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Hierarchization Process of Works of the Judicial Branch by the Topsis Multicriteria Method

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Abstract: *The execution of public works must be planned and supported by technical justifications and financial resources that indicate the need and possibility of carrying them out. This paper proposes the use of the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) multicriteria method to support decision-making, by hierarchizing the works of the judiciary. The methodology was validated in application to the Court of Justice of Paraná (Tribunal de Justiça do Paraná, TJPR), defining the districts of the state as 162 alternatives and seven technical criteria established based on resolution n° 114 of the National Council of Justice (Conselho Nacional de Justiça, CNJ). The application of the method, established academically for carrying out hierarchical processes, proved to be effective and fully applicable to the case study, in which it guides the public administration regarding priority works in the face of a set of works of a similar nature. The results converge to sustainability in hiring by optimizing resources through the decision process.*

Keywords: *Public Works; TOPSIS Method; Hierarchy; Sustainable Hiring.*

1. Introduction

The realization of a public work must necessarily constitute a planned action, with specific purposes based on technical justifications and with financial resources that indicate the need and possibility of its realization. For Queiroz (2021), with scarce resources, the population is demanding more and more transparency in public management decisions, starting to act as an observer of the use of public resources, requiring the adoption of tools to support transparent and objective decisions. The rationalization of public spending is only possible from the identification of effective public investment priorities, assessing which projects should be given priority in relation to a set of possible implementation projects. It is a primary function of Public Administration to use public resources efficiently, in order to guarantee the provision of services to the population (SILVA FILHO et al., 2014), considering administrative efficiency as the direct relationship of maximizing the provision of public services from available resources (MATEI & SAVULESCU, 2009).

The goal of this paper is to present a process to support decision-making through the TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution), developed by Hwang and Yonn (1981), for ranking public works. The methodology is validated through a case study applied to the Court of Justice of Paraná (TJPR).

2. Background to the Study

Multi-criteria decision-making processes help the manager to establish a hierarchy between possible alternatives according to scores and weights established for pre-selected technical criteria for the composition of decision-making. This section presents some works related to the theme and also a step-by-step description of the TOPSIS method.

2.1. Related Papers

Among the researchers who have already used the TOPSIS method in hierarchical processes of their research, there are: Arese et al. (2017), who carried out a study on the selection of professors for a higher education institution, using 14 alternatives, which were treated as the criteria used for the selection of professors. The analysis, carried out after judging 10 indexes for each criterion, suggests that there is the possibility of reducing subjectivity in decision-making, being a viable path for managerial actions in academic management. Li, Fang and Song (2019) applied the TOPSIS technique in their work to select suppliers of sustainable photovoltaic modules, seeking to establish sustainable supply chain management practices to obtain economic, environmental and social benefits. The paper was developed through the construction of a list of evaluation criteria through the literature review, in addition to the development of a hybrid technique for the selection of sustainable suppliers. The results, in order of supplier classification, enable validation of the effectiveness and viability of supplier selection. Memari et al. (2019) used the Fuzzy-TOPSIS technique to select a sustainable supplier in the industrial area of automotive parts. A total of nine criteria and 30 sub-criteria were used in the decision process, which adopted triangular fuzzy numbers to calculate the weights. For the authors, the sustainable selection of suppliers is a complex and difficult decision and the TOPSIS method is dominant among the multicriteria methods to solve this type of selection because it is easier to understand and simpler to implement compared to other traditional multicriteria methods. Akram and Dudek (2019) used the Fuzzy-TOPSIS technique to solve group decision-making problems. For the authors, the TOPSIS technique is one of the classic multicriteria methodologies for classifying the order of preference of alternatives that are pre-selected and viable. Albahri et al. (2021) used the TOPSIS technique to prioritize patients with Covid-19 and who could be characterized as the patients who would need more attention. A pre-selected set of 56 patients was ranked in ascending order, starting with the most critical health condition and ending with the mildest condition. The results indicated a patient prioritization classification, facilitating the hospital service management. Liu et al. (2021) developed a method using the TOPSIS technique to assess urban flood risk levels in China, based on 25 previously selected assessment indexes, with the aim of determining flood control and prevention actions and disaster reduction. The results indicated the main provinces in terms of disaster control capacity, enabled the adoption of drainage standards and public actions. Compared to previous works that adopted the technique for order preference by similarity to ideal solution - TOPSIS Method - (BANAEIAN et al. 2018; ERVURAL et al., 2018; ZANDI et al., 2020; ZAHEDIFAR, 2023), the goal of this paper is to use the TOPSIS method to perform the ranking of public works validated through a case study applied to the TJPR.

