Colegio de Postgraduados

Comparative evaluation of multicriteria methods versus the traditional approach in the prioritization of public projects in Mexico

Pérez-Ramírez, Rodrigo[1]; Martínez-Damián, M.A.[1*]; Garza-Bueno, L.[1]; Mora-Flores, S.[1]; Pérez-López, A.[1]

[1] Colegio de Postgraduados-Campus Montecillo, Programa de Socioeconomía, Estadística e Informática-Economía, Carr. México - Texcoco km 36.5, Montecillo, Texcoco, Estado de México, México, C.P. 56264.
* Correspondence: angel01@colpos.mx

ABSTRACT
Objective: To compare the performance of the basic method used by Mexican public entities with various advanced multicriteria decision-making (MCDM) methods, aiming to prove that the latter are better suited to evaluate the competitive allocation of public resources.
Design/Methodology/Approach: The performance of six MCDM methods and two variants of the Weighted Sum Method (WSM) were assessed as part of the prioritization of 100 simulated projects, replicating the 2017 model of the Programa de Apoyo para Productores en Zonas de Atención Prioritaria (FAPPA). The analysis, conducted using R, included a linearity validation of rankings to measure the variability in ranking.
Results: The model currently used in public programs (WSM without normalization) has low discriminative capacity, with 98% ties between proposals. In contrast, methods that incorporate normalization reduced this percentage to 41%, with variations depending on the algorithm used. In contrast, the model currently used in public programs (WSM without normalization) exhibits low discriminative capacity, with 98% ties between proposals. In contrast, methods incorporating normalization reduced this percentage to 41%, with variations depending on the algorithm used. Evaluation based on Distance from Average Solution (EDAS) and Complex Proportional Assessment (COPRAS) recorded the rankings with the highest concordance (R^2=0.92), whereas Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and WSM recorded the lowest results (R^2=0.23). Clear differences in stability, discrimination, and complexity were recorded. Multi-Objective Optimization on the basis of Ratio Analysis (MOORA) stood out based on its balance between accuracy and simplicity.
Study Limitations/Implications: The study is limited to 100 FAPPA proposals, which may limit the generalisation of the results.
Findings/Conclusions: The comparison of multicriteria methods for public allocation emphasizes normalization, while the algorithmic structure influences proposal discrimination. Well-evaluated projects were consistently identified, reinforcing the validity of the model. Method selection should balance accuracy and feasibility to enhance transparency and equity.

Keywords: Public resource allocation, normalization, evaluation of large number of alternatives, multicriteria analysis.

INTRODUCTION

Efficient resource allocation represents a structural challenge for grant-allocation agencies, especially when demand exceeds budget availability. This difficulty becomes more noticeable as the number of requests increases, demanding strict, transparent, and multi-criteria evaluation processes (Torres *et al.*, 2024).

In Mexico, public programs such as Desarrollo Forestal Sustentable para el Bienestar (CONAFOR), Apoyo a la Infraestructura Hidroagrícola (CONAGUA), and elements of the Programa de Fomento a la Agricultura, Ganadería, Pesca y Acuicultura (SADER) operate

Citation: Pérez-Ramírez, R., Martínez-Damián, M.A., Garza-Bueno, L., Mora-Flores, S., & Pérez-López, A. (2025). Comparative evaluation of multicriteria methods versus the traditional approach in the prioritization of public projects in Mexico. *Agro Productividad*. https://doi.org/10.32854/mnq11727

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: October 14, 2024.
Accepted: June 25, 2025.
Published on-line: September 9, 2025.

Agro Productividad, 18(7). July. 2025. pp: 107-118.

under competitive grant schemes, in which resources are allocated to the top-evaluated projects according to the criteria established in the operating rules of each program.

The most used methods in these processes are checklists and the Weighted Sum Model (WSM), also known as Simple Additive Weighting (SAW). On the one hand, checklists help to identify the presence or absence of criteria through binary assessments or simple scales, without considering their relative weight (Concha *et al.*, 2020). The WSM, on the other hand, assigns a value to each alternative as the sum of weighted products, assuming that all criteria can be subjected to a linear aggregation.

While these methods are useful in simple contexts, they have limitations when they deal with criteria that have different natures, scales, or units —for example, public programs that take social, technical, economic, and environmental dimensions into consideration. In such cases, data normalization is necessary to guarantee that variables can be compared. The lack of data normalization —a common situation in this type of evaluation— can both distort the results by favoring criteria with broader ranges (Kolios *et al.*, 2016; Ciptayani and Dewi, 2018; Soria *et al.*, 2023) and diminish the accuracy of the evaluation (Altamirano and Lucero, 2023). Ochoa *et al.* (2019) and Pérez and Martínez (2019) agree that the basic methods currently used by the Mexican government fail to capture the complexity of the problems or adequately prioritize a multitude of proposals. In contrast, specialized literature has documented that the effectiveness of advanced Multicriteria Decision Methods (MCDM) enables the integration of multiple dimensions and the comparison of heterogeneous alternatives (Álvarez *et al.*, 2023). These methods include techniques such as the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Hwang and Yoon, 1981), Weighted Aggregated Sum Product Assessment (WASPAS) (Zavadskas *et al.*, 2012), Complex Proportional Assessment (COPRAS) (Zavadskas, Kaklauskas and Šarka, 1994), Evaluation based on Distance from Average Solution (EDAS) (Keshavarz Ghorabaee *et al.*, 2015), and Multi-Objective Optimization on the basis of Ratio Analysis (MOORA) (Brauers and Zavadskas, 2006). These techniques have been widely validated in international contexts to address alternative selection problems (Ayan and Abacıoğlu, 2022).

