International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 1 Jan. 2023, pp: 738-745 www.ijaem.net ISSN: 2395-5252

Application of CRITIC and PROMETHEE II Methods for Determination of Library User Identification

Aliu Folasade Mercy, Agbele K. Kehinde
Department of Computer Science, Elizade University, Ilara-Mokin,Ondo State, Nigeria.
Department of Computer Science, Elizade University, Ilara-Mokin,Ondo State, Nigeria.

Date of Submission: 12-01-2023 Date of Acceptance: 24-01-2023

ABSTRACT
One of the major challenges a library faces is user identification. To address this issue, a number of technologies and approaches have been adapted over time. Some of these technologies include Barcodes, Radio Frequency Identification (RFID), smart card and biometrics. The determination of an appropriate technology can be quite tedious due to several factors that must be considered in the selection process. Hence, the need for a multicriteria decision method cannot be over-emphasized. This research study applies a combination of CRITIC (Criteria Importance Through Intercriteria Correlation) and PROMETHEE II (Preference Ranking Organization Method for Enrichment Evaluation)procedures in choosing an appropriate user identification tool for a school library. CRITIC was employed to calculate the empirical weightings for the criteria, and PROMETHEE II was applied to select the technology with the best value.Four user identification technologies (barcode, RFID, magstripe and fingerprint) were examined based on four criteriato include affordability, maturity, security and adoption. The output of the analysis shows that securityis the most important factor in the selection process, with the weight of 33.26%, and Magstripe technology had the highest-ranking score.

Keywords
CRITIC, PROMETHEE II, Barcode, RFID, Magstripe, Fingerprint

I. INTRODUCTION

A library is seen as a place for keeping books and resources for learning and research. The materials are usually organized in a manner they can be easily accessed by the intending users. These materials can be in the form of audio, visual or audiovisuals. Many libraries make use of library management systems to automate the activities involved in their day-to-day operations and to reduce operational costs. This saves a lot of time for the users and the librarians. As libraries become bigger, there is a need to secure the available resources. The need for protection of these materials has led to a shift from manual records to electronic storage systems (Mittal, 2017) (Kabel et al., 2021).

Identification of books and users is one of the major processes involved in library procedures. This is required to prevent theft and to ensure that library materials are returned to their appropriate location. Identity management involves processes and technology that identify users and implement restrictions on access to resources (Lodwick, 2014) (Oluyemi, 2019). There are quite a number of different access control technologies that are in use or can be utilized in a library. Some of these include but are not limited to barcodes cards, magstripes, radio frequency identification (RFID) tags and biometrics.

According to Focardi et al. (2017), a barcode is a simple visual representation which holds data in special structures of perpendicularly dispersed lines as well as special correlations of transverse and longitudinal squares.Barcode scanners are used to retrieve the information.A magstripe card is a card that contains magnetic stripes that can store information and can be read when swept through a card reader (Avinash&Vajrashri, 2019).RFID tags store and broadcast information to reader devices. It uses electromagnetic fields to automatically identify and track tags linked to an object. RFID systems have readers and antennas that are used to interrogate the RFID tags (Aliu, 2020). They are used to identify and track personnel that require access control management. The concept of biometrics makes use of a person's distinctive physiological and behavioral characteristics to recognize and authenticate his or her identity(“Technology Landscape for Digital Identification,” 2018).

Each of these tools have their strengths and weaknesses. For example, an unauthorized individual can read an RFID tag when the tag is not in its shield wallet. Likewise, barcode cards and magstripe cards can be easily cloned and stolen. According to Jacobs and Poll (2010), one of the privacy risks of biometrics is that storing data in its original form, rather than vague formats, can sometimes boost the likelihood of fraudulent activity.These do not mean that we should ‘throw out the baby with the bath water.’ Choices can be made with the reduced risks in mind. This is possible using multi-criteria decision-making (MCDM) mechanisms.MCDMs help to make decisions when multiple criteria need to be considered to make a choice among several alternatives.