2.2. TOPSIS Method

The TOPSIS method aims to evaluate the performance of alternatives through similarity with the ideal solution, in which the evaluation criteria are classified in benefit and cost. While in the cost criteria, the lower the rating, the better the alternative, in the benefit criteria, the opposite prevails, that is, the higher the rating, the better the alternative. In its methodological procedure, the positive ideal solution is the one that maximizes the benefit criteria and minimizes the cost criteria, while the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria (KAYA & KAHRANAN, 2011; MAO et al., 2016). There are basically seven steps that must be adopted (PENG et al. 2017):

- Matrix creation and matrix normalization;
- Calculation of matrix weights;
- Determining the worst and best alternative;
- Calculation of the Euclidean distance of the best condition;
- Calculation of the Euclidean distance of the worst condition;
- Performance calculation;
- Ordered ranking of alternatives.

Next, the steps of the methodology adopted by the TOPSIS method will be presented. **Step 1:** Creation of the matrix. The initial matrix A will be represented by numbers x_{ij} with “m” alternatives and “n” criteria. **Step 2:** Matrix normalization. Matrix normalization is calculated using the initial matrix elements in formula (1) to create balanced parameter estimates and normalize the attributes (ARAS et al., 2017; YANG et al., 2018).

$$\bar{X}_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (1)$$

where $i = 1, 2, ..., m$; $j = 1, 2, ..., n$

Step 3: Creation of the weighted decision matrix. In this step, the weighted standard decision matrix *V* calculates the values with weighted criteria, based on the applied weights, according to formula (2).

$$V = \begin{pmatrix} V_{11} & \dots & V_{1n} \\ . & . & . \\ . & . & . \\ V_{m1} & \dots & V_{mn} \end{pmatrix} = \begin{pmatrix} x_{11}W_1 & \dots & x_{1n}W_n \\ . & . & . \\ . & . & . \\ x_{m1}W_1 & \dots & x_{mn}W_n \end{pmatrix} \quad (2)$$

where: $V_{ij} = x_{ij}\, W_{ij}$; $i = 1, 2, ..., m$; $j = 1, 2, ..., n$

Step 4: Determination of the positive (V^+) and negative (V^-) ideal solutions for each criterion "n" of the *V* matrix. **Step 5:** Obtaining Euclidean distances. The ideal solution is a hypothetical option consisting of the most desirable level of each criterion in the considered alternatives. The measure of the distance of each alternative from the ideal solution and the least desirable solution using the Euclidean distance method is determined according to formulas (3) (CHEN, 2019).

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^+)^2} \quad (3)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^-)^2}$$

where $i = 1, 2, ..., m$; $j = 1, 2, ..., n$

In equations (3) S_i^+ is the Euclidean distance of each alternative from the ideal solution and S_i^- is the Euclidean distance of each alternative from the worst optimal solution. **Step 6:** Calculation of the relative proximity of the ideal solution. The calculation of the performance score is performed by formula (4) (KROHLING & CAMPANHARO, 2011).

$$P_i = \frac{s_i^-}{s_i^+ + s_i^-} \quad (4)$$

where $i = 1, 2, ..., m$

Step 7: Ordered ranking of alternatives. The list of preference alternatives must be ordered according to the result of P_i, and the best alternative will be the one closest to the ideal solution (OZTAYSI, 2014).