In this context, this study aims to compare the performance of the basic method used by Mexican public entities with various advanced MCDMs, seeking to show that the latter achieve a better evaluation of problems involving the competitive allocation of public resources. The hypothesis is that traditional methods have significant limitations when ranking projects in contexts with multiple criteria and large volumes of proposals, while MCDMs overcome these shortcomings by providing more accurate results, tailored to the complexity of the problem.

To this end, a case study for the year 2017 was developed based on the evaluation model of the Programa de Apoyo para Productores en Zonas de Atención Prioritaria (FAPPA). On the said year, the federal government allocated MXN$536.63 million to finance 3,682 productive projects out of a total of 19,471 proposals received, which implies an acceptance rate of 18.91% (SAGARPA, 2018). This scenario offers an ideal context to compare the performance of the traditional method with the advanced MCDM performances under real-life conditions (*i.e.*, high competitiveness and multiple criteria).

MATERIALS AND METHODS

A non-experimental, quantitative, and comparative design was used to evaluate the performance of the various prioritization methods applied to the competitive allocation of public resources. The evaluation framework used by the FAPPA during the fiscal year 2017 was replicated, as established in its operating rules. This model, based on the WSM without data normalization, was compared with five advanced MCDMs (TOPSIS, WASPAS, COPRAS, EDAS, and MOORA), in addition to WSM with data normalization.

To assess their performance in scenarios with many alternatives, 100 hypothetical project profiles —designed to simulate real-life conditions of competition for funding— were analyzed. The algorithms were implemented and processed in the R software (version 4.1.2). As part of the validation process, pairs of methods were subjected to a comparative analysis of linearity to assess how each alternative position varies in the different rankings generated. This analysis quantifies the direct relationship between the ranking assigned by each pair of methods, where a linearity value equal to 1 indicates that both methodologies place each alternative in the same position, consequently enabling an accurate identification of the variability in the ranking of each proposal between different methods.

Case Study Description

The first stage to select the best alternative is to define the criteria and weights that reflect their relative importance. Table 1 shows the criteria and weights established in the 2017 FAPPA operating rules. Meanwhile, Table 2 includes the evaluation of the 100 investment proposals to which the said rules were applied. Finally, Figure 1 provides a step-by-step description of the application of each of the MCDMs used in this study.

RESULTS AND DISCUSSION

Table 3 details the scores and rankings obtained after applying six MCDMs to a set of 100 investment proposals, while Figures 2 through 8 show the performance of each method in the assignment and ranking of the scores. The results reveal substantial differences in the discriminatory capacity of the different methods. In particular, the model adopted by the FAPPA program —based on the WSM method without data normalization— displays a critical limitation: 98% of the proposals receive identical scores (Figure 2), preventing an effective ranking and jeopardize transparency, and equity in the allocation of public resources.

In contrast, the MCDM methods applied with normalization processes recorded a considerable improvement in the discrimination of alternatives. On average, the proportion of ties was reduced to 41% —a significant improvement over the original scheme. Data normalization both improve comparability between criteria expressed on different scales and reduces the weight of variables with high variance, resulting in more equitable and accurate evaluations, which are consistent with specialized literature (Kolios *et al.*, 2016; Altamirano and Lucero, 2023).

However, the improvement achieved through normalization was not uniform across all methods. For example, in the case of WASPAS (Figure 6), rating percentage matches

Table 1. Criteria and weights established in the 2017 FAPPA operating rules.

Criterion and Weight	Indicator	Global Weight	Unit of Measurement	Response Levels	Score
Social (30%)	Inclusion	0.2	Number of members directly benefiting from the Investment Project	More than 35	100
				From 21 to 30	50
				From 11 to 20	25
				Fewer than 10	0
	Expected Employment	0.1	Number of direct jobs expected	More than 13	100
				From 9 to 12	75
				From 4 to 8	50
				From 1 to 3	25
				None or not specified	0
Technical (35%)	Technical Assistance and Training	0.05	The Technical Assistance Programme includes specific training activities for members in productive terms	Yes	100
				No	0
	Innovation	0.1	The Project considers the use of new technologies to improve the production process	Yes	100
				No	50
	Expected Percentage Increase in Production Volume	32	Percentage	More than 10	100
				From 6 to 10	75
				From 4 to 5	50
				From 1 to 3	25
				Less than 1 or not specified	0
Economic (25%)	Internal Rate of Return (IRR) with subsidy	0.05	Percentage	Greater than 30	0
				From 21 to 30	50
				From 10 to 20	100
				Less than 10 or not specified	0
	Marketing	0.2	Scheme	National/International	100
				State level	75
				Regional	50
				Local	25
Environmental (10%)	Sustainability	0.1	Number of actions considered to mitigate the environmental impact of the project	More than 2	100
				2	50
				1	25
				Not specified	0

Table 2. Evaluation of 100 investment projects from the FAPPA program (2018).

