University of Baghdad
College of Engineering
JE
JOURNAL OF ENGINEERING

Journal of Engineering

journal homepage: www.joe.uobaghdad.edu.iq

Volume 28 Number 12 December 2022

Civil, and Architectural Engineering

Multi-Criteria Optimization for Governmental Projects Priority Ranking Depending on Fuzzified Experts' Opinion using Hygiene Approach

Ahmed Reyadh Radhi *	Abbas M. Burhan
Ph.D. student and Lecturer	Asst. Prof. Dr
College of Engineering	College of Engineering
Al – Musaib-University of Babylon	Civil Engineering Department.
Iraq, Babil	University of Baghdad
Email: Ahmedrr989@gmail.com	Iraq, Baghdad
	Email: abbasm.burhan@coeng.uobaghdad.edu.iq

ABSTRACT

Each organization struggles to exploit each possible opportunity for gaining success and continuing with its work carrier. In this field, organization success can be concluded by fulfilling end user requirements combined with optimizing available resources usage within a specified time and acceptable quality level to gain maximum profit. The project ranking process is governed by the multi-criteria environment, which is more difficult for the governmental organization because other organizations' main target is maximizing profit constrained with available resources. The governmental organization should consider human, social, economic and many more factors. This paper focused on building a multi-criteria optimizing projects ranking framework using hygiene methodology from sequential stages. The proposed framework can deal with numerical and linguistic criteria considering experts, or consultant evaluation on projects, in addition to criteria weights. Fuzzy logic and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) methods are used to control the ranking process within a limited allocated budget. The importance of the proposed approach is making projects ranking getting out from dependence on economic measures that govern the overall process to non – measurable criteria that affect organization success and the proposed projects selection process.

Keywords: Multi-criteria optimization, Project priority, Project ranking, Fuzzy, PROMETHEE.

أمثلية متعددة الخصائص لتصنيف أولوية المشاريع الحكومية بالاعتماد على أراء الخبراء المضببة بإستخدام أسلوب هجين.

احمد رياض راضي	عباس محمد برهان
طالب دكتوراه و مدرس	استاذ مساعد دكتور
كلية الهندسة / المسيب جامعة بابل و كلية الهندسة - جامعة بغداد	كلية الهندسة جامعة بغداد

*Corresponding author
Peer review under the responsibility of University of Baghdad.
https://doi.org/10.31026/j.eng.2022.12.08

Article received: 25/6/2022
Article accepted: 13/8/2022
Article published: 1/12/2022

الخلاصة

تكافح كل مؤسسة لاستغلال كل فرصة ممكنة لتحقيق النجاح والاستمرار في مجال العمل الخاص بها. في هذا المجال ، يمكن تلخيص نجاح المؤسسة عن طريق تلبية متطلبات المستخدم النهائي مع العمل على أمثلية استخدام الموارد المتاحة في غضون وقت محدد ، ومستوى جودة مقبول لتحقيق أعلى ربح. تخضع عملية تصنيف المشروع لبيئة متعددة المعايير والتي تكون أكثر صعوبة بالنسبة للمنظمات الحكومية لأن الهدف الرئيسي للمؤسسة الأخرى هو تعظيم الأرباح المقيدة بالموارد المتاحة. يجب أن تأخذ المنظمات الحكومية في الاعتبار العوامل البشرية والاجتماعية والاقتصادية والعديد من العوامل الأخرى. يركز هذه البحث على بناء هيكلية متعددة المعايير لتحسين تصنيف المشاريع باستخدام منهجية هجينة تتكون من مراحل متسلسلة. يمكن أن تتعامل الهيكلية المقترحة مع المعايير العددية واللغوية مع الأخذ بنظر الاعتبار تقييم الخبراء ، أو المستشارين للمشاريع ، بالإضافة إلى النسبة الوزنية للمعايير. يتم استخدام المنطق الضبابي وطريقة تنظيم الترتيب التفضيلي لإثراء التقييمات (PROMETHEE) للتحكم في عملية التصنيف ضمن ميزانية مخصصة محدودة. تكمن أهمية النهج المقترح في جعل ترتيب المشاريع يخرج من الاعتماد على المقاييس الاقتصادية التي تحكم العملية الكلية إلى معايير غير قابلة للقياس تؤثر على نجاح المنظمة ، وعملية اختيار المشاريع المقترحة.

