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Analysis Of The Fuzzy Multi-Criteria Decision Making Method In Determining The Place For Telecommunication System Installation

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Abstract. *Well-known projects with large investments, high risks, and long repair periods have unique facilities and infrastructure. For companies that concentrate on technical services and telecommunications system planning, investment priorities in project facilities and infrastructure are efficiency and suitability of location for system placement. Therefore, careful planning and selecting the right location is very important for these companies so that the installed system can function optimally and effectively for telecommunications customers. Making decisions regarding where to place the system is a challenge due to the uncertainty inherent in the site selection process which is complex and has diverse data. The Promethee method which uses a fuzzy approach can help optimize the decision-making process by providing clear and definite values for the factors that influence the decision in the calculations carried out.*

Keywords *: Decision Making System, Promethee Telecommunications, Fuzzy*

INTRODUCTION

A decision support system is a computer-based system to support decision-based systems (Sutanto, 2008). One of the characteristics of a decision support system is that it supports all phases of decision making, namely Intelligence, Design, Choice and Implementation (Turban et al., 2005; Fitria and Fitriana, 2008). So this decision support system functions to assist managerial activities in making decisions for the continuity of work in the company and is expected to have an impact on increasing effectiveness in decision making, both in terms of accuracy, time and quality and not the cost of making decisions or the cost of using computer time.

The decision-making process in a company is difficult, because the factors that influence decision-making in a company may have uncertain and unclear values, so the decisions taken are more intuitive. Ultimately it can have fatal consequences for the company's survival. In situations like this, the fuzzy concept can be used to optimize the decision-making process so that the factors that influence decision-making have definite and clear values for use in calculations.

Often in the decision making process, the decision maker is faced with a problem, namely that there are many criteria that must be considered to get a choice from the various existing options. For this reason, the *Multi-Criteria Decision Making* (MCDM) method is used, namely the decision making process must consider criteria which are factors that support successful decision making so as to produce optimal decisions. One method in MCDM for analyzing multi-criteria problems is the PROMETHEE (*Preference Ranking Organization Method for Enrichment Evaluation*) method.

Multi-Criteria Decision Making (MCDM) method is expected to help decision makers in situations where there are many alternative decisions with several criteria (Kusumadewi and Guswaludin, 2005) and help in overcoming the vagueness, ambiguity and subjectivity of decision makers' judgments (Wang, LY, and YH 2008). Using this method, a decision support system will be developed for selecting the location for placing a new system. In this case, decision making regarding selecting the location for placing a new system at PT. XXX.

There are many advantages to be gained in combining fuzzy theory with *decision making* , namely that fuzzy tools and methodology can be used to translate inaccurate and vague information in making decisions about several alternative choices (Chiclana et al., 1996). Jiang and Eastment (2000) say that fuzzy provides a strong logic for the standardization process and fuzzy bridges the big difference between Boolean estimation and continuous scaling of linear combinations of weighting. Wulandari (2005) said that fuzzy models are easier to understand, build and modify. Baba, Kuscu and Han (2009) say that fuzzy allows computers to make decisions like humans do so that it can be used in every area where human decisions are needed. Arslan and Aydin (2008) added that fuzzy using the Multi-Criteria Decision Making method can be used even though each decision maker has their own ranking for each criterion and even though each decision maker's evaluation comes from a different source. Applications with MCDM can also be used to handle non-quantifiable and qualitative criteria so as to provide reliable results (Hung, Chiang, and Ta-Hwa 2008).

However, apart from having advantages, FMCDM has disadvantages too. Arslan and Aydin (2008) argue that the application of the FMCDM method may produce several problems in the calculation process because if the calculation is carried out for a relatively small problem it will be quite time consuming and can cause *errors* because it can produce inconsistent results. Therefore, it is very important to choose the right software to create with the FMCDM method. Hidayat (2008) added that FMCDM is also unable to handle optimization problems against constraints that are very likely to exist in the problem of selecting optimal options.