Project	C1	C2	C3	C4	C5	C6	C7	C8	Project	C1	C2	C3	C4	C5	C6	C7	C8
1	25	100	100	50	25	0	50	100	51	0	50	100	50	50	0	25	50
2	0	50	100	100	75	0	75	50	52	50	25	100	50	50	50	75	0
3	0	50	100	100	100	0	25	100	53	50	25	100	50	50	0	25	50
4	0	75	100	100	75	0	75	50	54	25	50	100	50	25	0	25	50
5	0	50	0	50	25	50	25	100	55	50	50	100	50	50	0	25	50
6	0	75	100	50	75	0	75	50	56	50	25	100	50	50	0	25	50
7	25	100	100	100	75	100	50	50	57	50	25	100	50	50	100	25	50
8	25	100	100	50	50	50	50	100	58	25	50	100	50	0	0	25	0
9	25	75	100	50	0	0	25	50	59	25	25	100	50	25	0	25	50
10	0	50	100	50	0	0	25	50	60	25	25	100	50	50	0	25	50
11	50	75	100	50	25	0	25	50	61	50	25	100	50	50	0	25	25
12	100	100	0	50	25	100	25	25	62	50	50	100	50	50	50	25	50
13	25	75	100	50	50	0	25	50	63	0	50	100	50	25	0	25	100
14	50	75	100	50	25	0	75	50	64	0	50	0	50	25	0	25	50
15	100	100	100	50	25	100	25	100	65	0	50	100	50	25	0	25	50
16	50	75	100	50	25	0	25	50	66	50	25	100	50	25	50	25	0
17	0	50	100	50	50	0	25	0	67	50	25	100	50	25	0	25	50
18	50	75	100	50	25	100	50	50	68	50	25	100	50	25	0	25	100
19	25	75	100	50	25	0	50	50	69	0	50	100	50	25	100	50	50
20	25	75	0	50	25	0	50	50	70	0	50	100	50	25	0	50	25
21	100	100	100	100	25	0	25	25	71	50	25	100	50	25	0	25	50
22	50	75	100	100	75	0	25	50	72	50	25	0	50	50	0	25	50
23	0	50	100	50	25	0	25	50	73	0	50	100	50	25	100	25	50
24	0	50	100	50	25	0	75	100	74	25	25	100	100	25	0	25	50
25	25	75	100	50	25	0	25	50	75	50	25	100	50	25	0	25	25
26	25	75	100	50	25	0	25	25	76	0	50	100	50	25	0	25	50
27	50	75	100	50	75	0	25	50	77	0	50	100	50	25	0	25	50
28	25	75	100	50	25	0	25	50	78	0	50	100	50	50	0	25	50
29	0	50	100	50	25	0	75	50	79	0	50	100	50	25	50	50	50
30	50	75	100	50	25	50	25	0	80	0	50	100	50	25	0	25	50
31	0	50	100	50	25	50	25	50	81	0	50	100	50	50	0	25	0
32	25	75	100	50	50	0	50	50	82	50	25	100	50	50	0	25	50
33	0	50	100	50	50	0	25	50	83	0	50	100	50	25	0	50	50
34	50	75	100	50	75	0	25	50	84	50	25	100	100	25	50	25	50
35	50	75	100	50	50	100	25	50	85	0	50	100	50	25	0	25	50
36	25	50	100	100	50	0	25	50	86	25	50	100	50	25	0	25	50
37	25	25	100	100	25	0	25	50	87	50	50	100	50	50	0	25	50
38	50	75	100	100	50	50	75	100	88	50	75	100	50	25	100	25	50
39	25	75	100	50	75	0	25	100	89	0	50	100	50	25	0	25	25
40	25	25	100	50	50	0	25	50	90	50	75	100	50	25	0	25	25
41	50	50	100	50	0	0	50	0	91	0	50	100	50	50	0	25	50

Table 2. Continues....

Project	C1	C2	C3	C4	C5	C6	C7	C8	Project	C1	C2	C3	C4	C5	C6	C7	C8
42	50	75	100	50	25	0	25	50	92	0	50	0	50	75	50	25	50
43	0	50	100	50	50	0	25	50	93	0	50	100	100	25	0	25	100
44	0	50	100	50	50	0	75	50	94	50	75	100	50	25	0	25	50
45	50		100	50	50	100	25	50	95	0	50	100	50	50	50	50	50
46	0	50	100	50	50	0	25	50	96	0	50	100	50	25	0	50	100
47	0	50	100	50	0	0	25	50	97	0	50	100	50	25	0	25	50
48	0	50	100	50	50	0	50	50	98	50	75	100	50	75	100	25	0
49	25	25	100	50	50	0	25	50	99	25	75	100	50	25	0	25	50
50	25	50	100	50	50	0	25	50	100	50	75	100	100	25	0	25	50

Where: C1=Inclusion, C2=Expected Employment, C3=Technical Assistance and Training, C4=Innovation, C5=Expected Percentage Increase in Production Volume, C6=Internal Rate of Return (IRR) with subsidy, C7=Marketing, C8=Sustainability.