CRITIC method belongs to the group of correlation techniques which establishes the analytic assessment of a decision matrix to evaluate the information based on the various criteria. CRITIC method has been used in conjunction with other analytical methods over the years. For instance, the collective bargaining agreement evaluation issue was addressed by Adali&Isik (2017) using the CRITIC as well as MAUT (Multi Attribute Utility Theory) techniques. While the overall assessment of the service agreement competitors was achieved using MAUT, the values for the contract manufacturer decision were acquired from the CRITIC technique.

Krishnan et al. (2021) introduced a modified CRITIC method to evaluate five smart phone models based on five criteria. In order to address comprehensive evaluation issues about the functional status of shorelines in canals, Zhang et al. (2022) merged the AHP (Analytic Hierarchy Process) with the CRITIC technique. Abas et al. (2022) combined CRITIC with CODAS (Combinative Distance-Based Assessment) method to perform multi-response optimization of end-milling operations. Their output produced better results than other traditional methods.In addition, the CRITIC-WASPAS (weighted aggregated sum product assessment) cross judgment procedure was used in the study of Slebi-Acevedo et al. (2020) to determine the best option across a range of materials utilizing the findings of diagnostic procedures.

Tanvir et al. (2022) carried out an investigation to prioritize the potential fire elements of fully prepared apparel industry.The fire-risk factors were categorized into six groups and the fifty alternatives were analyzed and given objective weights through the CRITIC technique.Aksakal et al. (2022) also applied CRITIC procedure to get the unbiasedvalues of insulation materials based on eight criteria.Mitra (2021) integrated CRITIC and Range of Value (ROV) methods to grade raw jute fibers and recommended it a as a potent decision-making tool with good background logic.

Vahid et al. (2014) used a time-series strategy in addition to the ÉLECTRE III (Élimination Et Choix Traduisant la REalite) and PROMETHEE II methods to select the best masonry for multi-housing installations.Anjali et al., (2021) proposed a methodology motivated by PROMETHEE II to identify the best criteria and compute preference indices in line with the selected criteria.PROMETHEE II has also been employed in supplier selection, which is a challenging undertaking that may have an effect on different logistics activities.(Agrawal, 2021). Hongju et al. (2013) proposed an improved PROMETHEE II to help enhance occurrence operational effectiveness and turnaround time.PROMETHEE II procedure was also employed to solve the problem of selecting a facility location in the productionsector(Vijay et al., 2010). Katerina and Aristotelis (2021) used a perfect blend of AHP and PROMETHEE II to evaluate environmental content websites. The outcome demonstrated that PROMETHEE II is beneficial for ranking alternatives.

Furthermore, Lazim et al. (2018) suggested utilizing the PROMETHEE as a preference for eco-friendly providers based on a number of threshold preference models. Seven ecological and economic criteria, four vendors, and five decision-makers made up the major structures of the sustainable supplier selection dilemma.Ade et al. (2019) applied PROMETHEE II in a Decision Support System to determine the most outstanding student in a university. AHP and PROMETHEE was applied by Sharma et al. (2018) to solve a multicriteria problem on banking industries based on four criteria. Their ranking showed high correlation coefficient between the models. Palczewski&Sałabun(2019) solved the problem of solving a new airport location with PROMETHEE II method. Seven criteria were considered and ten alternatives were examined. Veza et al. (2014) employed PROMETHEE II to compare and rank industrial enterprise based on their competences. They concluded that the determination of criterion weights should be a transparent process. Laila et al. (2021) analyzed the application of PROMETHEE on transportation and came up with the limitations that could be worked on to improve the quality of public transportation service.

In this research, we consider barcodes cards, RFID tags, magstripes and fingerprints biometrics for the multicriteria decision process using CRITIC and PROMETHEE II methods. The factors for the selection process are based on affordability, maturity, security and adoption. CRITIC is used to determine weights of criteria when decision makers have conflicting views. PROMETHEE II helps in ranking the various technologies for selection.

