Journal of Intelligent Systems and Internet of Things
Vol. 12, No. 01, PP. 164-176, 2024
DOI: https://doi.org/10.54216/JISIoT.120113

Neutrosophic decision making using Saaty's AHP method and VIKOR

Sheila B. Esparza P[1, *], Luis A. Crespo-Berti [2,] Haro Teran Lilian Fabiola[1], Omar Mar Cornelio[3], Dinara Turaeva[4]

[1]Regional Autonomous University of the Andes (UNIANDES-Ibarra), Ecuador
[2]Regional Autonomous Communities University of the Andes (UNIANDES-Ibarra), Ecuador
[3]Centro de Estudio de Matemática Computacional. Universidad de las Ciencias Informáticas, Cuba
[4]Tashkent State University of Economics, Uzbekistan

Emails: docentetp81@uniandes.edu.ec; ui.luiscrespo@uniandes.edu.ec; ui.lilianharo@uniandes.edu.ec; omarmar@uci.cu; d.turaeva@tsue.uz

Abstract

This study analyzes the difficulties that arise in multicriteria decision making in condition that bear uncertainty, ambiguity, and contradictions at the very core. The key issue is the shortage of instruments allowing for not only ranking of alternatives but also efficiently combining qualitative and quantitative information in management decision making. The relevance of this research is due to the growing number of critical situations in a variety of disciplines, including organizational management and public policies, which have a limited number of traditional methodologies and thus need more effective evaluation processes. Still, concerning such aspects as the integration of approaches that tend to discuss a lot of the quite fuzzy context in a structured and dynamic way, there are significant gaps in the existing literature. A methodological framework for managing uncertainties inherent in expert judgments and for prioritizing alternatives was developed through the integration of Saaty's AHP method and the VIKOR approach from the perspective of neutrosophic logic. The results demonstrate that this integration not only improves the efficiency of ranking and selection of alternatives under complex environment but also enhances sensitivity to differences among evaluations. This progress is of central importance regarding practical implications of this advance, particularly in strategies design.

Received: August 19, 2023 Revised: November 25, 2023 Accepted: March 14, 2024

Keywords: multicriteria decision making; Contradictions; Analytical tools; Subjective perspectives; Quantitative data; Organizational management; Public policies; AHP method; VIKOR approach; Neutrosophic logic

1. Introduction

The decriminalization of abortion for congenital malformations has been a controversial issue in Ecuador [1] , as reflected in case 38-19-AN. A neutrosophic analysis considers the various legal, social and ethical aspects involved, addressed in the review of the non-compliance action filed by members of the National Coalition of Women of Ecuador before the Constitutional Court [2] . The plaintiffs argue that a series of recommendations from five United Nations (UN) Committees have been violated.

include the repeal of discriminatory provisions against women, the criminalization of abortion in certain cases, and the need for exceptions to the termination of pregnancy in specific situations such as rape, incest, congenital malformations, and fatal fetal disability [3,12] . These recommendations, issued by committees such as the Committee on the Elimination of Discrimination against Women (CEDAW), the Committee on Economic, Social and Cultural Rights (CESCR), the Human Rights Committee (CCPR), the Committee on the Rights of the Child (CRC), and the Committee against Torture (CAT), are essential to the plaintiffs' argument. The review focuses on the lack of compliance with these recommendations by the National Assembly, the President of the Republic of Ecuador, and the Attorney General of the State.

A. Ecuadorian legal analysis

The Comprehensive Organic Criminal Code (COIP) of 2014, in its articles 149 and 150, establishes sanctions for consensual and non-punishable abortion. Induced abortion without the consent of the woman is penalized, while non-punishable abortion, performed by a health professional with the consent of the woman, is provided for in specific cases such as risk to the life or health of the pregnant woman and rape of women with mental disabilities.