Several studies have shown interesting results in the field of FMCDM. Kusnandar and Marimin (2003) conducted research regarding the development of herbal medicine agro-industry products where the source of research analysis came from three types of institutional institutions that understand the problems of the herbal medicine agro-industry and the technique used is the *Multi Expert-Multi Criteria Decision Making technique* , which is a group decision making technique or multiple expert systems. From the results of discussions between researchers and experts, three alternative herbal medicine products were obtained that could be developed and six criteria for selecting herbal medicine. Because the decision was made in groups, the pairwise comparison method was used to analyze the best alternative type of herbal medicine and after analysis it was found that the first alternative herbal medicine had the highest value. Analysis uses the product min-max method. The min product method is for calculating herbal alternative scores based on the criteria of each expert and the max product method is for calculating the expert's aggregate score to get a single result. However, this research still has shortcomings because the results of the product choices selected using the min-max method of this product are not very accurate so that further research is needed to select the selected products. Apart from that, the presence of many experts can cause inconsistencies that require the research to be repeated. .

Several relevant approaches and methods have been developed and used to solve *Multi-Criteria Decision Making problems* . One of the *Multi-Criteria Decision Making methods* used to complete the multi-criteria analysis in this research is PROMETHEE (*Preference Ranking Organization Method for Enrichment Evaluation*) which was introduced by Brans and Vincke (1985) by analyzing large differences and strong intensity in choices. regarding a criterion (Wang, LY, and YH 2008). By combining fuzzy theory, the weight of the criteria in the form of linguistic variables can be resolved.

Some of the advantages of using this method are that it is clearer and simpler for practitioners to understand, takes into account qualitative data as well as quantitative data, provides six types of preferences for criteria, takes into account different criteria at the same time which is not possible with process-based decisions based on only one criterion (Hidayat, 2008). Apart from that, Triyanti and Girls (2008) compared the PROMETHEE method with other MCDM methods, namely the PROMETHEE method provides many functions that can accommodate various data characteristics while other methods, such as the *Analytical Hierarchy Process* (AHP) and *Analytical Network Process* (ANP) methods, that in calculations data in the AHP and ANP methods is ultimately only considered linear because all weighting is only through normalization, even though not all data has characteristics and also data is not always the best " *higher better* " and " *smaller better* " but rather optimal, namely " *is better* " . Hidayat (2008) added that AHP cannot be used for decision problems where there is known interaction and dependence at the top level on lower level elements so that a hierarchical structure cannot be created.

Thus, the problem to be studied in this research is optimizing the decision making process at company xxx by using the *Fuzzy Multi-Criteria Decision Making concept* so that the determining factors in decision making whose value weight is uncertain, such as *blocking problems* , *government problems* , area coverage, and Other criteria have definite, clear and consistent values so that they can be used in calculating the decision-making process.

1. LITERATURE REVIEW

1.1. Decision Support Systems

Decision support systems are one of the theories underlying this scientific research. In general, a decision support system is a computer-based system to support decision-based systems (Sutanto, 2008). Martin et al. (2003) say that decision making is the process of looking for the best option from a number of possible options given as a possible solution to a definite problem. Meanwhile, according to Turban et al. (2005) in their book, they state that a Decision Support System (DSS) is an approach or methodology to support decision making that uses an interactive, flexible and adaptable computer-based information system, especially built to solve specific unstructured management problems. namely a fuzzy process with complex problems where there is no immediate solution.

One of the characteristics of a decision support system is that it supports all phases of decision making, namely Intelligence, Design, Choice and Implementation (Turban et al., 2005; Fitria and Fitriana 2008). Intelligence is the first phase in terms of searching for conditions that can produce decisions (Turban et al., 2005) or the process of tracing and detecting the scope of the problem as well as the problem recognition process. Input data is obtained, processed and tested in order to identify problems. Design is the second phase to find, develop and analyze possible materials to work with (Turban et al., 2005) or the process of finding, developing and analyzing alternative actions that can be taken to understand what the problem is, derive a solution and test the feasibility of the solution. Then enter the Choice phase, namely the phase of selecting possible alternatives (Turban et al., 2005). The election results are then implemented in the decision-making process. So this decision support system functions to assist managerial activities in making decisions for the continuity of work in the company and is expected to have an impact on increasing effectiveness in decision making, both in terms of accuracy, time and quality and not the cost of making decisions or the cost of using computer time.