II. METHODS

2.1. Criteria Importance Through Intercriteria Correlation (CRITIC)

The stages below are included in the CRITIC approach.

Create the decision matrix as Step 1 so that it displays the scores of the choices in relation to the different parameters.

Standardize the choice matrix as a second step.

$$X = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ X_{m1} & X_{m2} & \cdots & X_{mn} \end{bmatrix} (i = 1, 2 \ldots, m \text{ and } j = 1, 2, \ldots, n) \quad (1)$$

$$\overline{X_{ij}} = \frac{X_{ij} - X_j^{worst}}{X_j^{best} - X_j^{worst}} \quad (2)$$

where, $\overline{X_{ij}}$ is the standardizedscore value of i^{th}option on the j^{th}factor;X_{ij} represents the values of each criterion; X_j^{best} is the highest score possible for each condition; and X_j^{worst} is the worst scorein relationto each criterion.

The standard deviation, σ, for each factor should be computed in step three.

$$\sigma = \sqrt{\frac{\sum(\overline{X_{ij}} - \mu)^2}{N}} \quad (3)$$

where μrepresents the mean of each factor, and N is the quantity of values of each criterion.

The linear correlation coefficient between the vectors X_j and X_k. is represented by element r_{jk}in the symmetric matrix of n × n,which must be determined in step 4.

$$r_{jk} = \frac{n\left(\sum x_j x_k\right) - (\sum x_j)(\sum x_k)}{\left[n \sum x_j{}^2 - \left(\sum x_j\right)^2\right][n \sum x_k{}^2 - (\sum x_k)^2]} \quad (4)$$

The next step is to measure the conflict brought about by criterion j in relation to the choice scenario established by the other criteria.

$$\sum_{k=1}^{m} (1 - r_{jk}) \quad (5)$$

Evaluate the amount of data in regard to each criterion, C_{ij} ,as step six.

$$C_{ij} = \sigma_j \times \sum_{k=1}^{m} (1 - r_{jk}) \quad (6)$$

Step 7: Determine the objective weights, W_j.

$$W_j = \frac{C_{ij}}{\sum_{k=1}^{m} C_{ij}} \quad (7)$$

2.2 Preference Ranking Organization Method for Enrichment Evaluation(PROMETHEE)

One approach to multi-criteria decision making is PROMETHEE(Mesran et al., 2018). It is a way for determining the best alternative after analyzing some specified criteria.PROMETHEE method is a channel of determining order in multi-criteria assessment (Ade et al., 2019). According to Ishak et al. (2019), PROMETHEE handles the evaluation and determination of some alternatives based on certain benchmarks with the goal of ranking them. The result of Widiantaet al. (2018) showed that the application of PROMETHEE on multicriteria decision making gives an accurate outcome with many criteria.

PROMETHEE has several extensions. However, PROMETHEE II is utilized in this study's evaluation because it offers a comprehensive ranking for the options(Mareschal, 2005). Herein are highlighted the procedures for PROMETHEE II.

Step 1: Standardize the evaluation matrix (decision matrix) as expressed in equation 8 and equation 9.

Beneficial Criteria: $R_{ij} = \frac{[x_{ij} - \min(x_{ij})]}{[\max(x_{ij}) - \min(x_{ij})]}$ (8)

$(i = 1,2, \ldots, m; j = 1,2, \ldots, n)$

Non-beneficial Criteria: $\acute{R}_{ij} = \frac{[\max(x_{ij}) - x_{ij}]}{[\max(x_{ij}) - \min(x_{ij})]}$ (9)

where x_{ij} is the value of each criterion, $\min(x_{ij})$ is the minimum score for each factor, and $\max(x_{ij})$ is the maximum score for each factor.

Step 2: Determine the i^{th} alternative's evaluation differences from the other alternativesas expressed in equation 10.

$$D = R_{aj} - R_{bj} \quad (10)$$

where R_{aj} is the normalized score of a factor, a, and R_{bj} is the normalized value of a factor, b.