الكلمات الرئيسية: تصنيف المشاريع، أختيار المشاريع، الامثلية متعددة المعايير، المنطق المضبب.

1. Introduction:

The organization struggles to survive a continually and rapidly changing environment. The opportunity to optimize resource usage can mainly start from selecting the best project process, which is one of the most important priorities for top management **(Almusawi, 2020)**.

For commercial companies and profit base organizations, top management selects projects depending mainly on economic measurements and maximum profit within the company's limitation of available resources. An approach introduced to help the decision maker to evaluate the proposed project with available financial and technical information use four alternative evaluation methods (B/C ratio, ROR NPV, and payback period) in Analytical Hierarchy Process as a criterion weight and improves it with a fuzzy set theory and TOPSIS algorithm (S. Mahmoodzadeh). At the same time, a procedure is based on a research and development project selection model to maximize net present value. The model is quadratic (zero – one) programmed and uses fuzzy logic to deal with project expenditures and (NPV) values as non–crisp numbers **(Yi, 2008).**

For private sector companies, project selection process is constrained by organization resources. Many opportunities emerged to manage resources and maximize benefits by optimizing the project selection process **(Burhan, 2022)**. A mathematical formula is developed as a mixed integer linear program, and the ant colony method deploys four criteria of ant generation, colonial, update Pareto front, and pheromone updating mechanisms. Scatter search and Genetic algorithm are used as a comparison algorithm with this multi-criteria mathematical model **(Ali Asghar Tofighian, 2015)**.

This process is more complex for the non – governmental organization or governmental authorities having multi goals and scopes. In order to perform a successful project selection process, we need to detect the selection criteria that govern the overall process (**Ahmed R. R., 2018)**. Many researchers are worked on this issue. A linear goal programming model was presented for public sector project selection with seven priority levels categorized into (no multiple projects, economic goals, social, political, and other goals) **(Benjamin, 1985)**.

Most of this type of organization deal with multi-criteria and/or multiobjective optimization. A proposed multi-criteria selection model that uses fuzzy logic for governmental projects **(Lilian Noronha Nassif, 2013)** extends the methodology of macro procedures of portfolio management introduced by **(Mulcahy, 2009)**. The methodology consists of seven stages and adopted criteria pair comparison that affects project success potential. At the same time, a multiobjective model was formulated using a probability distribution. With data from American governmental agencies for more than 80 projects, the model combines Analytic Hierarchy Process and Monte Carlo simulations **(Steven A. Gabriel, 2005)**. The main objectives of this model are average cost and project value labor requirements due to its easiness of dealing with the randomness of ambiguous factors.

Due to uncertainty associated with the project life cycle environment, fuzzy logic can be used combined with optimization methods to deal with uncertainty and preferred to rank projects. This can be noticed when fuzzy triangular numbers are used to evaluate the criteria of examining seven critical paths of the project found by the analytical hierarchy process and ranked by the Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) (**Cristobal, 2013**). A fuzzy Visekriterijumska Optimizacija I Kompromisno Resenje (VIKOR) approach is used to detect the best project critical path **(A. Ali-Mohammad, 2010)**. The researcher used a fuzzy analytical network process to find activities' priorities and correlations to each other for the effect of the project's minimum duration.

The project selection approach is formulated work on by merging Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) responsible for project selection based on criteria recommended by experts under an ambiguous environment with evaluate Decision – Making Trial and Evaluation Laboratory (DEMATEL) as triangular neutrosophic number (**Mohamed Abdel-Basset, 2018**).