1.1.1. Fuzzy Logic Concept

The concept of fuzzy logic itself has actually been widely used to model various systems (Djuanidi, Setiawan, and Andista, 2005). Kusumadewi and Guswaludin (2005) explain the reasons why people use the concept of fuzzy logic, namely:

1. The concept of fuzzy logic is easy to understand. The mathematical concepts underlying fuzzy reasoning are very simple and easy to understand.
2. Fuzzy logic is very flexible.
3. Fuzzy logic has tolerance for inaccurate data.
4. Fuzzy logic is capable of modeling very complex non-linear functions.
5. Fuzzy logic can build and apply the experiences of experts directly without having to go through a training process.
6. Fuzzy logic can work together with conventional control techniques.
7. Fuzzy logic is based on natural language.

The concepts of fuzzy sets and fuzzy logic will later underlie the creation of a fuzzy system (Suyanto, 2008). Plato, an Ancient Greek philosopher, discovered the idea of fuzzy logic (Suyanto, 2008). The systematic concept of fuzzy logic was first discovered by Lotfi A. Zadeh (Carlsson and Fuller, 1996; Djunaidi, Setiawan, and Andista, 2005; Kusumadewi and Guswaludin, 2005; Suyanto, 2008; Luo and Yu, 2008), a professor of science. computers at The University of California, Berkeley, United States (Suyanto, 2008). Fuzzy sets are better than the old classical theory, namely classical sets. Classical sets are sets or collections of elements (Suyanto, 2008). In fuzzy, classical sets are better known as crisp sets, namely sets that differentiate members and non-members with clear boundaries (Suyanto, 2008). Example of crisp set:

$A = \{ x \mid x \text{ is an integer}, x > 6\}$

So it is clear that the members of the set A are 7,8,9, and so on. While the non-members are 6,5,4, and so on.

However, this classical set form has shortcomings if in real problems, the nature of this set is less human, because a problem is seen in "black" and "white" only, even though many problems have values between "black" and "white" (Suyanto, 2008). Fuzzy sets are widely used for more human reasoning, because fuzzy has a fairly broad problem domain, such as process control, classification and pattern matching, management and decision making, and others (Anggraeni, Indarto, and Kusumadewi, 2004; Wulandari, 2005; Lukas, Ariwibowo, and Tjia, 2008). Compared to ordinary digital logic or called Boolean logic which only recognizes two states, namely "0" and "1", fuzzy logic can state that in one state the membership of an element in a set is expressed by a number whose size is from 0 to 1 which is called the degree of membership (Wulandari, 2005; Grant and Naesh, 2005; Lukas, Ariwibowo, and Tjia, 2008).

For example, if U is the universe of discussion and x is a member of U, then a fuzzy set A in U is defined as a membership function or the membership function A (x) states the degree of x's membership in A (Suyanto, 2008). For example, see Table II-1. For example, x = {10,25,35,45,76} is a crisp set of product quality value levels in percent (%). Meanwhile, Good, Fair and Not Good are three fuzzy sets which are subsets of x. The members of this fuzzy set are the degree of membership x in the fuzzy set.

2. RESEARCH METHODOLOGY

In Decision Making Systems (DSS) many approaches are used to overcome multi-criteria problems and linguistic information problems (Herrera, 1997). One approach that is also used for this software is Multi-Criteria Decision Making (MCDM). Fuller (1996) said there are four groups in this MCDM approach, one of which is the implementation of the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) method which will later be used to calculate the ranking of site location choices in this software.

Input data in the software or as attributes in the SPK are Fuzzy Variable data, Decision Maker data, Site Location Criteria data and Site Location Choice data. Meanwhile, the site location criteria used include area coverage, area security, area needs, material availability, material security, space for installing new systems, delivery time, community problems, government problems, material quality and traffic load.