Step 3: Perform the preference function calculation, $P_j(a,b)$ as seen in equation 11.

$$P_j(a,b) = \begin{cases} 0, & \text{if } R_{aj} \leq R_{bj} \\ D, & \text{otherwise } R_{aj} > R_{bj} \end{cases} \quad (11)$$

Step 4: Create a function that aggregates preferences, $\pi(a,b)$ as expressed in equation 12.

$$\pi(a,b) = \left[\sum_{j=1}^{n} w_j P_j(a,b)\right] \Big/ \sum_{j=1}^{n} w_j \quad (12)$$

where w_j represents the weights obtained in equation 7.

Step 5: Calculate the entering (negative) outranking flow and the exiting (positive) outranking flow, respectively, φ^-. They are expressed in equations 13 and 14.

$$\varphi^+ = \frac{1}{m-1} \sum_{b=1}^{m} \pi(a,b) \quad (a \neq b) \quad (13)$$

$$\varphi^- = \frac{1}{m-1} \sum_{b=1}^{m} \pi(b,a) \quad (a \neq b) \quad (14)$$

where m represents the number of options.

Step 6: Determine the net outranking flow for every option. It is shown in equation 15.

$$\varphi(a) = \varphi^+(a) - \varphi^-(a) \quad (15)$$

Step 7: Depending on the values of$\varphi(a)$, determine the order in which all the alternatives are to be reviewed.

III. RESULTS AND DISCUSSION

The analysis was performed on the selection process based on the following four criteria.

1. Affordability: This defines the cost-effectiveness of the technology based on the time required for it to be fully functional.
2. Maturity: This factor assesses how long the technology has been in use and how well-understood it is.
3. Security: This considers the protection of the technology from unauthorized access and its resilience to recover from any attack or breach.
4. Adoption: This explains the degree to which the users or operators are willing to accept the technology.

The assessment uses a five-point scale of 1 to 5, as depicted in Table 1, to represent the responses to each evaluation. Table 2 displays the opinions of the decision-makers.

Table 1: Assessment of Five-Point Scale

Scale	Interpretation
1	Extremely Low
2	Low
3	Midpoint
4	High
5	Exceptionally High

Table 2: Decision Makers' Assessment

	Criteria	Affordability	Maturity	Security	Adoption
Alternatives	Barcode	5	5	2	4
	RFID	3	3	4	4
	Magstripe	3	5	4	4
	Fingerprints	3	4	3	2

The criteria are all beneficial. CRITIC technique was employed to acquire the weightings for the criteria. The decision matrix was normalized using equation 2. The values shown in table 3, table 4, table 5, table 6 and table 7 are the outcomes of the CRITIC procedures.

Table 3: Normalized Decision Matrix with the Standard Deviation

Attribute	Affordability	Maturity	Security	Adoption
Barcode	1	1	0	1
RFID	0	0	1	1
Magstripe	0	1	1	1
Fingerprint	0	0.5	0.5	0
Standard Deviation,σ	0.5	0.478713554	0.478714	0.5

Table 4: Symmetric Matrix showing the Linear Correlation

	Affordability	Maturity	Security	Adoption
Affordability	1	0.522232968	-0.87039	0.333333
Maturity	0.522232968	1	-0.45455	0.174078
Security	-0.87038828	-0.454545455	1	0.174078
Adoption	0.333333333	0.174077656	0.174078	1

Table 5: Measure of Conflict

					$\sum_{k=1}^{m}(1-r_{jk})$
Affordability	0	0.477767032	1.870388	0.666667	**3.014822**
Maturity	0.477767032	0	1.454545	0.825922	**2.758235**
Security	1.87038828	1.454545455	0	0.825922	**4.150856**
Adoption	0.666666667	0.825922344	0.825922	0	**2.318511**

Table 6: The amount of data in regard to each criterion

	σ	$\sum_{k=1}^{m}(1-r_{jk})$	C_{ij}
Affordability	0.5	3.014821979	1.507411
Maturity	0.478714	2.758234831	1.320406
Security	0.478714	4.150856078	1.987073
Adoption	0.5	2.318511355	1.159256
		$\sum_j C_{ij}$	5.974145