3. Material and Methods

Figure 1 shows the flow of activities, detailed in the next section, for defining the decision-making process by hierarchizing the Districts to be served. According to the flow presented in Figure 1, the data collected for each selected alternative are applied in formulas, being transformed into technical indexes. Sequentially, the modeling is performed by creating a matrix, which must be normalized. The application of the TOPSIS method is then applied to obtain the results of the hierarchization process, whose final product is the order of priority of the selected alternatives.

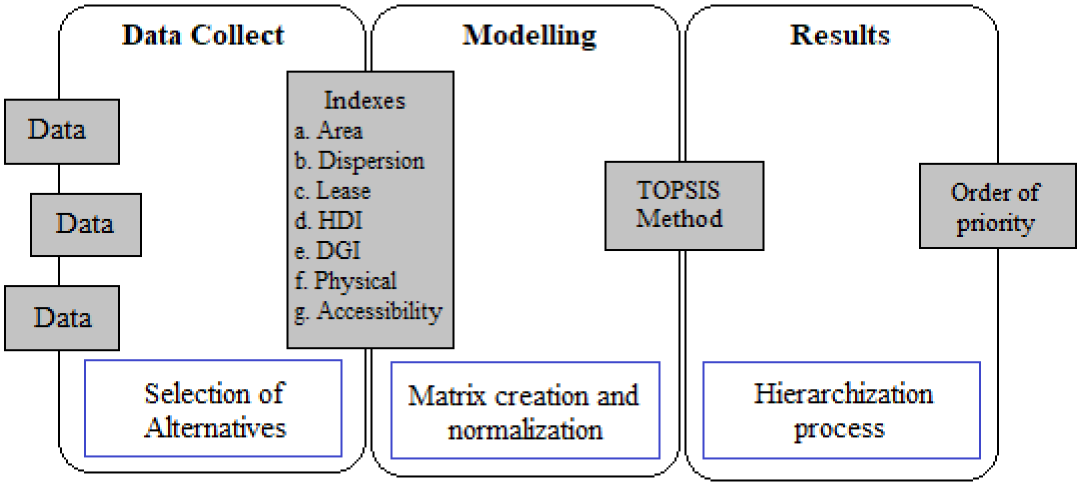

Figure1. *Flow of the Proposed Methodology.*

Source: *the Authors (2023).*

4. Results and Discussion

For validation in the case study applied in the TJPR, the alternatives adopted were the 162 Districts in the State of Paraná. In this study, the hierarchy process aims to define the Districts that should receive the construction of a new Forum, in a hierarchical way. The technical criteria were obtained based on the evaluation of Resolution No. 114 of the CNJ which, based on the needs program and the strategic planning of the institution are presented in Art. 2 of the Resolution, establishes in its 1st. paragraph that "each work must have the priority indicator, obtained from the implementation of a technical evaluation system that includes, among others, the grouped scoring and weighting criteria". There are seven indexes adopted in the study, as follows:

a) Area Index (AI): represents the ratio between the area suitable for the provision of the public service in relation to the reference area identified by the needs study program as sufficient for the provision of the judicial service;

b) Dispersion Index (DI): considers the existence of more than one property for the provision of a given jurisdictional service in the same District;

c) Lease Index (LI): considers the existence of more than a certain percentage M of leased area in relation to the area owned in forensic use in the same District;

d) Human Development Index (HDI): applied considering the principle of the need for the State to make priority investments in less favored regions in terms of economic and social development;

e) District Growth Index (DGI): determined through objective information that makes it possible to assess whether the location is growing, such as population growth and new cases by Judicial Court of the District;

f) Physical Index (PhI): aims to establish the state of maintenance and use of properties occupied by the institution in the District;

g) Accessibility Index (AcessI): aims to establish the accessibility status of the properties occupied by the institution in the District.

The weights of the criteria used are the result of a study applied to a panel of experts managing the TJPR, so they are pre-established. As Paraná has 162 Districts in the interior of the State and aiming at a better presentation of the applied methodology, this work will present the results for the first 15 alternatives.