The action for non-compliance, according to the Law on Jurisdictional Guarantees and Constitutional Control of 2009, aims to guarantee the application of the norms and compliance with the decisions of international human rights bodies. The requirements to file this action include the prior claim and the demonstration of a clear, express and enforceable obligation. Grounds for inadmissibility are established, such as the existence of other judicial mechanisms to achieve compliance.

The Constitution of the Republic of Ecuador and the action for non-compliance seek to protect constitutional rights by ensuring the application of the legal system. The effectiveness of the Constitution is achieved by activating jurisdictional guarantees in cases of non-compliance with international norms and decisions.

B. Analysis of case 38-19-AN

The investigation focuses on the analysis of case 38-19-AN of the Constitutional Court of Ecuador, which was dismissed for not complying with the recommendations of international organizations regarding abortion in cases of congenital malformations. The omission of requirements demanded by the plaintiffs prevented the analysis of the substantive aspects of the international recommendations on this matter.

The conditions and requirements of the action for non-compliance were addressed, focusing on the relevant constitutional and legal regulations. The action was brought by the National Coalition of Women of Ecuador, the Desafío Foundation and the Ecuadorian Front for the Defense of Sexual and Reproductive Rights against the National Assembly, the President of the Republic and the Attorney General of the State. [3]

The judgment, in dismissing the claim, was based on the failure to comply with the prior claim, considered an essential requirement before resorting to the action for non-compliance. It was emphasized that this prior claim is not a mere formality, but a necessary step to establish non-compliance with the norm. The Chamber indicated that the applicants did not adequately justify the prior claim made, which prevented them from ruling on the legal consequences of the alleged non-compliance. It should be noted that the Chamber did not carry out a substantive analysis of the claims presented, nor did it rule on the nature of the general recommendations and concluding observations of the international organizations whose compliance was required.

In the discussion on the action for failure to comply with the decriminalization of abortion due to congenital malformations [3] , the possibility of individuals and organizations filing such action before the Court when the State does not comply with this decriminalization process is highlighted. The main objective of this action is to guarantee respect for and compliance with the rights established in the legislation, as well as the implementation of policies and programs aimed at ensuring access and adequate care for women who require the termination of a pregnancy due to congenital malformations.

The arguments in favor of this action include the protection of women's rights, reproductive autonomy, access to legal and safe health services, and the prevention of unnecessary suffering for both women and fetuses. Despite the positive effects that the analysis and discussion of non-compliance actions have had in other cases, in this specific case, the Court argues that the legal requirements were not met, especially regarding the prior claim, which led to the dismissal of the case. Therefore, the main objective of this study is to analyze, using the neutrosophic approach, case 38-19-AN related to the decriminalization of abortion due to congenital malformations in Ecuador, to contribute to the understanding of the legal, social, and ethical elements involved.

Specific objectives:

- To analyze the applicability of international treaties and recommendations of human rights organizations to case 38-19-AN, highlighting its importance in the context of the decriminalization of abortion due to congenital malformations.
- Apply the AHP neutrosophic methodology to determine relevant criteria and subcriteria in the analysis.
- Use the VIKOR methodology to evaluate alternatives for action, providing a solid basis for making informed decisions.
- To summarize the results obtained from the neutrosophic analysis of case 38-19-AN and provide an action plan against abortion due to congenital malformations in Ecuador.

By applying the AHP and VIKOR methodologies from the Neutrosophic perspective [4,13], we aim to achieve a fair and respectful analysis of the different perspectives involved in case 38-19-AN, which will allow for a solid

framework for decision-making in the context of the decriminalization of abortion due to congenital malformations in Ecuador.

2. Related work

This section details the main concepts and techniques used in this study.