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 1 Jan. 2023, pp: 738-745 www.ijaem.net ISSN: 2395-5252

Table 7: Objective Weights of each Criterion

	W_j	PercentageW_j
Affordability	0.252322455	25.23224555
Maturity	0.221020009	22.1020009
Security	0.332612089	33.26120886
Adoption	0.194045447	19.40454469

Security was the most crucial consideration in the selection procedure, according to the results shown in table 7.Adoption is the least relevant criterion. The weights obtained in Table 7 were applied in PROMETHEE II to rank the various alternatives. The outcomes are seen in table 8.

Table 8:PROMETHEE II Ranking of the Alternatives

	Leaving Flow, φ^+	Entering Flow, φ^-	Net Outranking Flow, φ	RANK
Barcode	0.427514276	0.277176741	0.150337535	2
RFID	0.23098786	0.268290826	-0.03730297	3
Magstripe	0.341497864	0.084107485	0.257390379	1
Fingerprint	0.092272016	0.462696965	-0.37042495	4

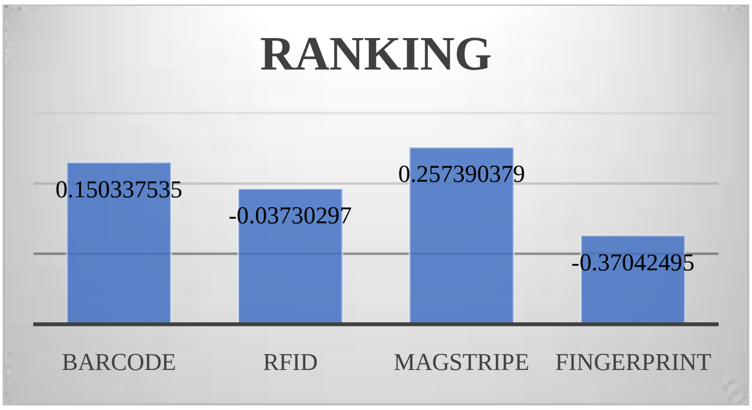

Figure 1: Graphical Representation of the Ranking of the Library Identification Technology

It can be seen from the outcome of the PROMETHEE II ranking that Magstripe has the highest value of 0.257 and Fingerprint option has the lowest value of -0.37. The decision makers therefore opt for the magstripe technology for the identification of library users in their school.

IV. CONCLUSION

The research shows that CRITIC and PROMRTHEE II methods can be combined to help decision makers solve the problem of complexity in their decision-making process. The objective weights for the four criteria(affordability, maturity, security and adoption) were obtained using the CRITIC approach while the ranking of the library identification technologies(barcode, RFID, magstripe and fingerprint) was performed using the PROMETHEE II approach.The result shows that security, with a weight of 33.3%, should be given high consideration when library user identification tools are being considered. The outcome gave magstripe technology as the best option with a ranking value of 0.257.

REFERENCES

[1]. Abas, M., Alkahtani, M., Khalid, Q. S., Hussain, G., Abidi, M. H., & Buhl, J. (2022). Parametric Study and Optimization of End-Milling Operation of AISI 1522H Steel Using Definitive Screening Design and Multi-Criteria Decision-Making Approach. Materials, 15(12), 4086. https://doi.org/10.3390/ma15124086

[2]. Abdullah, L., Chan, W., & Afshari, A. (2018). Application of PROMETHEE

method for green supplier selection: a comparative result based on preference functions. Journal of Industrial Engineering International, 15(2), 271–285. https://doi.org/10.1007/s40092-018-0289-z

[3]. Adalı, E. A., & Işık, A. T. (2017). Critic and Maut Methods for the Contract Manufacturer Selection Problem. European Journal of Multidisciplinary Studies, 5(1), 93. https://doi.org/10.26417/ejms.v5i1.p93-101

