider, one of which is the appropriate environmental atmosphere [2].

The appropriate environmental atmosphere is the form of a building whose composition, structure, function, decoration and the way it is made are passed down from generation to generation or have a traditional atmosphere. Along with the rapid development of the times, the development of traditional architecture become disappeared [1]. In order to maintain the traditional environmental architecture, it is necessary to make adjustments to the original environment. So, it is necessary to adjust the new building with the traditional area to maintain the beauty of the traditional environment [3].

The problems that occur in the world of architecture to carry out the development of traditional buildings often result in minimal information related to traditional buildings, such as past environmental conditions around traditional buildings, road conditions, beauty and distance between buildings and building models around these traditional houses. Therefore, it is necessary to document knowledge related to the atmospheric environment for traditional buildings with the aim of maintaining or providing an atmosphere like the past. The lack of information related to the past environmental conditions of a traditional building has an impact on the redesign of the building model where there are differences, for example the philosophy of the building that is not appropriate, the size that does not match the period of the building at that time or the typology model of the building.

This research was conducted aiming to get a clear and complete picture of the traditional architecture of village houses in Borobudur. From the results of this description, the data collected will be obtained and will be assessed with several criteria. Therefore, a decision support system (DSS) is needed. DSS is a system that can provide structured or unstructured problem solving. DSS is made by implementing high competency adaptation so that it can be used as an alternative in making a decision [4].

Research related to DSS has been widely used with various methods such as Technique for Others Reference by Similarity to Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP), Simple Additive Weighting (SAW) and Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) [5][6][7]. The TOPSIS method has a concept where the chosen alternative is the best alternative with the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. The preference value for each alternative is the final result of the TOPSIS method calculation, the higher the value, the alternative is the desired alternative [7].

Another method of DSS is AHP, this method is a hierarchy with input in the form of human perception. This method is used to find the priority ranking sequence of various alternatives in solving problems. In addition, the AHP method is able to solve problems involving subjective judgments effectively. With the aim of this method, it can solve a problem that is complex or unstructured and formed into a hierarchy [8].

Then, the PROMETHEE method is a method for determining sequence or priority in Multi Criteria Decision Making (MCDM). The use of value in the outranking relationship is the criterion used in PROMETHEE. This method is one of the simplest ranking methods in its concept. Where to indicate priorities and preferences for each criterion this method prioritizes value without thinking about the method of calculation with other solutions [9].

Research related to decision support systems using the PROMETHEE algorithm was carried out by researchers in various fields, both local and international research. Decision making has been used for the case of major selection at SMK Negeri (Public Vocational School) 6 Medan [5], for assessing nurse performance [10] and for selection of various types

of residences and facilities by considering the factors of price, environmental safety and location of residence [11].

Based on the results of the descriptions of these studies, this research uses the PROMETHEE method in developing SPK for determining the suitability of the environmental atmosphere for traditional buildings. This method is multi-criteria, where each criterion is given a weighting value based on the references of cultural architect experts by considering the priority of each criterion [12]. The weight of the assessment is given according to the priority that is most desired by the community around the traditional house area in Borobudur and knowledge of the environmental atmosphere.

Following are some theories related to this research, namely decision support systems, environmental architecture and the PROMETHEE algorithm.

1.1. Decision Support System

In the early 1970s, the DSS concept was first described by Michael S. Scott Morton with the term Management Decision System (MDS). This system is a computer-based system designed to help decision makers use certain data and models to assist in solving various unstructured problems [13]. The term MDS refers to a system that uses computer support in the decision-making process. To provide a deeper understanding, there are several definitions of MDS by several experts.

According to Ronal Watrianthos et al in [13], DSS is defined as a system that supports the work of a leader or a group of managers who solve semi-structured problems by providing information and advice about certain decisions. Decision support systems are used to describe systems designed to help managers solve specific problems [12]. From some of the experts above, it can be concluded that a decision support system is an information system that helps middle-level management to make semi-structure.

DSS is used for very effective and objective decision making. Therefore, to increase the usefulness of a Decision Support System (DSS) there are several components, as follows:

- Database Management

  Database management has an important role in the database. The data to be used is data relevant to the problems that are resolved through the system. All activities related to archiving, data processing and collection are related to the decisions that have been made. Tasks in database management include data storage, databases and data acquisition capabilities.

