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Neutrosophic Method to Evaluate Competencies of Mayoral Candidates

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Abstract. Democracy in Ecuador is based on the election of the highest authorities through popular election and the territorial division over which the elected has functions and powers to fulfill in case of being elected. The candidates make commitments on which they would work, as well as the concrete actions that they would take in office if elected. However, there are inconsistencies between the government plans proposed by the candidates and the obligations that are required by law to comply with the low level of competencies. This research proposes a solution to the posed problem with the development of a method to evaluate the competencies of mayoral candidates in the execution of government plans. The proposed method bases its operation on a multi-expert multi-criteria approach with the use of neutrosophic numbers.

Keywords: Multi-criteria decision-making method, neutrosophic numbers, government plans, mayoralty

1. Introduction

The democratic system in Ecuador is expressed through its electoral process where every four years citizens have the duty to choose who will lead the different levels of sectional governments [1, 2]. The elections are carried out under the principle of autonomy in force for prefectures, mayors and rural parish councils recognized as Decentralized Autonomous Governments [3, 4].

As stated in the Democracy Code, within the necessary requirements to be able to run for an elected position, it is required according to article 97 the presentation of a work plan. This document must contain, among other elements; a multi-year work plan with proposals and strategies that allow defining the actions that will be carried out if they are elected [5, 6].

In addition, the Constitution states in article 264 which are the powers that the Decentralized Autonomous Governments must assume exclusively. This leads to inquire as to whether or not there is concordance between government plans and the functions and powers that the law imposes on Decentralized Autonomous Governments [7, 8].

The Strategic Planning for Political Parties represents the transformation that occurs within political movements about the capacity that these organizations have to link members in a constant, participatory way and according to the guidelines that the organization preaches, in many cases they correspond to personal demands of the managers beyond the political vision of the group.

The plans made to the candidates for prefect and mayor in the city of Quito for the 2009-2013 elections revealed that not all of them had the minimum content established by this body, being the point of greatest recurrence of non-application in relation to the citizen participation mechanisms [9].

There is a paradigm regarding the public perception of the fulfillment of the campaign promises. Those must be supported by the work plans presented. However, its fulfillment is conditioned by two relevant factors. The first is related to the costs involved in the fulfillment of these proposals that many times have not been analyzed in depth. This situation has resulted that, after being chosen those present a financial reality inconsistent with the

magnitude of the proposals made. On the other hand, external factors that are related to unplanned priorities imposed by the own community or by higher powers such as macroeconomic factors, local and national regulations, among others[10].

In this context, the "Carta Magna" sets out the minimum obligations that the Decentralized Autonomous Government must assume and that must be present in the government plans of all candidates. On the other hand, the norm that regulates the electoral process, the Code of Democracy, provides in article 97, that all candidates for popular election must present a work plan that must contain at least four elements. Those elements are: A diagnosis that present the current situation, the presentation of a general objective and several specific ones, a work plan applicable during the four years of mandate with the actions to be carried out if elected and finally the presentation of the way in which the accountability of the management throughout the period would be[11].

On the other hand, the Organic Code of Territorial Ordering, Autonomy and Decentralization (OCTO), describes the functions of the Decentralized Autonomous Governments in article 54, and additionally the powers are recognized in article 55. The Royal Spanish Academy defines competition as the ability and willingness to do something [12]. Therefore, the competence is the aptitude assumed by an individual where he demonstrates the ability, talent or skill to execute an activity with success known as cognitive competence. Cognitive competence refers to the different intellectual competences demonstrated when developing a task; this allows the subject to appropriate knowledge to solve problems and transform their environment [13].

The generic skills are acquired in the formative or educational period and in the practice of work. They are used for any professional activity. They are supported by human factors, such as creativity, intellectual conditions and the ability to transfer knowledge to new situations[14, 15]. Examples of generic skills are: decision-making, initiative, empathy and sympathy, numerical and computational skills, verbal and conversational skills, problem solving, communication, personal attitudes, the use of technological information[16].