For step 1 of the method application, table 1 presents matrix *A* for alternatives *i*, with their respective weights W_j for each criterion

Table1. *Matrix A for applying the TOPSIS method.*

Alterna-tives	District	AI	DI	LI	DGI	HDI	PhI	AcessI
A1	AMPÉRE	0.00	1	1	0.82	0.709	0.871	0.742
A2	CENTENÁRIO DO SUL	0.00	1	1	1.10	0.668	0.863	0.884
A3	NOVA AURORA	0.00	1	1	0.71	0.733	0.828	0.900
A4	PONTAL DO PARANÁ	0.00	1	1	0.95	0.738	0.776	0.861
A5	COLOMBO	16.41	0.60	1	0.82	0.733	0.848	0.719
A6	CÂNDIDO DE ABREU	23.04	1	1	1.69	0.629	0.895	0.865
A7	SENGÉS	25.80	1	1	1.10	0.663	0.866	0.852
A8	SANTA MARIANA	26.86	1	1	1.41	0.700	0.805	0.819
A9	TEIXEIRA SOARES	24.87	1	1	1.51	0.671	0.745	0.872
A10	PRIMEIRO DE MAIO	27.44	0.90	1	1.67	0.701	0.765	0.761
A11	ALTO PARANÁ	24.66	1	1	0.79	0.696	0.874	0.783
A12	SÃO JERÔNIMO DA SERRA	31.50	1	1	1.14	0.637	0.877	0.727
A13	RIBEIRÃO DO PINHAL	30.28	1	1	0.84	0.701	0.829	0.833
A14	MANDAGUAÇÚ	29.29	1	1	0.80	0.718	0.868	0.774
A15	BOCAIÚVA DO SUL	30.89	1	1	2.06	0.640	0.855	0.865
	Weights (*Wj*)	**5.00**	**3.9829**	**3.9093**	**3.44553**	**3.5921**	**4.5244**	**3.9829**

Source: *the Authors (2023).*

The second step is the normalization of the matrix, adopting formula (1). The result of the calculation of the normalized *V* Matrix is shown in Table 2.

Table2. *Normalized V matrix.*

Alternatives	AI	DI	LI	DGI	HDI	PhI	AcessI
A1	0.000000	0.095165	0.093153	0.054366	0.065948	0.082972	0.061181
A2	0.000000	0.095165	0.093153	0.099477	0.058541	0.081391	0.086834
A3	0.000000	0.095165	0.093153	0.040710	0.070488	0.075024	0.090064
A4	0.000000	0.095165	0.093153	0.073955	0.071453	0.065773	0.082430
A5	0.429847	0.034259	0.093153	0.054646	0.070488	0.078711	0.057402
A6	0.847862	0.095165	0.093153	0.232874	0.051905	0.087515	0.083113
A7	1.063035	0.095165	0.093153	0.099624	0.057668	0.082041	0.080685
A8	1.152472	0.095165	0.093153	0.163496	0.064284	0.070929	0.074640
A9	0.987584	0.095165	0.093153	0.186749	0.059068	0.060739	0.084594
A10	1.202735	0.077083	0.093153	0.227953	0.064468	0.064019	0.064354
A11	0.971235	0.095165	0.093153	0.051411	0.063552	0.083494	0.068169
A12	1.585035	0.095165	0.093153	0.105950	0.053234	0.084192	0.058755
A13	1.464916	0.095165	0.093153	0.057129	0.064468	0.075244	0.077110
A14	1.369943	0.095165	0.093153	0.052688	0.067633	0.082465	0.066692
A15	1.524189	0.095165	0.093153	0.347371	0.053737	0.079967	0.083113

Source: *the Authors (2023).*

The third step is the weighting of the matrix based on the weights, adopting formula (2), with results presented in Matrix V, as shown in Table 3. The ideal positive (V^+) and negative (V^-) solutions are also determined for each criterion in the matrix.