[4]. Ade, P. N., Dahrul, D., Ronal, W., & Aman, H. (2019). Application Decision Support System using PROMETHEE Method. Journal of Advanced Research in Dynamical & Control Systems. https://doi.org/10.31227/osf.io/g37wx

[5]. Agrawal, N. (2021). Multi-criteria decision-making toward supplier selection: exploration of PROMETHEE II method. Benchmarking: An International Journal, 29(7), 2122–2146. https://doi.org/10.1108/bij-02-2021-0071

[6]. Aksakal, B., Ulutaş, A., Balo, F., & Karabasevic, D. (2022). A New Hybrid MCDM Model for Insulation Material Evaluation for Healthier Environment. Buildings, 12(5), 655. https://doi.org/10.3390/buildings12050655

[7]. Aliu, M. F., Thompson, F. A., & Akinyokun, K. O. (2020). Selection of a Suitable Electronic Toll Collection System. European Journal of Computer Science and Information Technology, 08(02).

[8]. Avinash, P. B., & Vajrashri, R. B. (2019). Smart and Secured Voting System using Magnetic Stripe Voter ID Card and Cloud Storage: A Client-Server Paradigm. International Research Journal of Engineering and Technology (IRJET), 06(04).

[9]. Balali, V., Zahraie, B., & Roozbahani, A. (2014). Integration of ELECTRE III and PROMETHEE II Decision-Making Methods with an Interval Approach: Application in Selection of Appropriate Structural Systems. Journal of Computing in Civil Engineering, 28(2), 297–314. https://doi.org/10.1061/(asce)cp.1943-5487.0000254

[10]. Focardi, R., Luccio, F. L., & Wahsheh, H. A. M. (2017). Security Threats and Solutions for Two-Dimensional Barcodes: A Comparative Study. Computer and Network Security Essentials, 207–219. https://doi.org/10.1007/978-3-319-58424-9_12

[11]. Ishak, A., Asfriyati, & Akmaliah, V. (2019). Analytical Hierarchy Process and PROMETHEE as Decision Making Tool: A Review. IOP Conference Series: Materials Science and Engineering, 505(1), 012085. https://doi.org/10.1088/1757-899x/505/1/012085

[12]. Jacobs, B., & Poll, E. (2011). Biometrics and Smart Cards in Identity Management. Information Technology and Law Series, 419–438. https://doi.org/10.1007/978-90-6704-731-9_23

[13]. Kabassi, K., & Martinis, A. (2021). Sensitivity Analysis of PROMETHEE II for the Evaluation of Environmental Websites. Applied Sciences, 11(19), 9215. https://doi.org/10.3390/app11199215

[14]. Kabel, N. A., Zhou, J., Zotoo, I. K., & Su, W. (2021). Electronic Records Adoption in Archive Management in Djibouti's Academic Libraries: Barriers and the Role of Knowledge Sharing. OALib, 08(02), 1–15. https://doi.org/10.4236/oalib.1107116

[15]. Krishnan, A. R., Kasim, M. M., Hamid, R., & Ghazali, M. F. (2021). A Modified CRITIC Method to Estimate the Objective Weights of Decision Criteria. Symmetry, 13(6), 973. https://doi.org/10.3390/sym13060973

[16]. Lodwick, D. (2014). Access and Identity Management for Libraries: Controlling Access to Online Information. Technical Services Quarterly, 32(1), 112–113. https://doi.org/10.1080/07317131.2015.972909

[17]. Mareschal, B. (2005). Promethee Methods. International Series in Operations Research &Amp; Management Science, 163–186. https://doi.org/10.1007/0-387-23081-5_5

[18]. Mesran Mesran, Surya Darma Nasution, Sandy Syahputra, Abdul Karim, & Elvitrianim Purba. (2018). Implementation of the Extended Promethee II in Upgrade Level of Mechanic. International Journal of Scientific Research in Science and Technology, 4(2), 125–130. https://doi.org/10.32628/ijsrst184152