- Model Base

  The role of the model base is to carry out a complete analysis by developing and comparing alternative solutions. Model base will explain the problem in quantitative form as a basis for decision making.

- User Interface

  A visual combination of the two previous components in a third component, having previously been delivered in the form of a model that computers understand. The purpose of the user interface is to display system output for the user and receive input from the user into the system being built.

1.2. Environmental Architecture

Environmental architecture is the science of building structures related to urban planning, landscape planning, urban design, interior and exterior which takes into account the physical conditions of natural resources such as water, soil, air, climate, light, sound and humidity. Environmental architecture is closely related to green architecture because both are related to natural resources [1].

1.3. PROMETHEE Methods

PROMETHEE will provide data for direct use by the user. The data will form in a simple multi-criteria table. The advantage of the PROMETHEE algorithm is that it has the ability to deal with comparison problems, decision makers use their own size scale without limitations,

to indicate the order (priority) and preferences of each criterion by focusing on the value without thinking about the method of calculation [14]. Fig. 1 shows the flowchart of the method's calculation decision flow.

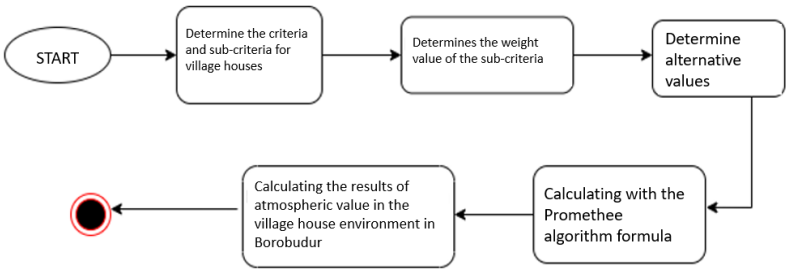

Fig. 1. Promethee Steps of Methodology [15]

The PROMETHEE algorithm is a method for determining order (priority) in multi-criteria analysis [14]. The result of this method is an alternative outranking based on the selected criteria [16]. The steps to calculate the PROMETHEE algorithm are as follows:

- Define criteria and sub-criteria data.
- Determine alternative data for house 1 (a), house 2 (b), and house 3 (c).
- Determine the preference type to calculate the preference value using the following equation:

$$H\ (d) = 0\ if\ d = 0 \tag{1}$$

$$1\ if\ d \neq 0$$

where:
$H\ (d)$: criterion difference function between alternatives
d : difference in criterion values

- Calculating the multi-criteria preference index using the following equation:

$$\vartheta(a,b) = \sum_{n=1}^{j} Pj(a,b)\ wj\ (a,b), \forall a,b \in A \tag{2}$$

- Determine *PROMETHEE*
  - Calculate *Leaving Flow*, by using the following equation:

$$\phi^{+} = \frac{1}{n-1} \sum x \in A\ \varphi(x,a) \tag{3}$$

  - Calculate *Entering Flow,* by using the following equation:

$$\phi^{-} = \frac{1}{n-1} \sum x \in A\ \varphi(x,a) \tag{4}$$

  - Calculating the final result obtained by calculating Net Flow, with the following equation:

$$Net\ Flow\ =\ Leaving\ Flow\ -\ Entering\ Flow \tag{5}$$

2. Methodology

This research is an applied research, to develop the basic concept formulation of decision making with the PROMETHEE algorithm to be applied into a website-based product. The variables used in this research are the criteria for road conditions in the building environment, the delicacy around the building, the distance between buildings, the temperature of the surrounding environment, the shape of the fence surrounding the building, the distance between the fence and the building and the condition of the building [17].

ISSN 2086-8138 (print) | 2745-7249 (online)
Jurnal Informatika
Vol. 17., No. 1, January 2023, pp. 18-27

Data collection was carried out using three methods; literature study, observation and documentation (seen in Fig. 2). Observations were made through the intended object in order to obtain the necessary information regarding the characteristics and condition of the Village House buildings in Borobudur. Documentation is done by taking pictures by researchers to collect data from various things in order to strengthen research results. The pictures were taken in the form of photos of the research location, the delicacy surrounds the village house buildings, the shape of the village house fences and others. After observing and documenting, 300 photos were observed to determine the criteria and sub-criteria data.