2. Project Ranking Process Framework.

Due to complicated circumstances and continuously changing boundary conditions that affect the project ranking process, most organizations depend on experts committee to evaluate proposed projects depending on various criteria to reveal their goals **(Hela Moalla Frikha, 2017**). One of the most governed constraints is the allocated budget which forced us to optimize project selection. The proposed framework gives high flexibility by dealing with a numerical value of quantitative criteria and linguistic evaluation of qualitative criteria type. Ranking criteria behavior can be benefit or non–benefit criteria considering criteria weight.

The project ranking framework consists of multi stages that deal with all details of the ranking process. The first stage is working on ranking process criteria identification and detecting its relative importance weight. In addition, clarify ranking criteria categories, whether qualitative or quantitative. Real data is used to verify the model, and the proposed project is evaluated according to six ranking criteria using an expert committee and decision–making procedure.

In this part, the main abbreviations and equations used to build the ranking framework re introduced.

I. List of proposed Projects Pr_i (Pr_1, Pr_2, Pr_3, ..., Pr_i) where i = total no. of projects.

II. List of Experts or decision makers Exj (Ex_1, Ex2, Ex_3, ..., Ex_j) where j = total number of experts.
III. List of ranking Criteria Cr_n (Cr_1, Cr_2, Cr_3, . . ., Cr_n) where n = total number of ranking criteria.
IV. F_{nij} is Expert opinion related to each project according to specific criteria.
V. W_{cn} is the weight of the criteria. (Can be applied if required).

Ranking criteria can be divided depending on behavior to fitness function into two types: benefits criteria are maximizing the fitness function when its maximized, while cost criteria are maximizing the fitness function when minimized. Even more, the criteria can be quantitative (input as number value) or qualitative (linguistic formula), expert opinion, or evaluation.

Projects will be evaluated individually according to experts' opinions with respect to qualitative ranking criteria **(Zadeh, 1988)**. These evaluations will be interred on five Likert scales (Very High, High, Medium, Low, Very Low). These evaluations will be processed by fuzzy logic using triangular fuzzy numbers shown in **Fig. 1** and their values shown in **Table 1** below.

Table 1 Linguistic five Likert scale using triangular fuzzy number.

Linguistic evaluation	Fuzzy number
Very High (VH)	(4, 5, 5)
High (H)	(3, 4, 5)
Medium (M)	(2, 3, 4)
Low (L)	(1, 2, 3)
Very Low (VL)	(1, 1, 2)

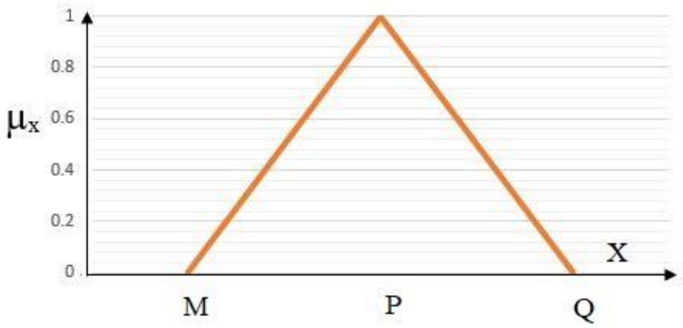

Figure 1 Triangular fuzzy number.

The framework starts by dealing with inputs using fuzzy logic due to its ability to deal with qualitative and quantitative variables. The evaluation of experts and project quantitative variables will be entered with their respective weights. The membership function shown in equation (1) will be used to deal with linguistic evaluation on qualitative criteria in addition to quantitative one F (M, P, Q) where (M < P < Q) and all values on the x-axis. All the criteria will be represented by the fuzzification process considering criteria weights.