[19]. Mitra, A. (2021). Grading of Raw Jute Fibres Using Criteria Importance through Intercriteria Correlation (CRITIC) and

Range of Value (ROV) Approach of Multi-criteria Decision Making. Journal of Natural Fibers, 19(14), 7517–7533. https://doi.org/10.1080/15440478.2021.1951422

[20]. Mittal, A. (2017). Emerging Technologies and their Impact on the Libraries. Indian Journal of Science and Technology, 10(31), 1–4. https://doi.org/10.17485/ijst/2017/v10i31/113915

[21]. Oluyemi, A., Christopher, U. E., Edward, O. A., & Hammawa, M. B. (2019). Development of a National Identity Management System using Blockchain Technology. Afr. J. Comp. & ICT, 12(04), 13–36.

[22]. Palczewski, K., & Sałabun, W. (2019). Influence of various normalization methods in PROMETHEE II: an empirical study on the selection of the airport location. Procedia Computer Science, 159, 2051–2060. https://doi.org/10.1016/j.procs.2019.09.378

[23]. Pamučar, D., Ecer, F., Cirovic, G., & Arlasheedi, M. A. (2020). Application of Improved Best Worst Method (BWM) in Real-World Problems. Mathematics, 8(8), 1342. https://doi.org/10.3390/math8081342

[24]. Sharma, A., Kaur, G., & Bansal, J. (2018). A comparative analysis of promethee, ahp and topsis aiding in financial analysis of firm performance. Proceedings of the First International Conference on Information Technology and Knowledge Management. https://doi.org/10.15439/2017km39

[25]. Singh, A., Gupta, A., & Mehra, A. (2020). Best criteria selection based PROMETHEE II method. OPSEARCH, 58(1), 160–180. https://doi.org/10.1007/s12597-020-00464-7

[26]. Slebi-Acevedo, C. J., Pascual-Muñoz, P., Lastra-González, P., & Castro-Fresno, D. (2019). A multi-criteria decision-making analysis for the selection of fibres aimed at reinforcing asphalt concrete mixtures. International Journal of Pavement Engineering, 22(6), 763–779. https://doi.org/10.1080/10298436.2019.1645848

[27]. Tanvir, S., Mehedi, H., Saiful, I., Asif, K., Mahbubur, R., & Ahmed, S. M. F. (2022). Prioritizing Fire Risk Criteria in Ready-Made Garments Factories of Bangladesh by Applying CRITIC Method. International Conference on Mechanical, Manufacturing and Process Engineering.

[28]. Technology Landscape for Digital Identification. (2018). World Bank Group's Identification for Development (ID4D). https://doi.org/10.1596/31825

[29]. Veza, I., Celar, S., & Peronja, I. (2015). Competences-based Comparison and Ranking of Industrial Enterprises Using PROMETHEE Method. Procedia Engineering, 100, 445–449. https://doi.org/10.1016/j.proeng.2015.01.389

[30]. Vijay Manikrao Athawale, & Shankar Chakraborty. (2010). Facility Location Selection using PROMETHEE II Method. International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh.

[31]. Widianta, M. M. D., Rizaldi, T., Setyohadi, D. P. S., & Riskiawan, H. Y. (2018). Comparison of Multi-Criteria Decision Support Methods (AHP, TOPSIS, SAW & PROMENTHEE) for Employee Placement. Journal of Physics: Conference Series, 953, 012116. https://doi.org/10.1088/1742-6596/953/1/012116

[32]. Zhang, F., Wang, P., Mu, P., Wang, M., Han, L., & Sun, J. (2022). A Comprehensive Evaluation Method for the Service Status of Groins in Waterways Based on an AHP-Improved CRITIC Combination Weighting Optimization Model. Sustainability, 14(17), 10709. https://doi.org/10.3390/su141710709

[33]. Zhao, H., Peng, Y., & Li, W. (2013). Revised PROMETHEE II for Improving Efficiency in Emergency Response. Procedia Computer Science, 17, 181–188. https://doi.org/10.1016/j.procs.2013.05.025