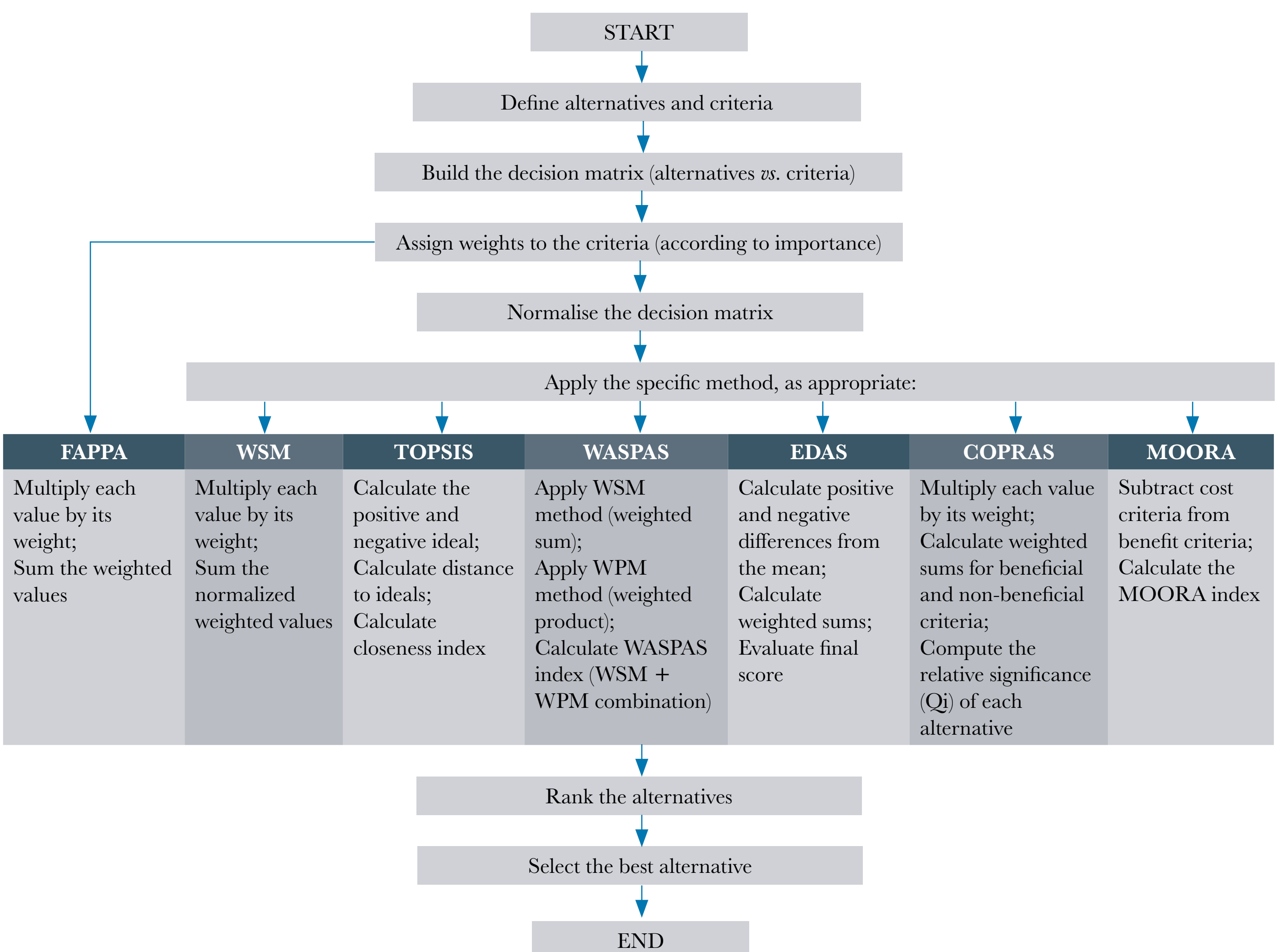

Figure 1. General process for multicriteria evaluation using multicriteria methods.

Table 3. Ranking of the top 20 alternatives according to the method applied.