A. Neutrosophic Analytical Hierarchy Process.

Definition 1: The neutrosophic set N is characterized by three membership functions [7,15] , which are the truth membership function TA, the indeterminacy membership function IA, and the falsehood membership function FA, where U is the Universe of Discourse and $\forall x \in U, TA(x), IA(x), FA(x) \subseteq]-0, 1+[, and\ -0 \leq inf\ TA(x) + inf\ IA\ (x) + inf\ FA\ (x) \leq sup\ TA(x) + sup\ IA\ (x) + sup\ FA\ (x) \leq 3+$.Note that by the definition, TA(x), IA(x) and FA(x) are standard or nonstandard real subsets of $]-0, 1+[$ and therefore TA(x), IA(x) and FA(x) can be subintervals of [0, 1].

Definition 2: The *single-valued neutrosophic set* (SVNS) N over U is $A = \{< x;\ TA(x), IA(x), FA(x) > : x \in U\}$, where $TA: U \rightarrow [0, 1], IA: U \rightarrow [0, 1]$, and $FA: U \rightarrow [0, 1]$, $0 \leq TA(x) + IA(x) + FA(x) \leq 3$. The *single-valued neutrosophic set the number* (SVNN) is represented by N = (t, I, f), such that $0 \leq t, I, f \leq 1\ and\ 0 \leq t + I + f \leq 3$.

Definition 3: The single-valued trapezoidal neutrosophic number [4] , $\tilde{a} = \langle(a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, is a neutrosophic set in $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined in [8] .

Definition 4: Given $\tilde{a} = \langle(a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$two $\tilde{b} = \langle(b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}}\rangle$single-valued trapezoidal neutrosophic numbers and λany non-zero number on the real line, the following operations are defined :

Addition :$\tilde{a} + \tilde{b} = \langle(a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle$

Remains :

$$\tilde{a} - \tilde{b} = \langle(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle \quad (1)$$

Investment: $\tilde{a}^{-1} = \langle({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.

Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{Bmatrix} \langle(\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle, & \lambda > 0 \\ \langle(\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle, & \lambda < 0 \end{Bmatrix}$$

Definitions 3 and 4 refer to *single-valued triangular neutrosophic numbers* when the condition a2 = a3 . For simplicity, the linguistic scale of triangular neutrosophic numbers is used, see Table 1 and compare also with the scale defined in [8] . We can find this in the theory of the AHP technique in a neutrosophic framework. Therefore, the indeterminacy of decision making can be modeled by applying neutrosophic AHP, or NAHP for short. Equation 2 contains a generic neutrosophic pairwise comparison matrix for NAHP.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (2)$$

The matrix $\tilde{A}$must satisfy the condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, according to the inversion operator in Definition 4.

Step 1. Select a group of experts.

Step 2. Structure the neutrosophic comparison matrix by pairs of factors, subfactors and strategies, through the linguistic terms shown in Table 1.

Table 1: The Saaty scale translated into a neutrosophic triangular scale. Source: own elaboration.

The Saaty scale	Definition	Neutrosophic triangular scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$

7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$ $\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$ $\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$ $\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

The neutrosophic scale is derived based on expert opinions. The neutrosophic comparison matrix for pairs of factors, subfactors and strategies is described in equation 2.

Step 3. Check the consistency of the experts' judgments.

If the pairwise comparison matrix has a transitive relationship, i.e., $a_{ik} = a_{ij}a_{ik}$ for all i, j,yk, then the comparison matrix is consistent and focuses only on the lower, middle, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4. Calculate the weight of the factors of the neutrosophic pairwise comparison matrix, transforming it into a deterministic matrix using:

$$S(\tilde{a}_{ji}) = {}^{1}\Big/_{S(\tilde{a}_{ij})} \quad (3)$$

$$A(\tilde{a}_{ji}) = {}^{1}\Big/_{A(\tilde{a}_{ij})} \quad (4)$$

To convert neutrosophic triangular numbers into crisp numbers [9] , two indices are defined, which are called score and precision indices, respectively:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (5)$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (6)$$

Determine the priority ranking, i.e. the eigenvector X, from the above matrix:

1. Normalize the column entries by dividing each entry by the sum of the column.

2. Take the total of the row averages.

Note that Step 3 refers to considering the use of the *Consistency Index* (CI) calculation when applying this technique, which is a function that depends on λ_{max} , the maximum eigenvalue of the matrix. Saaty states that the consistency of the evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n-1}, \quad (7)$$

$$CR = \frac{CI}{RI} \quad (8)$$

The IR is given in [5, 14] . If $CR \leq 0.1$the experts' assessment can be considered sufficiently consistent, NAHP is used. This procedure is applied to the matrix " *A* " in equation 2.