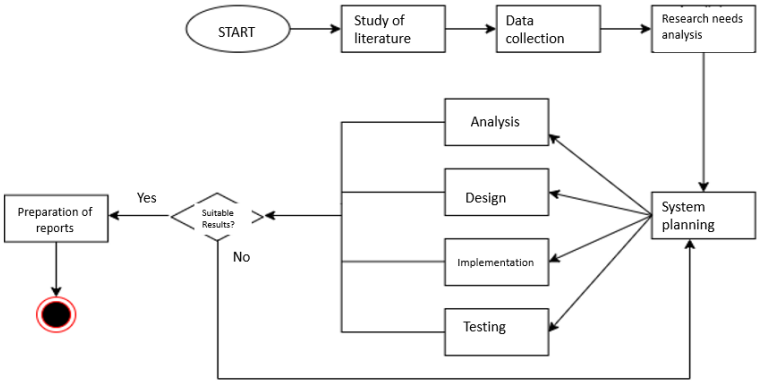

Fig. 2. Research Steps

3. Results and Discussion

3.1. Data Collection

The data used is data obtained from observations and documentation of Village Houses in Borobudur, Central Java which has 9 criteria and sub criteria needed in order a DSS system can be built. The following are the criteria used in this study:

- C1 = Road conditions in the building environment
- C2 = Delicacy around the building
- C3 = Distance between buildings
- C4 = Ambient temperature
- C5 = Fence/gate model that surrounds the building
- C6 = The distance between the fence and the building
- C7 = Buildings shape model
- C8 = Buildings condition

3.2. Data Processing

The stages of the PROMETHEE algorithm are carried out by inputting criteria data and sub-criteria data with the weighting value of each sub-criteria to determine alternative data. Furthermore, the process of calculating the weighting of each Alternative data is carried out by calculating the preference criteria value, the value of the multi-criteria preference index, leaving flow, entering flow and net flow value.

3.3. System Implementation

- Decision Flow with PROMETHEE

  The business process of the system for determining the suitability of the atmosphere of the village house environment in Borobudur is depicted on Fig. 3. and Entity Relationship Diagram on Fig. 4.