FAPPA		SWM		TOPSIS		EDAS		MOORA		WASPAS		COPRAS	
Project	**Ranking**	**Project**	**Ranking**	**Project**	**Ranking**	**Project**	**Ranking**	**Project**	**Ranking**	**Project**	**Ranking**	**Project**	**Ranking**
38	1	38	1	15	1	38	1	38	1	38	1	15	1
7	2	7	2	38	2	15	2	15	2	7	2	38	2
15	2	4	3	12	3	7	3	7	3	15	3	7	3
4	4	2	4	21	4	12	4	21	4	8	4	12	4
8	4	15	5	22	5	18	5	12	5	18	5	21	5
21	4	22	6	98	6	35	6	22	6	35	6	98	6
22	4	8	7	27	7	8	7	4	7	62	7	18	7
2	8	3	8	34	7	98	8	8	8	57	8	35	8
3	8	6	9	52	9	21	9	52	9	88	9	52	9
6	10	21	10	7	10	22	10	98	10	84	10	8	10
12	10	14	11	14	11	52	11	2	11	4	11	22	11
14	10	39	12	35	12	57	12	14	12	2	12	57	12
18	10	27	13	57	13	14	13	18	13	21	13	14	13
27	10	34	13	39	14	88	14	35	14	22	13	88	14
34	10	52	15	3	15	62	15	27	15	6	15	45	15
35	10	18	16	4	16	27	16	34	15	14	15	4	16
39	10	1	17	62	17	34	16	6	17	3	17	27	17
98	10	98	18	18	18	45	18	3	18	52	18	34	17
1	19	35	19	45	19	39	19	39	19	12	19	62	19
52	19	32	20	6	20	4	20	57	20	27	19	2	20

Where: FAPPA: Programa de Apoyo para Productores en Zonas de Atención Prioritaria, SWM: Weighted Sum Method, TOPSIS: Technique for Order of Preference by Similarity to Ideal Solution, EDAS: Evaluation based on Distance from Average Solution, MOORA: Multi-Objective Optimization on the basis of Ratio Analysis, WASPAS: Weighted Aggregated Sum Product Assessment, COPRAS: Complex Proportional Assessment.

remained high (72%). This result indicates that, despite its usefulness, normalization on its own is not sufficient to ensure an effective differentiation between proposals. This situation suggests that the algorithmic structure of the method also significantly influences its discriminatory capacity, as pointed out by Zavadskas *et al.* (2016), who underscored that the sensitivity of MCDMs depends both on the data transformation and on the way in which the partial evaluations are weighted and aggregated.

Although TOPSIS, EDAS, MOORA, WSM (with normalization), and COPRAS reduced the number of proposals with identical ratings to 41%, it is still considerably high, considering the magnitude of the evaluated set. This persistence can be partially attributed to the structural constraints of the FAPPA scoring system, which classifies all criteria as benefits and uses a 5-level ordinal scale (0, 25, 50, 75, and 100 points). This design restricts the specificity of the analysis and favors duplicate values, especially among proposals with similar performance.

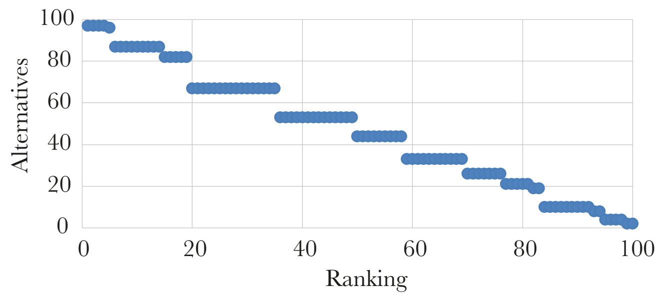

Figure 2. Distribution of the project ranking under the FAPPA model.

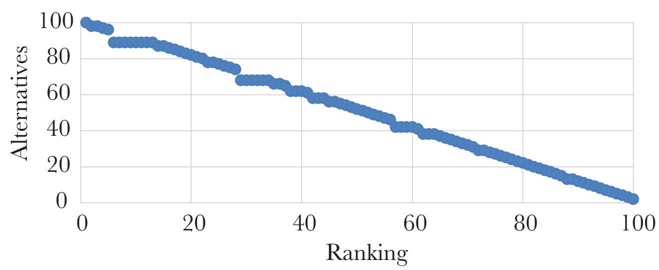

Figure 3. Distribution of the project ranking under the WSM model.

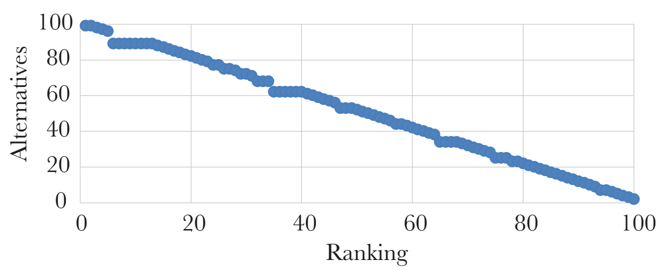

Figure 4. Distribution of the project ranking under the TOPSIS model.