3.1. Fuzzy

This software also uses fuzzy logic in the data weighting process. The weighting of each criteria data and choice of site location adopts five linguistic variables introduced by Chen and Hwang, namely "very low", "low", "medium", "high" and "very high" which are represented in a triangular function (Wang, LY and YH 2008). Linguistic variables in fuzzy logic function to replace quantitative variables used in crisp logic.

With fuzzy logic, unclear and ambiguous data can be resolved and the weighting of data in the form of linguistic variables can be translated into numbers whose values can be calculated.

3.2. Fuzzy PROMETHEE

The Fuzzy PROMETHEE method is used for ranking calculations that support multiple criteria systems with ambiguous and unclear input. The first step in the calculation process using the PROMETHEE fuzzy method is to determine the decision maker, choices and criteria for the location of the site to be analyzed. In this software, three decision makers will be determined, namely Mr. Dian Purnama, Mr. Rudi Susanto and Mr. Humaidi, there are two choices of site locations, namely the Seputih Raman site and the Seputih Mataraman site and there are eleven site location criteria, namely area coverage, area security, needs in the area, material availability, material security, space for installing new systems, delivery time, community problems, government problems, material quality and traffic load. After that, in the second step, define the linguistic values and fuzzy numbers. Linguistic values, as explained in sub-chapter 3.1.2, contain five fuzzy numbers, namely: very low (0.00, 0.00, 0.25), low (0.00, 0.25, 0.50), medium (0.25, 0.50, 0.75), high (0.50, 0.75, 1.00) and very high (0.75, 1.00, 1.00). Each set of values for this linguistic variable has three value parts, namely the left value, the middle value and the right value. Because it uses fuzzy triangles.

With a combination of fuzzy methods, the MCDM method, namely the PROMETHEE method, is used to calculate rankings in this software using fuzzy data input. So the weight values which are in the form of linguistic variables and are fuzzy in their calculations are translated into fuzzy numbers in the form of numbers that can be calculated. This process is summarized into a fuzzy stage, namely the Fuzzification Phase.

3.3. Weighting of Site Location Criteria and Site Location Choices

The third step in the fuzzy PROMETHEE process is determining the weight of the criteria. But first, the criteria weight values must be input into the system first. In PROMETHEE the input of criteria weights is based on the opinion of the decision maker regarding the existing site location criteria. In this software, the decision maker's opinion is based on whether or not a criterion is developed. So for the eleven site location criteria, the feasibility of development must be determined by each decision maker, where the weight values input are the linguistic variables that have been selected and have been input previously as explained in sub-chapter 3.1.3. For one criterion has one value from one decision maker. So, in this software one criterion has three weighted values, according to the number of decision makers available.

Meanwhile, the input process for weighting site location choices in Fuzzy PROMETHEE is in the fifth step. As with the weighting of site location criteria, data on site location criteria and site location choices must be input first if you want to determine the weight of site location choices. Because the weighting of site location choices depends on the choice data and site location criteria. In this software, each site location choice will be weighted based on eleven site location criteria. So a choice of site location has eleven value weights which are based on eleven site location criteria. The weighting of the values is also the same as the weighting of the site location criteria, namely the linguistic variables to be selected which have been input as explained in sub-chapter 3.1.3.