Quantifying the performance of the rulers in their functions represents an important task to avoid inconsistencies between the government plans proposed by the candidates and their obligations under the law. The aforementioned represents a problem of evaluation of the powers of the rulers that can be dealt with, from science by means of multi-criteria methods. Based on the above, the objective of this research is defined: to develop a method to evaluate the competencies of mayoral candidates based on multi-criteria methods. The use of the method is illustrated with the support of an example.

This article is divided into the following sections: Section 2 contains the fundamental concepts used in this investigation, such as the neutrosophic numbers and the Neutrosophic Linear Weighting method [17-20]. In section 3, we explain the method to use. In section 4, we apply the method to a real problem. Lastly, we expose the conclusions.

2 Preliminaries

In order to introduce the main theoretical references on the object of study, the different concepts that facilitate the understanding of the research are presented. A summary of the neutrosophic multicriteria methods for modeling uncertainty about the assessment of competencies is made [21-23]. In the 1980s, the international movement called Paradoxism[24], based on contradictions in science and literature, was founded by Romanian scientist Florentin Smarandache, who later extended it to Neutrosophy, based on contradictions and their neutrals[25, 26].The use of neutrosophic sets allows, in addition to the inclusion of membership functions of truth and falsehood, and additionally membership functions of indeterminacy. This indeterminacy is due to the existence of contradictions, ignorance, inconsistencies, among other elements [18, 27, 28].

Decision making is a selection process between alternative courses, based on a set of criteria, to achieve one or more objectives [29]. With regard to the concept of "decision making", Schein, declares[30]: it is the process of identifying a problem or opportunity and selecting an alternative for action among several existing ones, it is a key diligent activity in all types of organizations [31]. A decision-making process where objects or decisions vary is considered a multi-criteria decision-making problem. Multi-criteria evaluation constitutes an optimization with several simultaneous objective functions and a decision agent[32, 33]. Equation 1 formalizes the problem posed.

$$Max = F(x), x \in X \tag{1}$$

Where:

x: is a vector of the decision variables $[x_1, \cdots, x_n]$

X: is the so-called feasible region. Represents the domain of possible values that the variable can take.

F (x): is a vector of the objective functions that collect the criteria.$[F_1(x), \cdots, F_n(x)]$

Max: represents the function to be maximized, this is not restrictive.

Specifically, discrete multicriteria problems consist of two types of data that constitute the starting point for different discrete multicriteria decision-making (DMD) problems. Figure 1 shows a representation of a multi-criteria method.

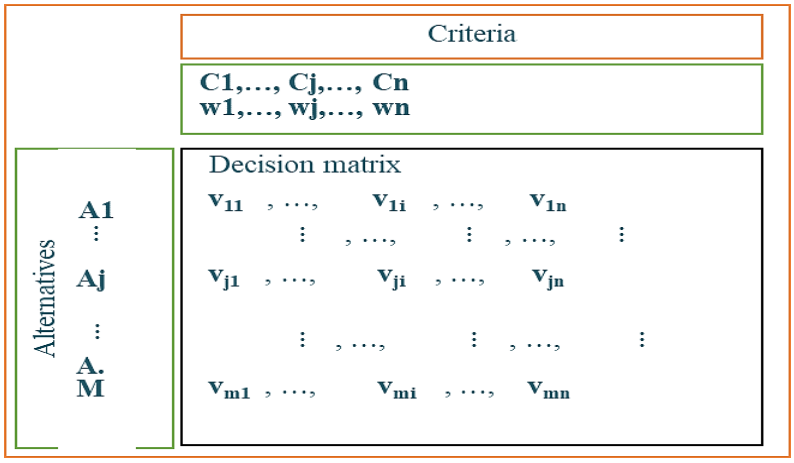

Figure 1. Representation of multicriteria method

Figure 1 shows a representation of a multi-criteria decision-making problem where:

r_{ij}: represents the evaluation of the alternative i against the criterion j.
w_i: represents the weight of criterion i.