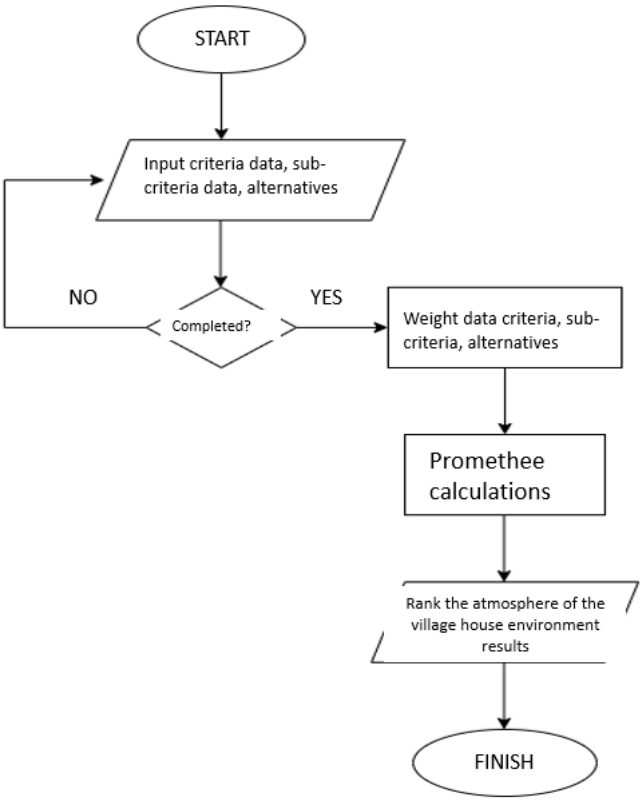

Fig. 3. Decision Flow with Promethee

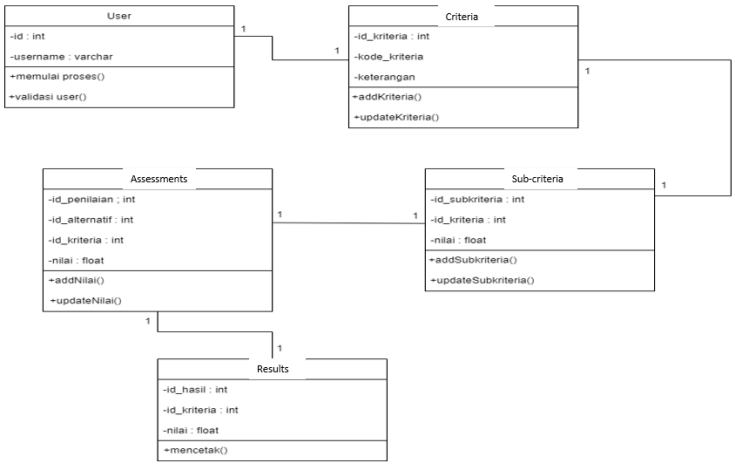

Fig. 4. Physical Schema of Database

3.4. Results and Discussions

- Weighting of Criteria and Sub-criteria

The weighting is carried out based on the policies of Central Javanese cultural experts who provide validation of a building based on values that are in accordance with ancient times(seen on Table 1).

Table 1. Criteria and Subcriteria Weighting

Criteria Code	Sub-criteria Name	Weight
C1	Soil	3
	Rocky soil	2
	Asphalt	1
C2	Lots of trees, flowers and grass	4
	Grass and flowers	3
	Only trees	2
	No Greenery	1
C3	5-10 meters	3
	>10-15 meters	2
	>15 meters	1
C4	Cool	3
	Mild	2
	Hot/Warm	1
C5	Traditional and in accordance with the philosophy of the building	4
	Traditional but not in accordance with philosophy	
	Fence made of plants	3
	Not using	
		2
		1
C6	2 meters	4
	0-1 meters	3
	>1-2 meters	2
	No Distance	1
C7	Relevant with Philosophy	3
	Less Relevant	2
	Not Relevant	1
C8	Good >=80%	3
	Quite Poor 60-80%	2
	Bad	1

Table 2 shows the assessment of the criteria and sub-criteria values for each Alternative.

Table 2. Alternatives Assessment

Criteria Code	House 1 (a)	House 2 (b)	House 3 (c)
C1	3	3	2
C2	4	4	3
C3	2	3	1
C4	3	3	3
C5	4	3	3
C6	4	4	4
C7	2	3	2
C8	3	1	2

PROMETHEE Calculation for Preference Value is explained on Table 3.

Table 3. Criteria Preference Value

Criteria Code	(a,b)		(a,c)		(b,a)		(b,c)		(c,a)		(c,b)	
	x	*P(x)*	*x*	*P(x)*	*x*	*P(x)*	*x*	*P(x)*	*x*	*P(x)*	*x*	*P(x)*
C1	0	0	1	1	0	0	1	1	-1	0	-1	0
C2	0	0	1	1	0	0	1	1	-1	0	-1	0
C3	-1	0	1	1	1	1	2	1	-1	0	-2	0
C4	0	0	0	0	0	0	0	0	0	0	0	0
C5	1	1	1	1	-1	0	0	0	-1	0	0	0
C6	0	0	0	0	0	0	0	0	0	0	0	0
C7	-1	0	0	0	1	1	1	1	0	0	-1	0
C8	2	1	1	1	-2	0	-1	0	-1	0	1	1

In calculating the preference value, the criteria are presented with a value of 0 and 1, where a value of 0 will indicate that the preference is weak $a > b$ based on the criterion data.

Meanwhile, a value of 1 will indicate that a strong preference is $a > b$ based on criterion data. Calculation of the Multicriteria Preference Index Value is seen at Table. 4.

Table 4. Multicriteria Preference Index Value

	a	b	c
a	-	0.25	0.625
b	0.25	-	0.5
c	0	0.125	-

Then calculate the value of the multi-criteria preference index according to equation (2):

(a,b) = 1/8(0+0+0+0+1+0+0+1) = 0.25
(a,c) = 1/8(1+1+1+0+1+0+0+1) = 0.625
(b,a) = 1/8(0+0+1+0+0+0+1+0) = 0.25
(b,c) = 1/8(1+1+1+0+0+0+1+0) = 0.5
(c,a) = 1/8(0+0+0+0+0+0+0+0) = 0
(c,b) = 1/8(0+0+0+0+0+0+0+1) = 0.125

- *Perhitungan Nilai Leaving Flow, Entering Flow dan Net Flow* pada Table. 5, Table. 6, Table. 7