3.4. Calculation of Criteria Weights and Preference Index

Calculation of criteria weights is the fourth step in the Fuzzy PROMETHEE stage. In this software, the process of calculating criteria weights cannot be carried out if the criteria weighting data as explained in sub-chapter 3.1.4 does not exist. If the data already exists then calculations can be carried out. The calculation process is by changing the linguistic variables according to the fuzzy numbers that have been input. If the weight values are in numerical form then to calculate the criteria weights the average value of each criterion will be searched based on the weight data from the three decision makers. The results of the calculation will obtain a single left value, a single middle value and a single right value for each criterion. Meanwhile, the sixth stage of Fuzzy PROMETHEE is the calculation of the preference index. This calculation is based on the linguistic weight value of the selected site location variable which is input as in sub-chapter 3.1.4 and converts this value into a fuzzy number. After that, for each criterion, a matrix of site location choices will be created with the order nxm, with n = m and n,m being the number of site location choices. The label for each column and row is the name of the selected site location in sequence. The value of each field in the nth site location choice row and mth site location choice column is the subtraction of the first site location choice with the second site location and so on for each site location choice row and column, provided that if n = m then there is no mark. If the site location choice matrix value has been obtained then based on the minimum and maximum requirements and the type of preference the preference value of the site location choice matrix can be determined. After obtaining the preference value, the next step is to find the preference index value, namely by calculating the average value of eleven site location criteria for each column of the site location choice matrix.

3.5. Fuzzy PROMETHEE I and II calculations

After calculating the preference index which is the Inference Phase of the fuzzy process, the Leaving Flow and Entering Flow values will be calculated. The calculation of the Leaving Flow value is by adding up the site location selection index values in the same row. Meanwhile, the Entering Flow calculation is by adding up the preference index values for site location choices in the same column.

After that, to get a single value, the Defuzzification Phase will be carried out, namely to get a single value from each option. This software uses the Centroid method by averaging the left value, middle value and right value of each option. If you have got one single value, the ranking process is with Fuzzy PROMETHEE I by looking at the largest Leaving Flow and smallest Entering Flow values or Fuzzy PROMETHEE II by subtracting the Leaving Flow and Entering Flow values to get the Net Flow value

3. RESULTS AND DISCUSSION

4.1 Interface Design

According to the analysis, there are several interface classes, namely Main Form, Login Form, Decision Maker Data Form, Site Location Choice Data Form, Site Location Criteria Data Form, Site Location Criteria Weight Form, Site Location Choice Weight Form, F Ranking Calculation Form -PROMETHEE I and F-PROMETHEE II Ranking Calculation Form.

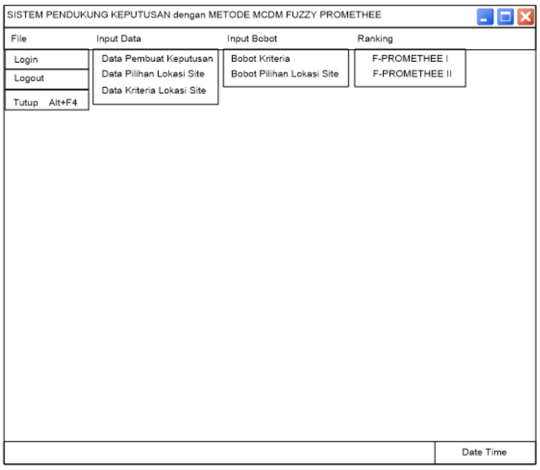

Figure 1. Interface Design [1]

The main form has four main menus, namely File, Data Input, Weight Input and Ranking. On the File menu there are sub menus, namely Login, Logout and Close. In the Data Input menu there are three sub menus, namely Decision Maker Data which is used to process decision maker data, site location choice data which is used to process site location choice data, and the Site Location Criteria Data sub menu which is used to process criteria data. Site Location. In the Weight Input menu there are two sub menus, namely Criteria Weight which is used to store criteria weights and the Site Location Choice Weight sub menu which is used to store site location choice weights. Meanwhile, in the Ranking menu there are two sub menus, namely F-PROMETHEE I which is used to calculate the F-PROMETHEE I ranking and the F-PROMETHEE II sub menu which is used to calculate the F-PROMETHEE II ranking.

4.2 Testing

Based on the results of the tests that have been carried out, it can be concluded that the unit and interface tested work well. This can be seen from all the test scenario conclusions being the same, namely accepted.

Accuracy testing in the data input process for decision makers, site location choices and site location criteria can be seen in Figures 2 to 4.

Figure 2: Successful Decision Maker Data Input testing with PK name input: Bpk. Dian Purnama and PK description: HARIFF DTE Palembang Coordinator.