Each decision-making problem can be different; however, based on the versatility of its nature, a procedure for solving problems can be defined. Figure 2 shows a diagram for solving decision-making problems.

Figure 2. Decision-making problem solving procedure.

For the resolution of various decision-making problems, the proposed multi-criteria methods have been proposed. When you want to issue a weight for a given alternative, the ordering and aggregation methods represent a viable way to apply it.[34-36]. Linear weighting is one of the classic multicriteria methods. The method consists of calculating a global score r_i for each alternative A_i as expressed in Equation 2 [37, 38].

$$R_i = \sum_j W_j \, r_{ij} \tag{2}$$

The linear weighting represents a compensatory method; it is applied after a previous normalization. The method is used in cases where there is a set m of alternatives and n criteria. For each criterion j, the decision maker estimates each alternative "i". The evaluation of the decision matrix that has a cardinal ratio weight is obtained. A weight $W_j \ (j = 1, \cdots, n) C_j$ of the cardinal ratio type is also assigned for each of the criteria a_{ij}

In the context of multi-criteria methods, neutrosophic numbers are introduced in order to represent the indeterminacy[39, 40]. It constitutes the bases of mathematical theories that generalize classical and fuzzy theories such as neutrosophic sets and neutrosophic logic[41]. A neutrosophic number (N) is represented as follows[42, 43]:

Let $N = \{(T, I, F) : T, I, F \subseteq [0, 1]\}$ be a neutrosophic valuation is a mapping of a group of formulas propositional to N, that is, for each p sentence we have:

$$v\,(p) = (T, I, F) \tag{3}$$

Where:
T: represents the truth value,
I: represents the indeterminacy value,
F: represents the falsehood value.
Mathematically a Neutrosophic Linear Weighting method can be defined as a 3-tuple (R, W, r) as represented by Equation 4.

$$R_{i(T,I,F)} = \sum_j W_{j(T,I,F)}\, r_{ij(T,I,F)} \tag{4}$$

Where:

$R_{i(T,I,F)}$: represents the resulting function that refers to a dimension of the space truth, indeterminacy, and falsehood (T, I, F).

$W_{j(T,I,F)}$: represents the weight of criterion i associated with the criteria that refer to a dimension of the space truth, indeterminacy, and falsehood(T, I, F).

$r_{ij:}$ represents the evaluation of the alternative i with respect to the criterion j that refers to a dimension of the space truth, indeterminacy, and falsehood (T, I, F).

3 Development of the method to evaluate the competencies of mayoral candidates in the execution of government plans

The proposed method is designed to support the process of evaluating the competencies of mayors in the execution of government plans. Its operation is based on multi-criteria, multi-expert techniques where the assessment of competencies is modeled from a set of criteria that represent the competencies to be performed.

It uses in its inference the multicriteria method Linear Neutrosophic Weighting. Figure 3 shows a diagram that illustrates the operation of the proposed method.

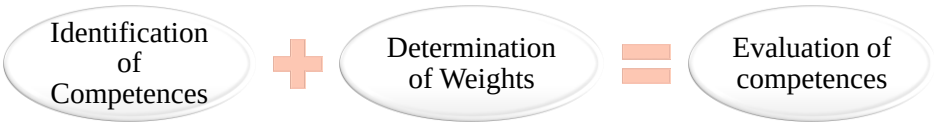

Figure 3: Structure of the proposed method.

The method is designed through a three-stage structure that as a whole determines the assessment of competencies.

Stage 1: Identification of the competences.

It represents the set of competencies that are assessed in the evaluation process for mayoral candidates. It constitutes a multi-criteria approach formalized as:

$C = \{c_1, \dots c_n\}$, n ≥ 2, criteria or competences to be evaluated in the method.

Stage 2: Determination of the weights.

To determine the weights associated with competences, a multi-expert approach is used so that:

$E = \{e_1, \dots e_m\}$, $m \geq 2$, where E, represents the experts involved in the process.

The use of a linguistic scale is recommended, where each of its elements is associated with an SVNN [44-46], as shown in Table 1.