$$\boldsymbol{\mu(x)} = \begin{cases} \boldsymbol{If\ X_i \in [M, P]} & \boldsymbol{\frac{X-M}{P-M}} \\ \boldsymbol{If\ X_i \in [P, Q]} & \boldsymbol{\frac{Q-X}{Q-P}} \\ \boldsymbol{Otherwise} & \boldsymbol{0} \end{cases} \quad (1)$$

For a better understanding of the model framework, suppose we have j of experts (Ex_1, Ex_2, ..., Ex_j). The proposed number of projects is equal to i (Pr_1, Pr_2, ..., Pr_i) are needed to be ranked according to the evaluation of the qualitative and numerical value of quantitative criteria. The number of ranking criteria n (Cr_1, Cr_2, ..., Cr_n) with criteria weights Wc_n (Wc_1, Wc_2, ..., Wc_n) that evaluate proposed projects.

Each expert will evaluate the proposed projects related to the qualitative criteria on a five Likert scale measure (Very High, High, Medium, Low, Very Low). So, each expert will provide a matrix that needs to be collected into one matrix to compensate linguistic evaluation by respective triangular fuzzy numbers using equation 2.

$$F_{nij} = (M_{nij}, P_{nij}, Q_{nij}) \quad (2)$$

For example, each expert will give his opinion about projects according to a specific qualitative criterion as a matrix.

$$\text{Expert on.1 evaluation matrix} = \begin{bmatrix} f_{111} & f_{211} & f_{311} & \cdots & f_{n11} \\ f_{121} & f_{221} & f_{321} & & \vdots \\ \vdots & & & & \vdots \\ \vdots & & & & \vdots \\ f_{1i1} & \cdots & \cdots & \cdots & f_{nij} \end{bmatrix}$$

All resulted matrices need to be an aggregated fuzzified matrix for each individual criterion according to equation (3). Each criterion will be transformed from a fuzzy number to a crisp value using the geometric mean value shown in equation (4). Depending on criteria behavior, whether its benefit criteria (better project having lower evaluation) or non-benefit criteria (better project having higher evaluation), the normalization process needs to be performed with ranking criteria according to equation (5) and equation (6) which is considered the starting of PROMETHEE II method (Brans, 1982).

$$\tilde{F} = (\sqrt[j]{(M_{111} \times M_{112} \times \ldots . \times M_{N1j})}, \sqrt[j]{(P_{111} \times P_{112} \times \ldots . \times P_{N1j})}, \sqrt[j]{(Q_{111} \times Q_{112} \times \ldots . \times Q_{N1j})}) \quad (3)$$

$$\tilde{F} = \frac{(M_{nij} + P_{nij} + Q_{nij})}{3} \quad (4)$$

$$\tilde{F} = \frac{[Xij - min(Xij)]}{[max(Xij) - min(Xij)]} \quad for\ benefit\ criteria \tag{5}$$

$$\tilde{F} = \frac{[\max(Xij) - Xij]}{[max(Xij) - min(Xij)]} \quad \text{for Non – beneficial criteria} \tag{6}$$

The crisp evaluation difference between each project and other proposed projects is calculated. The resulting matrices size will be (n × i) and apply the preference function shown in equation (7). The next step is applying the preference function to evaluate the difference for each matrix according to equation (8) and equation (9).

$$\mathrm{D}_{\text{in – (1 to i)n}} = \tilde{F}_{in} - \tilde{F}_{(k)n} \tag{7}$$

$$\mathrm{P}_{\text{in}} = 0 \qquad if\ \mathrm{D}_{\text{in – (k)n}} \leq 0 \tag{8}$$

$$\mathrm{P}_{in} = \mathrm{D}_{\text{in – (1 to i)n}} \qquad if\ \mathrm{D}_{\text{in – (k)n}} > 0 \tag{9}$$

Where k is project alternatives, and the total number of k = i – 1.