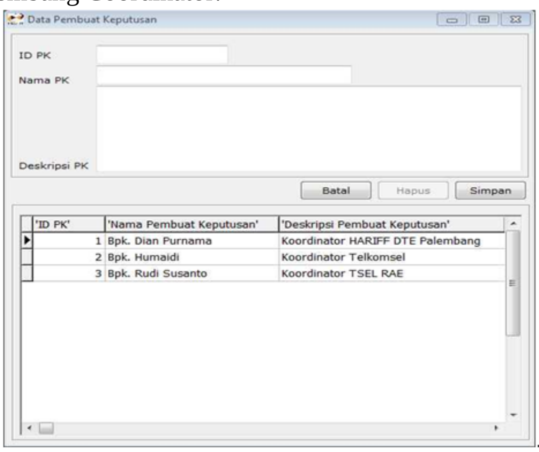

Figure 2. Testing Decision Maker Data Input

Figure 3 Successful Site Location Choice Data Input Test with input of PLS name: Seputih Raman and PLS description: Site Location 1.

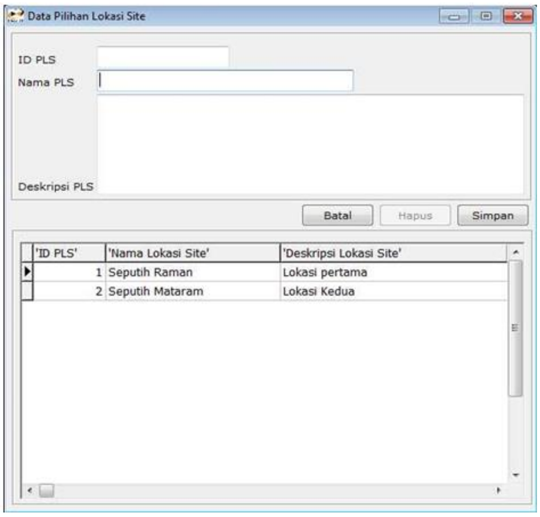

Figure 3. Data Input Test for Site Location Choices

Meanwhile, Figure 4 is a successful Site Location Criteria Data Input Test by inputting the KLS name: Area Coverage, KLS Rule: Min and KLS preference type: V-Shape Criterion.

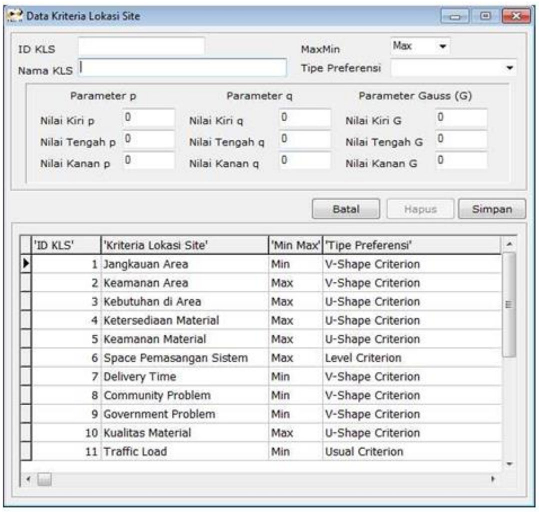

Figure 4. Testing Data Input for Site Location Criteria

The successful weight input testing can be seen in Figures 5 and 6 . Figure 5 is a test of the Site Location Criteria Weight Input with decision maker ID input: 1, namely Mr. Dian Purnama, ID criteria: 1, namely Area Coverage and criteria weight: 2, namely Medium.