Linguistic term	Value
Not important	(0.10,0.90,0.90)
Less important	(0.20,0.85,0.80)
Slightly important	(0.30,0.75,0.70)
Somewhat important	(0.40,0.65,0.60)
Average importance	(0.50,0.50,0.50)
Important	(0.60,0.35,0.40)
Very important	(0.70,0.25,0.30)
Strongly important	(0.8,0,15,0.20)
Very strongly important	(0.9, 0.1, 0.1)
Extremely important	(1,0,0)

Table 1. Domain of values to assign weight to the criteria.

- Each expert proposes a weight for each criterion, using the scale that appears in Table 1; let's call $\widetilde{w}_{ij}$ the weight assigned by the i-th expert to the j-th criterion.
- $\widehat{w}_j = \frac{1}{m}\sum_{i=1}^{m} \widetilde{w}_{ij}$ is obtained. The weight of the j-th criterion is calculated as $w_j = \frac{s(\widehat{w}_j)}{\sum_{j=1}^{n} s(\widehat{w}_j)}$, where $s(\cdot)$ is the operator that appears in Equation 5.

$$s(\tilde{a}) = \frac{1}{3}(2 + \mathrm{T} - \mathrm{I} - \mathrm{F}) \quad (5)$$

For a neutrosophic number $\tilde{a} = (\mathrm{T}, \mathrm{I}, \mathrm{F})$

Stage 3: Assessment of skills

The evaluation stage represents the processing of the method to emit the result of the proposed inference. The data are processed using the method of linear weighting through Equation 4. As a result, it expresses the value attributed to the competencies of the candidates. This is measured according to the following steps:

- The i-th expert issues an evaluation on compliance with the j-th criterion by the mayor's office. Let's call $\tilde{v}_{ij}$ this value. The evaluation scale is the following given in Table 2:

Linguistic term	Neutrosophic number
Extremely good (EG)	(1,0,0)
Very very good (VVG)	(0.9, 0.1, 0.1)
Very good (VG)	(0.8,0.15,0.20)
Good (G)	(0.70,0.25,0.30)
Medium good (MDG)	(0.60,0.35,0.40)
Medium (M)	(0.50,0.50,0.50)
Medium bad (MDB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very bad (VB)	(0.20,0.85,0.80)
Very very bad (VVB)	(0.10,0.90,0.90)
Extremely bad (EB)	(0,1,1)

Table 2. Linguistic terms used.

- The result is calculated with the support of formula 6.

$$\bar{v} = \frac{\sum_{i=1}^{m} \sum_{j=1}^{\mathrm{n}} w_j * \tilde{v}_{ij}}{nm} \quad (6)$$

Where * means the product of a vector by a scalar, "/" is the division of a vector by a scalar and the sum is performed between vectors.

To obtain a more understandable final value on $\bar{v}$, the $s(\bar{v})$ is applied. The closer this value is to 0 the evaluation will be worse, the closer to 1 the evaluation will be better and around 0.5 is an intermediate evaluation.

4 Implementation of method to evaluate the competencies of mayoral candidates in the execution of government plans

For the implementation of the proposed method, a case study was carried out with the government plans presented before the National Electoral Council in the Province of Los Ríos for the mayoral election process in the Babahoyo canton for the 2018-2021 period.

Stage 1: Identification of the competences

For the analysis and operation of the proposed method, 14 competences were used as described in Table 3.

Number	Competences
1	The planning of the canton in accordance with the organization of the superior and inferior governments specifically in relation to land use.
2	The supervision and control of the way the land is used.
3	Address public works related to the streets in urban areas.
4	Take charge of public services.
5	Manage the system of rates and special contributions through ordinances.
6	Manage traffic and urban public transport within the canton.
7	In accordance with the central government is the implementation of schools and health centers, as well as recreational spaces.
8	Assume the preservation and creation of spaces related to architectural heritage.
9	To govern the real estate cadaster system in rural and urban areas.