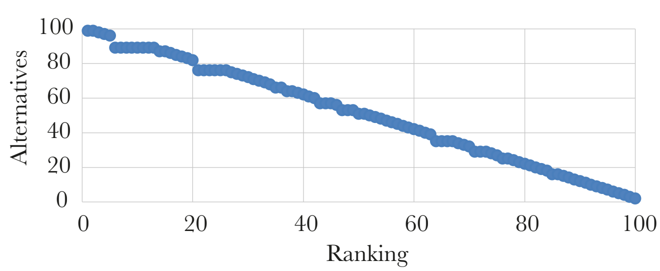

Figure 5. Distribution of the project ranking under the EDAS model.

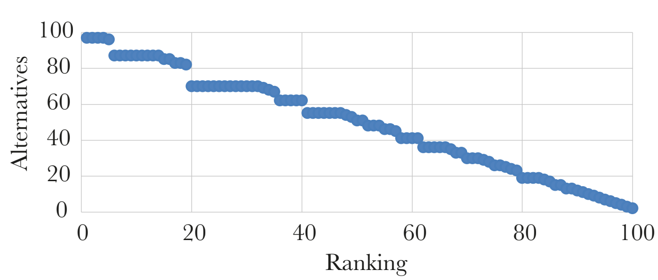

Figure 6. Distribution of the project ranking under the WASPAS model.

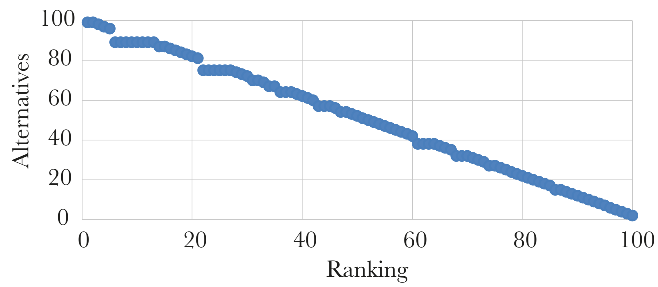

Figure 7. Distribution of the project ranking under the COPRAS model.

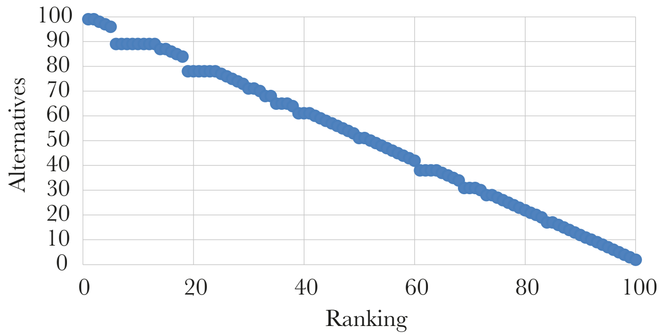

Figure 8. Distribution of the project ranking under the MOORA model.

Regarding the ranking generated by each method, the best alternatives placement was highly consistent. Projects 38, 15, and 7 received the top positions in most of the methods evaluated, indicating that their overall assessment was stable. However, slight discrepancies were identified in the third position: project 12 and project 4 held that position in the case of TOPSIS and WSM, respectively. These variations reflect underlying methodological differences: while TOPSIS is based on the relative distance to ideal and nonideal solutions, WSM uses a weighted linear aggregation, which responds differently to small changes in individual criteria.

Figure 9 compares the rankings assigned to each project per pairs of methods analyzed. The X and Y axis show the positions generated by the first and the second method, respectively. Each figure includes the R^2 coefficient of determination, which quantifies the linearity degree between both arrangements, providing a measure of relative consistency in the ranking of alternatives.

EDAS and COPRAS had the greatest correspondence; its coefficient of determination (R^2=0.9245) proved that there is a highly consistent ranking between them. This coincidence can be explained by the similarity in their structural approaches, both of which are centered on proportional evaluation relative to average or collective references and the transformation of normalized data that prioritize relative stability between alternatives.

For their part, TOPSIS and WSM (with normalization) recorded the lowest correspondence (R^2=0.2301). This low linearity reveals a substantial difference between the rankings generated by these methods, especially for the mid-performing alternatives.