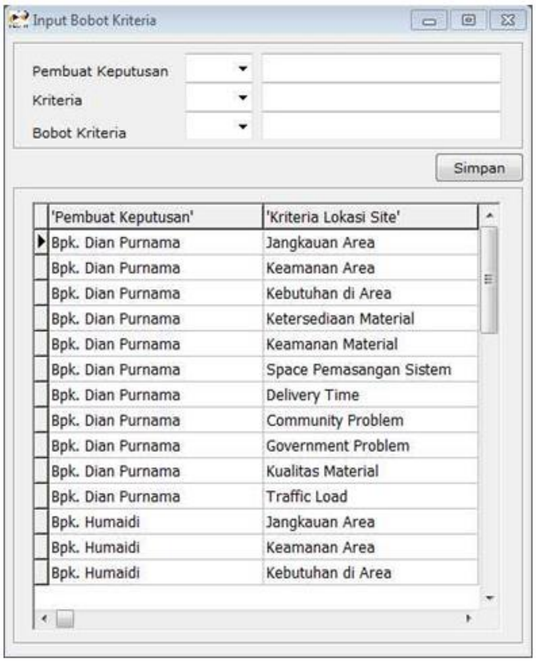

Figure 5. Criteria Weight Input Testing

Figure 6 is a test of the Site Location Choice Weight Input with input of Site Location choice ID: 1, namely Seputih Raman, criteria ID: 1, namely Area Coverage and Site Location choice weight: 1, namely Low .

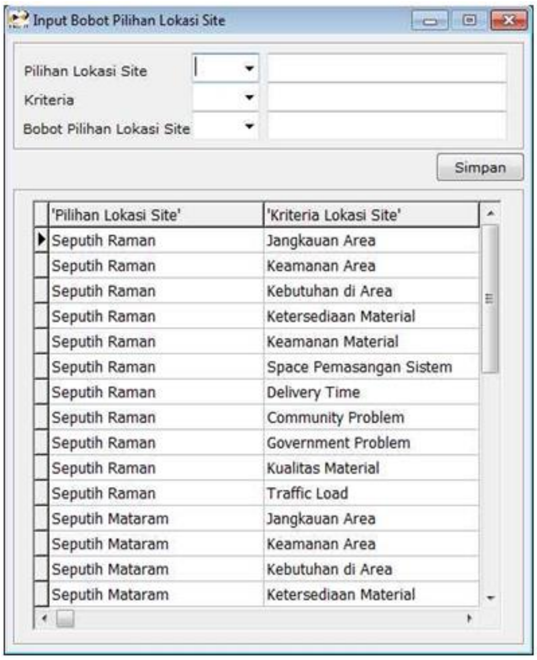

Figure 6. Testing Input Weights for *Site Location Choices*

Meanwhile, the results of the successful ranking calculation test can be seen in Figures 7 and 8.

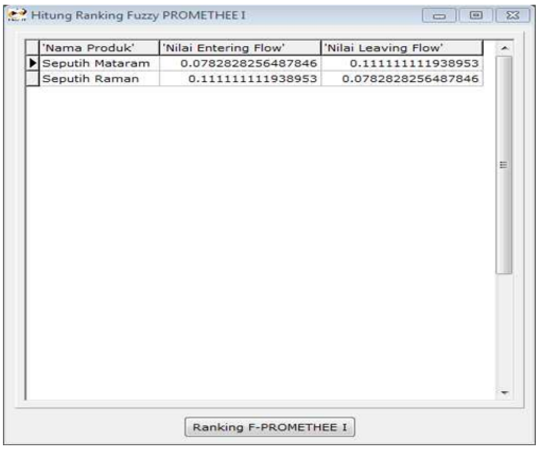

Figure 7. F-PROMETHEE I Ranking Calculation Test

Figure 8. F-PROMETHEE II Ranking Calculation Test

In this section, the research results are explained and at the same time a comprehensive discussion is given. Results can be presented in numbers, graphs, tables, and others that make it easy for readers to understand. Discussion can be carried out in several sub-chapters. It is strongly recommended that comparisons with results from other published articles be provided to provide more context and to substantiate claims of novelty.

4. CONCLUSIONS AND RECOMMENDATIONS

The design and implementation of the F-PROMETHEE ranking calculation application has been successfully carried out, but it still has weaknesses, namely: Calculations only up to PROMETHEE II, the accuracy of which is still not 100% compared to the next generation PROMETHEE. Decision making using ranking calculations is still not fully capable of determining good decisions due to limited knowledge and data obtained.