Criteria weight will be applied on resulted matrices using normalized criteria weights collected from experts' opinions for each criterion according to equation (10). The resulting metrices will be aggregated in order to conclude aggregate preference function matrix that used as a major factor of project ranking using PROMETHEE part of the methodology **(Macharis, 1998)**. This resulting matrix is a unique comparison matrix between proposed projects, revealing that each project aggregated evaluation according to all ranking criteria. Finding leaving (φ+) and entering (φ –) outranking flows is calculated next using equations (11) and (12). The alternative net outranking flow (φ) will be calculated for each project using equation (13). This ranking is performed according to variable experts' number, individual experts' weights, number of criteria, experts' opinion according to ranking criteria, criteria weights, and criteria behavior, whether it is qualitative or quantitative or benefit or non–benefit criteria.

$$\mathrm{WP}_{\text{in}} = \frac{\sum_{i=1}^{i} \mathrm{P}_{\text{in}} \times \mathrm{Wc}_{\text{n}}}{\sum_{i=1}^{i} Wc_n} \tag{10}$$

$$\varphi^{+} = \frac{1}{i-1} \sum_{1}^{i} \mathrm{WP}_{\text{(in,(i+1)n)}} \tag{11}$$

$$\varphi^{-} = \frac{1}{i-1} \sum_{1}^{i} \mathrm{WP}_{\text{((i+1)n,in)}} \tag{12}$$

$$\varphi = \varphi^{+} - \varphi^{-} \tag{13}$$

3. Example with real data.

To apply the proposed approach to data, six projects and four experts were used. Ranking criteria are two quantitative criteria and four qualitative criteria, which are Cr_1 manpower employing (benefit criteria), Cr_2 project cost (non-benefit criteria), Cr_3 cost escalation risk (non-benefit criteria), Cr_4 using of local resources (benefit criteria), Cr_5 Compliance with environmental legislation (benefit criteria), Cr_6 project contribution on economic and food security (benefit criteria). The first two criteria are quantitative, with values shown in **Table 2**. Experts' evaluations of the other four qualitative criteria are shown in **Table 3** and **Table 4,** taking into consideration the symbols shown below:

Proposed projects from Pr1 to Pr_i
Criteria numbers from Cr1 to Cr_n
Experts numbers from Ex1 to Ex_j

Table 2. Quantitative criteria.

	Cr_1	Cr_2
Pr_1	80	1,100,000
Pr_2	110	1,500,000
Pr_3	27	750,000
Pr_4	150	2,000,000
Pr_5	30	800,000
Pr_6	42	1,250,000

Table 3. Expert no.1 and Expert no.2 evaluation on qualitative criteria.

Projects	Expert no.1				Expert no.2			
	Cr_3	Cr_4	Cr_5	Cr_6	Cr_3	Cr_4	Cr_5	Cr_6
Pr_1	M	VH	VH	M	M	H	VL	VL
Pr_2	VH	L	VH	L	H	L	VH	VL
Pr_3	M	H	VH	M	VH	M	M	H
Pr_4	H	M	M	M	H	M	H	H
Pr_5	VL	VL	L	VL	L	M	L	M
Pr_6	M	VL	L	L	VL	M	H	M

Table 4. Expert no.3 and Expert no.4 evaluation on qualitative criteria.

Projects	Expert no.3				Expert no.4			
	Cr_3	Cr_4	Cr_5	Cr_6	Cr_3	Cr_4	Cr_5	Cr_6
Pr_1	VH	M	M	VH	VL	M	H	VL
Pr_2	VH	H	L	M	M	VH	H	VL
Pr_3	M	VL	VL	M	H	VH	VH	VL
Pr_4	VL	VL	H	H	L	VH	L	H
Pr_5	VH	H	VH	VH	VL	H	VH	L
Pr_6	M	H	VH	VL	VH	M	M	VH

The triangular fuzzy number for each linguistic evaluation are shown in **Table 1**. The aggregated fuzzy project evaluations, defuzzification, and normalized criteria matrices are calculated for each expert, in addition to inputs regarding quantitative criteria taking into consideration criteria behavior are also shown in **Table 5**, **Table 6**, and **Table 7**. The difference between i_{th} project and other alternatives is shown in **Table 8** to **Table 13**. The comparison matrix is built depending on previous tables results shown in table 14 and calculate leaving, entering, and net outranking values that reveal the final project ranking, which is considered the main objective of this approach shown in **Table 15.**

Table 5. Aggregated qualitative criteria fuzzy number evaluations.