Table3. *Weighted decision matrix V.*

Alternatives	AI	DI	LI	DGI	HDI	PhI	AcessI
A1	0.0000	0.0133	0.0128	0.0066	0.0083	0.0132	0.0086
A2	0.0000	0.0133	0.0128	0.0121	0.0074	0.0129	0.0122
A3	0.0000	0.0133	0.0128	0.0049	0.0089	0.0119	0.0126
A4	0.0000	0.0133	0.0128	0.0090	0.0090	0.0105	0.0115
A5	0.0756	0.0048	0.0128	0.0066	0.0089	0.0125	0.0080
A6	0.1490	0.0133	0.0128	0.0283	0.0066	0.0139	0.0116
A7	0.1868	0.0133	0.0128	0.0121	0.0073	0.0130	0.0113
A8	0.2026	0.0133	0.0128	0.0199	0.0081	0.0113	0.0105
A9	0.1736	0.0133	0.0128	0.0227	0.0075	0.0097	0.0118
A10	0.2114	0.0108	0.0128	0.0277	0.0081	0.0102	0.0090
A11	0.1707	0.0133	0.0128	0.0062	0.0080	0.0133	0.0095
A12	0.2786	0.0133	0.0128	0.0129	0.0067	0.0134	0.0082
A13	0.2575	0.0133	0.0128	0.0069	0.0081	0.0120	0.0108
A14	0.2408	0.0133	0.0128	0.0064	0.0085	0.0131	0.0093
A15	0.2679	0.0133	0.0128	0.0422	0.0068	0.0127	0.0116
V^+	**2.7714**	**0.0133**	**0.0128**	**0.0422**	**0.0108**	**0.0139**	**0.0126**
V^-	**0.0000**	**0.0048**	**0.0104**	**0.0029**	**0.0054**	**0.0084**	**0.0067**

Source: *the Authors (2023).*

Step 5 is the determination of the Euclidean distances for the determination of the positive (S_i^+) and negative (S_i^-) ideal solution, adopting the formulas presented in (3). Then, in step 6, the performance score (P_i) must be calculated for each alternative, adopting formula (5) adapted from equation (4), so that the optimal solution is the smallest among the alternatives.

$$P_i = \frac{s_i^+}{s_i^+ + s_i^-} \tag{5}$$

where $i = 1, 2, ..., m$

The result of the hierarchization process, or classification of the *m* alternatives, is shown in Table 4. As it is possible to evaluate the value of P_i, it results from the application of formula (5) and the higher its value, the better its ranking in order of preference among the selected alternatives should be.

Table4. *Determination of the positive and negative ideal solution and the performance score of each alternative i.*

Alternatives	Si^+	Si^-	P_i	Order of Preference
A1	2.7716	0.0113	0.9959	1
A2	2.7716	0.0147	0.9947	4
A3	2.7717	0.0119	0.9957	2
A4	2.7716	0.0125	0.9955	3
A5	2.6961	0.0759	0.9726	5
A6	2.6224	0.1516	0.9453	6
A7	2.5847	0.1874	0,9324	9
A8	2.5689	0.2035	0,9266	10
A9	2.5979	0.1750	0.9369	8
A10	2.5601	0.2130	0.9232	11
A11	2.6010	0.1711	0.9383	7
A12	2.4930	0.2790	0.8994	18
A13	2.5142	0.2577	0.9070	14
A14	2.5309	0.2411	0.9130	12
A15	2.5035	0.2710	0.9023	16

Source: *the Authors (2023).*

The analysis of the results of the TOPSIS method presented in Table 4, step 7, indicates that alternative A1 (District of Ampére) should be the priority in decision-making regarding the construction of a new forensic building, followed by alternative A3 (District of Nova Aurora) and so on, according to the order established in the results shown in the column on the right of Table 4.

5. CONCLUSION

This work presents a methodology to help decision-making on the execution of new works by the Judiciary, through a process of hierarchization of the Districts, aiming at the construction of new forensic headquarters among alternatives that were selected through technical analysis processes. The application of the TOPSIS multicriteria decision-making method proved to be simple and perfectly suited to the purpose of this work, mainly due to the previous definition of the alternatives established in the study, the technical criteria to be considered and their weights. This study demonstrates that the adoption of decision techniques by the Public Administration based on objective criteria, with the decision under certainties, in which the future results that are expected are known, converges to the sustainability of hiring. In this way, public resources are applied objectively, with principles and technical grounds for contracting, thus avoiding wastage, both in terms of budget and allocation of human resources activities.

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