10	Regulates the use of beaches in the different bodies of natural waters of the canton.
11	Guarantee free access to the natural water banks sources.
12	Control the use of mineral resources present in quarries and aquatic spaces.
13	Manage the fire defense system.
14	Develop international cooperation mechanisms.

Table 3: Competences for the evaluation of candidates.

Stage 2: Determination of the weights

For the stage of determining the weights attributed to the competences, seven experts were consulted who expressed their assessments of the competences. The valuation tables were obtained which were added up in a resulting table. Table 4 shows the result of the evaluation of the criteria once the aggregation process has been carried out.

Competencies	Criterion assessment $\widehat{w}_j$	Criterion assessment w_j
C1	[0.85,0.25,0.25]	0.074132
C2	[0.75,0.25,0.25]	0.070978
C3	[0.55,0.25,0.25]	0.064669
C4	[0.75,0.25,0.25]	0.070978
C5	[0.60,0.25,0.25]	0.066246
C6	[0.80,0.25,0.25]	0.072555
C7	[0.85,0.25,0.25]	0.074132
C8	[0.75,0.25,0.25]	0.070978
C9	[0.60,0.25,0.25]	0.066246
C10	[0.75,0.25,0.25]	0.070978
C11	[0.90,0.25,0.25]	0.075710
C12	[0.85,0.25,0.25]	0.074132
C13	[0.85,0.25,0.25]	0.074132
C14	[0.85,0.25,0.25]	0.074132

Table 4: Weight attributed to the competences of the expert consultation.

Stage 3: Assessment of competencies

Based on the behavior of the weights attributed to the alternatives and the development of the manifestations, the degree of membership to a competence is determined through an aggregation process. Table 6 shows the result of the calculation performed.

Competences	Weights w_j	Average preferences for all experts	$\overline{v}$
C1	0.074132	[1,0.10,0.15]	[0.0741325,0.0074132, 0.0111199]
C2	0.070978	[0.75,0.10,0.15]	[0.0532334, 0.0070978,0.0106467]
C3	0.064669	[0.75,0.10,0.15]	[0.0485016, 0.0064669, 0.0097003]
C4	0.070978	[1,0.10,0.15]	[0.0709779, 0.0070978, 0.0106467]
C5	0.066246	[0.75,0.10,0.15]	[0.0496845, 0.0066246, 0.0099369]
C6	0.072555	[0.50,0.10,0.15]	[0.0362776, 0.0072555, 0.0108833]
C7	0.074132	[1,0.10,0.15]	[0.0741325, 0.0074132, 0.0111199]
C8	0.070978	[0.75,0.10,0.15]	[0.0532334, 0.0070978, 0.0106467]
C9	0.066246	[0.55,0.10,0.15]	[0.0364353, 0.0066246, 0.0099369]
C10	0.070978	[1,0.10,0.15]	[0.0709779,0.0070978, 0.0106467]

C11	0.075710	[0.7,0.10,0.15]	[0.0529968, 0.0075710, 0.0113565]
C12	0.074132	[1,0.10,0.15]	[0.0741325, 0.0074132, 0.0111199]
C13	0.074132	[1,0.10,0.15]	[0.0741325, 0.0074132, 0.0111199]
C14	0.074132	[1,0.10,0.15]	[0.0741325, 0.0074132, 0.0111199]
Index			[0.84298, 0.10000, 0.15000]

Table 5: Weight attributed to demonstrations

The value $s(\bar{v}) = 0.86433$, is close to 1, therefore the evaluation of the mayor's office in its management is "good".

Conclusions

From the research carried out, we obtained a method to evaluate the competencies of the mayoral candidates or the current mayor based on a multi-expert multi-criteria approach. The implementation of the method made it possible to obtain the neutrosophic vectors of weights attributed to the competences through a multi-expert approach. With the application of the method proposed in the case study, it was possible to evaluate the competences of the current mayor in the Babahoyo canton. The proposed case study presents an application of the proposed method, although it is recommended to implement different multi-criteria methods to compare the behavior of the evaluations carried out.

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