Project	Cr3			Cr4			Cr5			Cr6		
Pr$_1$	2.00	2.59	3.56	2.38	3.41	4.23	2.21	2.78	3.76	1.68	1.97	2.99
Pr$_2$	3.13	4.16	4.73	3.72	4.73	5.00	2.63	3.76	4.40	1.19	1.57	2.63
Pr$_3$	2.63	3.66	4.47	2.83	3.87	4.47	2.38	2.94	3.76	1.86	2.45	3.56
Pr$_4$	1.73	2.38	3.50	2.45	2.99	3.98	2.06	3.13	4.16	2.71	3.72	4.73
Pr$_5$	1.41	1.78	2.78	1.86	2.51	3.50	2.00	3.16	3.87	1.68	2.34	3.31
Pr$_6$	2.00	2.59	3.56	1.68	2.28	3.36	2.21	3.31	4.16	1.68	2.34	3.31

Table 6. Fuzzification criteria evaluations.

	Cr$_1$	**Cr$_2$**	**Cr$_3$**	**Cr$_4$**	**Cr$_5$**	**Cr$_6$**
	BENEFIT	NON-BENEFIT	NON-BENEFIT	BENEFIT	BENEFIT	BENEFIT
Wc$_n$ (%)	**15 %**	**25 %**	**15 %**	**15 %**	**15 %**	**15 %**
Pr$_1$	80	1100000	2.715526	3.338852	2.919042	2.213493
Pr$_2$	110	1500000	4.00689	4.483709	3.59777	1.79548
Pr$_3$	27	750000	3.589042	3.724515	3.027283	2.622419
Pr$_4$	150	2000000	2.5367	3.138847	3.117243	3.720644
Pr$_5$	30	800000	1.991884	2.625237	3.011754	2.443964
Pr$_6$	42	1250000	2.715526	2.441629	3.228302	2.443964

Table 7. Normalized ranking criteria.

	Cr$_1$	**Cr$_2$**	**Cr$_3$**	**Cr$_4$**	**Cr$_5$**	**Cr$_6$**
Pr$_1$	0.440	0.720	0.621	0.513	0.013	0.189
Pr$_2$	0.680	0.400	0.000	1.000	0.845	0.000
Pr$_3$	0.016	1.000	0.201	0.677	0.146	0.374
Pr$_4$	1.000	0.000	0.707	0.428	0.256	0.871
Pr$_5$	0.040	0.960	0.969	0.210	0.127	0.293
Pr$_6$	0.136	0.600	0.621	0.132	0.392	0.293

Table 8. First project difference.

	Cr_1	Cr_2	Cr_3	Cr_4	Cr_5	Cr_6	WP_{1n}
Pr_2	0	0.08	0.096131	0	0	0.03257	**0.208701**
Pr_3	0.064634	0	0.065026	0	0	0	**0.12966**
Pr_4	0	0.18	0	0.014691	0	0	**0.194691**
Pr_5	0.060976	0	0	0.052418	0	0	**0.113394**
Pr_6	0.046341	0.03	0	0.065905	0	0	**0.142247**

Table 9. Second project difference.

	Cr_1	Cr_2	Cr_3	Cr_4	Cr_5	Cr_6	WP_{2n}
Pr_1	0.036585	0	0	0.084095	0.15	0	**0.27068**
Pr_3	0.10122	0	0	0.055766	0.126079	0	**0.283064**
Pr_4	0	0.1	0	0.098786	0.106197	0	**0.304983**
Pr_5	0.097561	0	0	0.136513	0.12951	0	**0.363585**
Pr_6	0.082927	0	0	0.15	0.081653	0	**0.31458**

Table 10. Third project difference.