Table 5. Leaving Flow

Alternative	Leaving flow Value
a	0.4375
b	0.375
c	0.0625

Table 6. Entering Flow

Alternative	Entering flow Value
a	0.125
b	0.1875
c	0.5625

Table 7. Net Flow

Alternative	Net flow Value
a	0.3125
b	0.1875
c	-0.5

- PROMETHEE calculation for its results validation is seen on Table. 8

Table 8. PROMETHEE Results Validation

Alternative	Leaving Flow	Entering Flow	Net Flow	Ranking	Notes
House 1	0.4375	0.125	0.3125	1	Suitable
House 2	0.375	0.1875	0.1875	2	Suitable
House 3	0.0625	0.5625	-0.5	3	Not Suitable

It is known that the results of calculations on the system have 3 alternatives: House 1, House 2 and House 3. Judging from the net flow value, House 1 fits the criteria determined by the experts according to the atmosphere like the past. The result of the preference value for House 1 is 0.3125.

- System Validation

System testing for determining environmental atmospheres uses SUS, Black-box and Expert Judgment. The test data uses a sample of 10 village house data as alternative data. Where tests using the SUS method were carried out by architects and cultural experts in Central Java. This test contains 10 questionnaires that will be answered by respondents.

System testing using Black-box will be carried out by architects and cultural experts from Central Java. In this Black-box test, the tester will carry out several stages that have been made, then the tester will see the results obtained. After that, the examiner will compare the results obtained with the expected results whether they are appropriate or not. To provide better system testing results, testing is carried out using Expert Judgment which will be carried out requiring experts. In this study, the thesis supervisor will be assisted by the thesis supervisor to conduct a validation test. This validation test will use an assessment table which is divided into 3 aspects, namely content, technique and presentation.

4. Conclusions

Based on the research conducted, a System for Determining Environmental Atmosphere Suitability for Kampung Houses in Borobudur Using the PROMETHEE Method has been developed. System testing is carried out to find out whether the system is suitable or not as expected. System testing is carried out using SUS, Black-box and Expert Judgment. The results of the SUS questionnaire can be concluded that it produces a system accuracy test of 89%. Meanwhile, the results of testing using Black-box and Expert Judgment, it can be concluded that the system is stated to have tested blackbox and Expert Judgment. The conclusion from the test results is that information is obtained that the percentage value of the final result of determining the suitability of the environmental atmosphere is successful as expected.

Acknowledgment

Thanks to the Team of Architecture and Cultural Experts in Central Java for facilitating the implementation of this research. Thanks also go to the Ahmad Dahlan University Research and Service Institute for their support in carrying out this research. Thank you also to all the research teams who helped to finish the research with the outcomes as promised.

Declarations

Author contribution. All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.
Funding statement. None of the authors have received any funding or grants from any institution or funding body for the research.
Conflict of interest. The authors declare no conflict of interest.
Additional information. No additional information is available for this paper.

References

[1] A. Harapan, "Sistem Bangunan Rumah Tradisional," vol. 1, no. 1, pp. 35–47, 2019, doi: 10.30595/sainteks.v18i1.10563

[2] A. M. A. Aziz, R. S. Rukayah, and W. Wijayanti, "Arsitektur Rumah Tradisional Di Kawasan Kampung Kapitan Palembang," *J. Arsit. ARCADE*, vol. 4, no. 3, p. 199, 2020, doi: 10.31848/arcade.v4i3.484.

[3] J. Adiyanto, M. F. Oktarini, H. M. Hapsari, M. Hanum, N. Al Farizi, and N. A. Mahdalena, "Pendampingan Konservasi Arsitektur Tradisional Melalui Pengembangan Desa Wisata," vol. 6, no. 1, pp. 107–112, 2022, doi: 10.30595/jppm.v6i1.7319.

[4] A. I. Jamhur, "Sistem Pendukung Keputusan Pemilihan Supplier Obat," vol. 4307, no. June, 2022, doi: 10.54314/jssr.v5i2.871

[5] N. S. Atmaja, "Sistem Pendukung Keputusan Pemilihan Jurusan Menggunakan Metode PROMETHEE (Studi Kasus : SMK Negeri 6 Medan)," *InfoTekJar J. Nas. Inform. dan Teknol. Jar.*, vol. 5, no. 2, pp. 124–133, 2021, doi: 10.30743/infotekjar.v5i2.3575

[6] D. A. Adibrata and H. Mustafidah, "Sistem Pendukung Keputusan Online untuk Menentukan Kelayakan Tenaga Kerja Indonesia (TKI) Menggunakan Metode Simple Additive Weighting (SAW) dan Weighted Product (WP)," *Sainteks*, vol. 18, no. 1, p. 75, 2021, doi: 10.30595/sainteks.v18i1.10563.