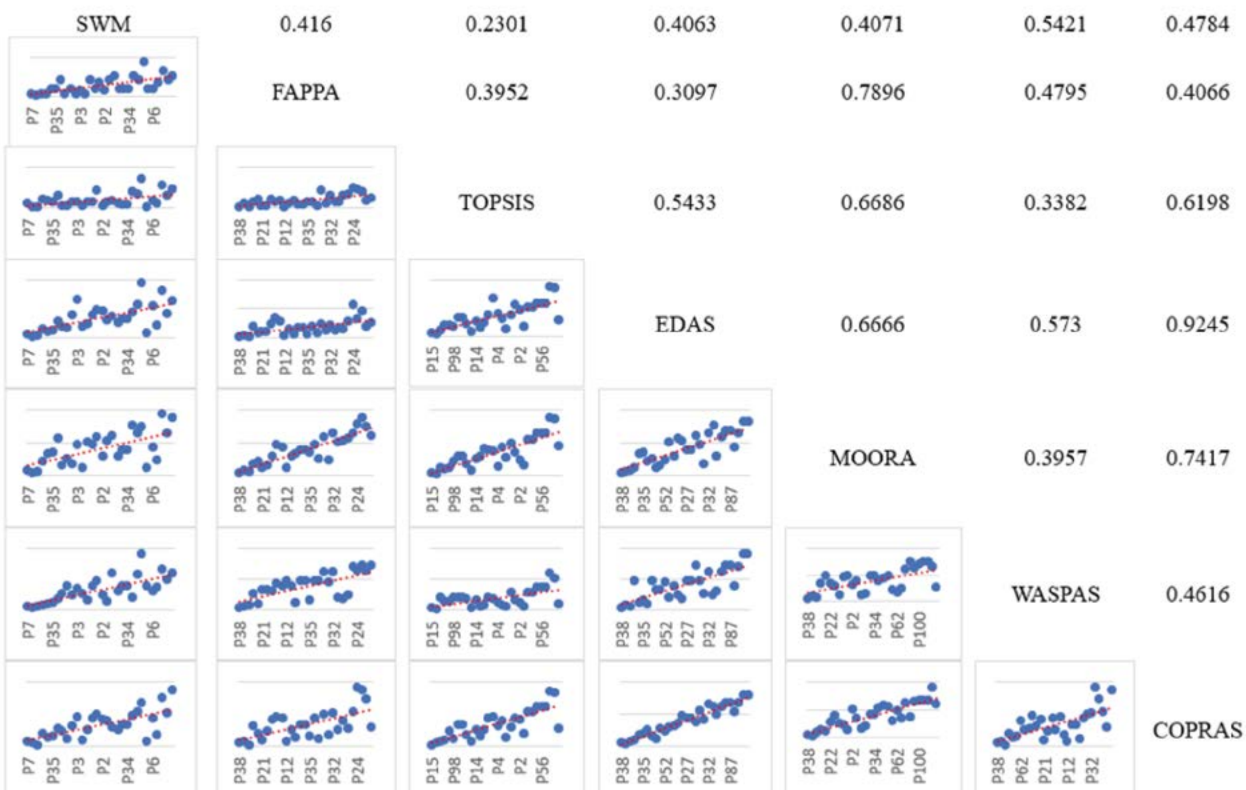

Figure 9. Analysis of the coefficient of determination (R^2) of the linear correlation between rankings generated by paired multicriteria methods.

These differences reflect how the aggregation logic —based on distances and direct weighting in the case of TOPSIS and WSM, respectively— can alter the relative position of these proposals, reinforcing the need to carefully select the evaluation method based on the application context.

The MOORA method showed intermediate variability and was consistent with several methods, including WSM, TOPSIS, EDAS, and COPRAS. Therefore, it is positioned as a strong methodological option for scenarios requiring a balance between operational simplicity and stability of results. As a whole, these findings underscore the value of linearity analysis as an internal validation tool, allowing for the assessment of the positional consistency of the alternatives, beyond the overall correlation offered by Spearman, Kendall, and other indicators (Martin, 2017).

Finally, from an operational implementation point of view, significant differences were identified in the computational complexity of the methods. The simple algorithmic structure and low technical demands of WSM, WASPAS, MOORA, and COPRAS makes them suitable for institutional contexts with limited resources. In contrast, given the need to calculate relative distances or deviations from ideal or average values, EDAS and TOPSIS require more intensive processing, which could represent a barrier in environments with limited analytical capabilities (Mayor, Botero, and González, 2016).

CONCLUSIONS

This study compared six multi-criteria methods with the traditional FAPPA program which is usually used to allocate public resources. The results show that MCDMs substantially increase distinction ability between proposals, reducing on average the percentage of projects with identical ranking from 98% to 41%. This improvement is largely attributed to the application of normalization processes, which contributes to the comparability between criteria measured on different scales. However, the improvement was not homogeneous: In the case of WASPAS, the matching results remained high (72%), which proved that the algorithmic structure of each method decisively influences its discriminatory capacity.

The linearity analysis showed high consistency between methods such as EDAS and COPRAS (R^2=0.9245) and low correspondence between TOPSIS and WSM (R^2=0.2301). These results confirm that the methodological choice can significantly alter the ranking of proposals. Furthermore, consistently well-evaluated projects (38, 15, and 7) were identified, providing cross-validation to the models.

In conclusion, the selection of the evaluation method should consider both the technical differentiation capacity and its operational feasibility in public allocation schemes. This work provides evidence that strengthens the transparency and equity in the distribution of public resources, through the adoption of MCDM methods with solid methodological foundations and adapted to the institutional context.