B. VIKOR Neutrosophic

The VIKOR method is suitable for solving decision problems with conflicting and incommensurable criteria, using single-valued neutrosophic units [10,16] . The compromise solution is determined as the one that comes closest to the ideal solution. For the development of the method, it is proposed to define the neutrosophic decision matrix (see Figure 1).

$$
\begin{array}{cc}
 & \begin{array}{cccccc} k_{Q1} & k_{Q2} & \dots & k_{Qj} & \dots & k_{Qn} \end{array} \\
 & \begin{array}{cccccc} w_1 & w_2 & \dots & w_j & \dots & w_n \end{array} \\
\boldsymbol{F_j} & \begin{array}{cccccc} Min & Max & \dots & \dots & \dots & \dots \end{array} \\
 & \\
\boldsymbol{Max\ V_i} & \begin{array}{c} T_1 \\ T_2 \\ \vdots \\ T_i \\ \vdots \\ T_m \end{array} \begin{bmatrix} m_{11} & m_{12} & \dots & m_{1j} & \dots & m_{1n} \\ m_{21} & m_{22} & \dots & m_{2j} & \dots & m_{2n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ m_{i1} & m_{i2} & \dots & m_{ij} & \dots & m_{in} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ m_{m1} & m_{m2} & \dots & m_{mj} & \dots & m_{mn} \end{bmatrix} \\
\boldsymbol{Min\ V_i} & \\
 & \\
\boldsymbol{f_{Qi}^{*}} & \begin{array}{cccccc} m_{11} & m_{22} & \dots & \dots & \dots & \dots \end{array} \\
\boldsymbol{f_{Qi}^{-}} & \begin{array}{cccccc} m_{i1} & m_{i2} & \dots & \dots & \dots & \dots \end{array}
\end{array}
$$

Figure 1. Neutrosophic decision matrix.

Before analyzing the neutrosophic decision matrix of the method, it is necessary to define the neutrosophic set under analysis . The neutrosophic set is defined by the following elements: true ϑ, indeterminate η and false δ of x in Q, respectively, and their images constitute standard or nonstandard subsets within the range {0,1 }. For X in the universe of discourse, the single-valued neutrosophic set Q over X is defined as an object in the representation $Q = \{\langle x, \vartheta_A(x), \eta_A(x), \delta_A(x)\rangle : x \in X\}$.

Where $\vartheta_A(x), \eta_A(x), \delta_A(x)$the following condition is met $0 \leq \vartheta_A(x), \eta_A(x), \delta_A(x) \leq 3$for all $x \in X$. Therefore, to define each neutrosophic number is expressed in the following form h, i , j for modeling VIKOR neutrosophic method. Therefore, the following functions are defined:

$h = \vartheta_A(x)$ for true membership functions, where $h \in \{0,1\}$.

$i = \eta_A(x)$ for indeterminate membership functions, where $i \in \{0,1\}$.

$j = \delta_A(x)$ for false membership functions, where $j \in \{0,1\}$.