[7] R. D. Mainingsih and M. Hamka, "Sistem Pendukung Keputusan untuk Menentukan Penerima Bantuan Beasiswa dengan Metode AHP dan TOPSIS Decision Support System for Determining the Scholarity Recipients Using," *Sainteks*, vol. 18, no. 1, pp. 65–74, 2021, doi: 10.30595/sainteks.v18i1.9613

[8] H. J. Pramana, T. Mufizar, D. S. Anwar, and I. Septianingrum, "Sistem Pendukung Keputusan Penilaian Kinerja Guru Dengan Metode AHP dan PROMETHEE," *It (Informatic Tech. J.*, vol. 10, no. 1, p. 87, 2022, doi: 10.22303/it.10.1.2022.87-99.

[9] N. Rinaldi and L. N. Zulita, "Implementasi Metode Promethee Dalam Pemilihan Peminatan Pada Program Studi Informatika (Studi Kasus Fakultas Ilmu Komputer Universitas Dehasen bengkulu)," vol. 5, no. 1, pp. 1–6, 2022, doi: 10.37729/intek.v5i1.1604

[10] A. M. Arif, K. Kusrini, and E. Pramono, "Sistem Pendukung Keputusan Dalam Penilaian Kinerja Perawat Menggunakan Metode Promethee Pada Puskesmas Rena Kandis Kabupaten Bengkulu Tengah," *J. Inf. J. Penelit. dan Pengabdi. Masy.*, vol. 5, no. 1, pp. 7–15, 2019, doi: 10.46808/informa.v5i1.62

[11] L. Marlinda and W. Indrarti, "Sistem Pendukung Keputusan Rumah Tinggal Menggunakan Metode Promethee," *J. Penelit. Tek. Inform.*, vol. 2, no. April 2018, pp. 172–175, 2018. [Online]. Available: https://jurnal.polgan.ac.id/index.php/sinkron/article/view/143

[12] N. Fachira and C. Nst, "Sistem Pendukung Keputusan Pemilihan Karyawan Terbaik OMI KSU Bukit Maradja Menggunakan metode PROMETHEE," vol. 2, no. 3, pp. 162–166, doi: 10.30645/kesatria.v2i3.77

[13] R. Watrianthos, K. Kusmanto, E. F. S. Simanjorang, M. Syaifullah, and I. R. Munthe, "Penerapan Metode Promethee Sebagai Sistem Pendukung Keputusan Pemeringkatan Siswa," *J. Media Inform. Budidarma*, vol. 3, no. 4, p. 381, 2019, doi: 10.30865/mib.v3i4.1546.

[14] G. Widyarini, W. G. Pamungkas, and Y. I. Pratiwi, "Pemilihan Moda Transportasi Saat Pandemi Covid-19 dengan Metode Promethee (Studi Kasus : Ruas Jalan Pemuda Kota Semarang)," *Teknika*, vol. 17, no. 1, p. 12, 2022, doi: 10.26623/teknika.v17i1.4666http://dx.doi.org/10.26623/teknika.v17i1.4666.

[15] J. A. Alam, I. L. Sardi, R. R. Riskiana, F. Informatika, and U. Telkom, "Sistem Pendukung Keputusan Menggunakan Metode PROMETHEE Untuk Pemetaan Potensi Siswa Sekolah Menengah Atas Sebagai Dasar Pemilihan Program Studi," vol. 7, no. 2, pp. 8451–8460, 2020, doi: 10.34818/eoe.v7i2.13141

[16] T. Apriani and A. Simangunsong, "Sistem Pendukung Keputusan Penentuan Kualitas Getah Hevea brasiliensis (Karet) Terbaik pada PT Timbang Deli Verdant Bioscience dengan Metode Promethee," *J. Ilmu Komput. dan Inform.*, vol. 2, no. 1, pp. 47–56, 2022, doi: 10.54082/jiki.22.

[17] M. Ahp, I. Apriansyah, M. F. Abdurrahman, V. Y. Dengi, and J. Siregar, "Sistem Penunjang Keputusan Pemilihan Social Learning Network dengan Sistem Penunjang Keputusan Pemilihan Social Learning Network dengan Metode AHP dan Promethee," no. April, 2022, doi: 10.31294/swabumi.v10i1.11629.