REFERENCES

Altamirano-Cárdenas, A. I., & Lucero-Calvache, F. A. (2023). Predicción de producción de fluidos empleando machine learning en T inferior del Campo Sacha. *FIGEMPA: Investigación y Desarrollo, 16*(2), 70-78. https://doi.org/10.29166/revfig.v16i2.4542

Álvarez-Aranda, M., Martínez-Urbina, L. D., Aparicio-Urbano, J., & Cruz-Romero, M. (2023). Método de pronóstico y multicriterio para analizar la demanda y selección de proveedores en una PYME. *Ingeniería, Investigación y Tecnología, 24*(2). https://doi.org/10.22201/fi.25940732e.2023.24.2.009

Ayan, B., & Abacıoğlu, S. (2022). Bibliometric analysis of the MCDM methods in the last decade: WASPAS, MABAC, EDAS, CODAS, COCOSO, and MARCOS. *International Journal of Business and Economic Studies, 4*(2), 65-85. https://doi.org/10.54821/uiecd.1183443

Brauers, W. K. M., & Zavadskas, E. K. (2006). The MOORA method and its application to privatization in a transition economy. *Control and Cybernetics, 35*(2), 445-469.

Ciptayani, P. I., & Dewi, K. C. (2018). Decision support system of e-book provider selection for library using Simple Additive Weighting. *Journal of Physics: Conference Series, 953*(1), 012066. https://doi.org/10.1088/1742-6596/953/1/012066

Concha-Torre, A., Díaz Alonso, Y., Álvarez Blanco, S., Vivanco Allende, A., Mayordomo-Colunga, J., & Fernández Barrio, B. (2020). Las listas de verificación: ¿una ayuda o una molestia? *Anales de Pediatría, 93*(2), 135.e1-135.e10. https://doi.org/10.1016/j.anpedi.2020.05.006

Hwang, C. L., & Yoon, K. (1981). Multiple attribute decision making: Methods and applications. Springer-Verlag.

Keshavarz Ghorabaee, M., Zavadskas, E. K., Olfat, L., & Turskis, Z. (2015). Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS). *Informatica, 26*(3), 435-451. https://doi.org/10.3233/INF-2015-1070

Kolios, A., Mytilinou, V., Lozano-Minguez, E., & Salonitis, K. (2016). A comparative study of multiple-criteria decision-making methods under stochastic inputs. *Energies, 9*(7), 566. https://doi.org/10.3390/en9070566

Martín-Mateos, P., Hayden, J., Acedo, P., & Lendl, B. (2017). Heterodyne phase-sensitive dispersion spectroscopy in the mid-infrared with a quantum cascade laser. *Analytical Chemistry, 89*(11), 5916-5922. https://doi.org/10.1021/acs.analchem.7b00303

Mayor, J., Botero, S., & González-Ruiz, J. D. (2016). Modelo de decisión multicriterio difuso para la selección de contratistas en proyectos de infraestructura: Caso Colombia. *Obras y Proyectos*, (20), 56-74. https://doi.org/10.4067/S0718-28132016000200005

Ochoa-Medina, I. E., Ruiz-Iduma, S., & Villa-Carbajal, M. M. (2019). La selección de proveedores en organizaciones públicas de México ante los desafíos de la era digital. *Vinculatégica EFAN, 5*(2), 930-938.

Pérez-Ramírez, R., & Martínez-Damián, M. Á. (2020). Modelo de decisión multicriterio para seleccionar los mejores proyectos productivos en el medio rural mexicano. *Agro Productividad, 13*(2), 101-107. https://doi.org/10.32854/agrop.vi.1470

SAGARPA. (2017). Reglas de operación del programa FAPPA. https://www.dof.gob.mx/nota_detalle.php?codigo=5509748&fecha=29/12/2017

SAGARPA. (2018). Resultados del programa de apoyos a pequeños productores, componente proyectos productivos FAPPA 2017.

Soria Leyva, E., Mariño Vivar, J. L., Díaz-Pompa, F., Parra Parra, D., & González Odio, Y. I. (2023). Modelo sintético para estandarizar el índice de potencial turístico: Un enfoque basado en el concepto de distancia. *Revista de Métodos Cuantitativos para la Economía y la Empresa*, 36, 1-30. https://doi.org/10.46661/rev.metodoscuant.econ.empresa.7447

Torres-Barreto, M. L., Hazbon-Manrique, S. D., & Álvarez-Melgarejo, M. (2024). Aplicación del Proceso Analítico Jerárquico en proyectos de Triple Hélice: Un caso sobre innovación educativa en Colombia. *Journal of Technology Management & Innovation, 19*(3), 113-126. https://doi.org/10.4067/S0718-27242024000300113

Zavadskas, E. K.; Kaklauskas, A., & Sarka, V. (1994) The new method of multicriteria complex proportional assessment of projects. *Technological and Economic Development of Economy*, 1994, Vol 1, No 3, p. 131-139.

Zavadskas, E. K., Govindan, K., Antucheviciene, J., & Turskis, Z. (2016). Hybrid multiple criteria decision-making methods: A review of applications for sustainability issues. *Economic Research-Ekonomska Istraživanja, 29*(1), 857-887. https://doi.org/10.1080/1331677X.2016.1236019

Zavadskas, E. K., Turskis, Z., Antucheviciene, J., & Zakarevicius, A. (2012). Optimization of weighted aggregated sum product assessment. *Elektronika ir Elektrotechnika, 122*(6), 3-6. https://doi.org/10.5755/j01.eee.122.6.1810