	Cr_1	Cr_2	Cr_3	Cr_4	Cr_5	Cr_6	WP_{3n}
Pr_1	0	0.07	0	0.028329	0.023921	0.031862	**0.154112**
Pr_2	0	0.15	0.031105	0	0	0.064431	**0.245537**
Pr_4	0	0.25	0	0.04302	0	0	**0.29302**
Pr_5	0	0.01	0	0.080747	0.003432	0.013904	**0.108083**
Pr_6	0	0.1	0	0.094234	0	0.013904	**0.208138**

Table 11. Fourth project difference.

	Cr_1	Cr_2	Cr_3	Cr_4	Cr_5	Cr_6	WP_{4n}
Pr_1	0.085366	0	0.013312	0	0.043803	0.11743	**0.259911**
Pr_2	0.04878	0	0.109443	0	0	0.15	**0.308224**
Pr_3	0.15	0	0.078338	0	0.019881	0.085569	**0.333788**
Pr_5	0.146341	0	0	0.037727	0.023313	0.099473	**0.306855**
Pr_6	0.131707	0	0.013312	0.051214	0	0.099473	**0.295706**

Table 12. Fifth project difference.

	Cr_1	Cr_2	Cr_3	Cr_4	Cr_5	Cr_6	WP_{5n}
Pr_1	0	0.06	0.053869	0	0.02049	0.017957	**0.152316**
Pr_2	0	0.14	0.15	0	0	0.050527	**0.340527**
Pr_3	0.003659	0	0.118895	0	0	0	**0.122553**
Pr_4	0	0.24	0.040557	0	0	0	**0.280557**
Pr_6	0	0.09	0.053869	0.013487	0	0	**0.157356**

Table 13. Sixth project difference.

	Cr_1	Cr_2	Cr_3	Cr_4	Cr_5	Cr_6	WP6n
Pr_1	0	0	0	0	0.068347	0.017957	**0.086304**
Pr_2	0	0.05	0.096131	0	0	0.050527	**0.196658**
Pr_3	0.018293	0	0.065026	0	0.044426	0	**0.127744**
Pr_4	0	0.15	0	0	0.024544	0	**0.174544**
Pr_5	0.014634	0	0	0	0.047858	0	**0.062492**

Table 14. Projects comparison matrix.

	Pr_1	Pr_2	Pr_3	Pr_4	Pr_5	Pr_6	$\varphi+$
Pr_1	0	0.208701	0.12966	0.194691	0.113394	0.142247	**0.157738**
Pr_2	0.27068	0	0.283064	0.304983	0.363585	0.31458	**0.256149**
Pr_3	0.154112	0.245537	0	0.29302	0.108083	0.208138	**0.168148**
Pr_4	0.259911	0.308224	0.333788	0	0.306855	0.295706	**0.250747**
Pr_5	0.152316	0.340527	0.122553	0.280557	0	0.157356	**0.175551**
Pr_6	0.086304	0.196658	0.127744	0.174544	0.062492	0	**0.107957**
$\varphi-$	**0.184665**	**0.216608**	**0.166135**	**0.207966**	**0.159068**	**0.186338**	

Table 15. Leaving, entering and net outflow, and project ranking.

	$\varphi+$	$\varphi-$	φ	Ranking
Pr_1	**0.157738**	**0.184665**	**-0.02693**	**5**
Pr_2	**0.256149**	**0.216608**	**0.039541**	**2**
Pr_3	**0.168148**	**0.166135**	**0.002013**	**4**
Pr_4	**0.250747**	**0.207966**	**0.042781**	**1**
Pr_5	**0.175551**	**0.159068**	**0.016483**	**3**
Pr_6	**0.107957**	**0.186338**	**-0.07838**	**6**

4. CONCLUSIONS

Project ranking is a strategic process for each organization and individual. Most of the project ranking methods are based on economic measures and risk of vagueness. A hygiene approach consists of two main stages: the first stage is based on fuzzy logic using triangular fuzzy numbers to deal with qualitative criteria depending on experts' evaluations. Preference Ranking Organization Method for Enrichment of Evaluations PROMETHEE II method deals with criteria weights, behavior, and first-stage outputs to rank the proposed projects.