BIBLIOGRAPHY

Biasrori, R., Arimbawa, IWA, & W., IWW (2019). ELECTRICITY CONSUMPTION DECISION SUPPORT SYSTEM WITH IMPLEMENTATION OF IOT AND FUZZY RULE MINING. Journal of Informatics and Electronic Engineering , 2 (1), 60–69. https://doi.org/10.36595/jire.v2i1.91

Dwitama, RS (2019). Selection of the Multi Criteria Decision Making (MCDM) Method Using the Rank Similarity Simulation (RSS) Approach. In Proceedings of the Darmajaya National Seminar , 1 , 27–37.

Herlambang, IE (2022). DECISION MAKING SYSTEM FOR PRODUCT PURCHASE RECOMMENDATIONS USING THE FUZZY MCDM METHOD (Case Study of PT. Nerangi Sarana Karya). Scientific Journal of Information Systems , 1 (1), 51–61.

Karim, J. (2018). DECISION SUPPORT SYSTEM FOR DETERMINING DEVELOPMENT PRIORITIES USING THE PROMETHEE METHOD IN AYULA VILLAGE, RANDANGAN DISTRICT, POHUWATO DISTRICT, GORONTALO PROVINCE. ILKOM Scientific Journal , 10 (1), 86–91. https://doi.org/10.33096/ilkom.v10i1.232.86-91

Lestari, SP, & Sudarsono, BG (2021). Selection of Strategic Locations for Culinary Business Using the Extended Promethee II Method. J-SAKTI (Journal of Computer Science and Informatics) , 5 (1), 172–183. https://doi.org/10.30645/j-sakti.v5i1.310

Limbong, T., Muttaqin, M., Iskandar, A., Windarto, agus Perdana, Simarmata, J., Mesran, Sulaiman, oris krianto, Siregar, D., Nofriansyah, D., Napitupulu, D., & Wanto, A. (2020). Decision Support Systems: Methods & Implementation (A. Rikki (ed.)). We Write Foundation.

Loganathan, A., & Mani, I. (2018). A Discourse of Multi-criteria Decision Making (MCDM) Approaches. Ain Shams Engineering Journal , 9 (4), 2943–2950. https://doi.org/10.1016/j.asej.2017.11.005

Putri, IK, & Asrun, B. (2017). APPLICATION OF FUZZY LOGIC IN PREDICTING DISEASES USING THE FUZZY MULTI CRITERIA DECISSION MAKING METHOD AT ATMEDIKA HOSPITAL IN PALOPO CITY. D'ComPutarE: Scientific Journal of Information Technology , 7 (2), 1–8.

Qiao, D., Shen, K., Wang, J., & Wang, T. (2021). Multi-criteria PROMETHEE method based on possibility degree with Z-numbers under uncertain linguistic environment. Journal of Ambient Intelligence and Humanized Computing, 11(5), 2187–2201. https://doi.org/10.1108/BIJ-02-2021-0071

Rusli, M. (2017). Dasar Perancangan Kendali Logika Fuzzy. universitas Brawijaya Press.

Samanlioglu, F., & Ayağ, Z. (2017). A fuzzy AHP-PROMETHEE II approach for evaluation of solar power plant location alternatives in Turkey. Journal of Intelligent & Fuzzy Systems, 33(2), 859–871. https://doi.org/10.3233/JIFS-162122

Sanusi, S., & Husna, J. (2018). DECISION MAKING SYSTEM USING TOPSIS FUZZY MCDM FOR WEB BASED TOURISM SELECTION. Scientific Journal of Information Systems Engineering and Management , 4 (1), 26–35. https://doi.org/10.24014/rmsi.v4i1.4889

Widyasari, R., Cipta, H., & Husein, I. (2019). INTEGRATED AHP AND FUZZY-PROMETHEE ON BEST SELECTION PROCESS. ZERO: Journal of Science, Mathematics and Applied Science , 2 (1), 23–34. https://doi.org/10.30829/zero.v2i1.3164