The proposed approach gives the ability to deal with a variety of ranking criteria, a committee of expert opinion, criteria weights, and overcome the barriers of ranking boundary conditions associated with the project's ranking process.

The proposed methodology depends on comparing projects according to all ranking criteria. These comparisons will produce a matrix that has dimension (no. of projects × no. of criteria) for each project and can reveal the strength and weaknesses of each project relevant to each specific criterion. Currently, adopting a project ranking system in a large number of governmental authorities is based on points methodology that majority of proposed projects have the same degree of importance. These classical systems need to be updated in order to optimize all available resources and allocate budget usage, which in turn meet more end-user requirements in minimum time. More attempts need to be performed with other optimization methods.

REFERENCES

A. Ali-Mohammad, B. M., 2010. The critical path definition with fuzzy multi criteria decision making, The 2nd International Conference on Computer and Automation Engineering (ICCAE), pp. 206-210.

Ahmed Riyadh Radhi, B. A., 2018. Engineer's decision effect on delayed governmental construction project with budget abundance (case study), *International Journal of Civil Engineering and Technology (IJCIET)*.

Ali Asghar Tofighian, B. N, 2015. Modeling and solving project selection and scheduling problem, *Computers & Industrial Engineering*.

Almusawi, H. T., 2020. Developing a Model to Estimate the Productivity of Ready Mixed Concrete Batch Plant, *Journal of Engineering*, 80-93.

Benjamin, C. O., 1985. A Linear Goal-Programming Model for Public-Sector Project Selection, *Journal of the Operational Research Society*, 13-23.

Brans, J., 1982. L'ingénierie de la décision: élaboration d'instruments d'aide à la decision, La méthode PROMETHEE, Presses de l'Université Laval.

Burhan, A. M., 2022. Developing Crisis Management System for Construction Projects in Iraq, *Journal of Engineering*, 33-51.

Cristobal, J. S., 2013. Critical Path Definition Using Multicriteria Decision Making: PROMETHEE Method, *Journal of Construction Engineering and Management*, 158-163.

Hela Moalla Frikha, H. C., 2017. Location of a new banking agency in Sfax: A multi-criteria approach, *International Journal of Information and Decision Sciences* .

Lilian Noronha Nassif, J. C., 2013. Project Portfolio Selection in Public Administration Using Fuzzy Logic, *Procedia - Social and Behavioral Sciences*, 41 – 50.

Macharis, C. B., 1998. The GDSS promethee procedure. Journal of decision systems, *Journal of Decision Systems*, 283-307.

Mohamed Abdel-Basset, A. A., 2018. A hybrid neutrosophic multiple criteria group decision making approach for project selection, Cognitive Systems Research.

Mulcahy, R., 2009. PMP Exam Prep, Sixth Edition: Rita's Course in a Book for Passing the PMP Exam. 6th edition, Minnesota: RMC Publications, Inc.

S. Mahmoodzadeh, J. S., (n.d.). Project Selection by Using Fuzzy AHP and TOPSIS Technique, *International Journal of Humanities and Social Sciences*.

Steven A. Gabriel, S. K., 2005. A multiobjective optimization model for project selection with probabilistic considerations, *Socio-Economic Planning Sciences*, 297–313.

Yi, C., 2008. A Decision-making Approach for R&D Project Selection in a Fuzzy Environment, *IEEE Computer society*.

Zadeh, L., 1988. Fuzzy logic, *Computer*, 83-93.