Therefore, the neutrosophic number defined for the study is determined as $Q = (h, i, j)$, where h, i, j $\in$ {0,1}and satisfies the following condition $0 \leq h + i + j \leq 3$. Therefore, the scoring function B of a neutrosophic number is defined by the following equation [17, 18]

$$B(Q) = \frac{1 + h - 2i - j}{2} \qquad (9)$$

Analysis of the elements of the neutrosophic decision matrix:

Decision criteria $K_Q = K_{Q1}, K_{Q2}, K_{Qj}, \dots, K_{Qn}$can be defined as the conditions or parameters that allow the discrimination of alternatives and the establishment of the decision-maker's preferences [19]. The decision criteria for each alternative are evaluated based on the single-valued neutrosophic linguistic terms (SVNN) according to the scales shown in Table 3.

Table 3: Linguistic terms that represent the weight of the importance of the alternatives. Source: Own elaboration.

Linguistic scale	**SVNN** (h, i, j)
Very high (VH)	(0.95,0.05,0.05)
Height (H)	(0.8,0.15,0.1)
Medium (M)	(0.5,0.4,0.5)
Low (L)	(0.45, 0.6, 0.85)
Very Low (VL)	(0.25, 0.75, 0.95)

The weights or ponderations are measures of the neutrosophic importance that the criteria have for the decision-maker. Associated with the criteria, a weight vector is generated. $(w_Q) = (w_{Q1}, w_{Q2} \dots w_{Qj} \dots w_{Qn})$It is assigned, where w $\in$is the number of criteria of the linguistic term used (SVNN). The weight w_{Qi}reflects the importance of

the criterion k_{Qi}in each decision of the neutrosophic set, and is assumed to be positive. For the assignment of weights per criterion, the direct assignment method or the auto-vectorial method can be applied (see Table 4).

Table 4: Linguistic terms that represent the weight of importance for (w_Q). Source: own elaboration.

Linguistic scale	**SVNN**(h, i, j)
Very important (VI)	(0.9;0.1;0.1)
Important (I)	(0.75; 0.25; 0.20)
Medium (M)	(0.50;0.5;0.50)
Not important (NI)	(0.35; 0.75; 0.80)
Very unimportant (VNI)	(0.10;0.90;0.90)

Each set of alternatives T consists of different, mutually exclusive, and exhaustive alternatives represented as $T = \{t_1, t_2, \dots, t_n\}$, where $T \epsilon m$as $(i = 1, 2, \dots, m)$is the number of each of the possible alternatives.

Once the criteria and their associated weights for the linguistic term used (SVNN) have been established, the decision-maker can provide, for each of the criteria considered and each alternative in the neutrosophic choice set, a SVNN or symbolic value.Q_{ij} which expresses an evaluation or judgment of an alternative T_i with respect to the criterion k_j. This neutrosophic evaluation can be represented in the form of a matrix, evaluation matrix or decision matrix. Each row of the matrix expresses qualities of the alternative $T_i$with respect to the n criteria considered. Each column of the matrix contains the evaluations or judgments issued by the decision-maker for all the alternatives with respect to the criterion k_j. Therefore, to obtain the compromise solution (or solutions), one must:

I.Calculate the values f_{Qi}^*, and the worst f_{Qi}^-, of each criterion.

$f_{Qi}^* = max_i f_{Qij}$ $\quad$ $f_{Qi}^- = min_i f_{Qij}$ $\quad$ If function *i* represents a gain

$f_{Qi}^* = min_i f_{Qij}$ $\quad$ $f_{Qi}^- = max_i f_{Qij}$ $\quad$ If function *i* represents a cost

II.Calculate the values $S_{Qj}, R_{Qj} and\ P_{Qj}$ for each alternative:

$$S_{Qj} = \sum_{i=1}^{n} w_{Qj} \frac{f_{Qi}^* - f_{Qij}}{f_{Qi}^* - f_{Qi}^-} \quad (10)$$

$$R_{Qj} = max_i \left\{ w_{Qj} \frac{f_{Qi}^* - f_{Qij}}{f_{Qi}^* - f_{Qi}^-} \right\} \quad (11)$$

$$P_{Qj} = v\ \frac{S_{Qj} - S_Q^*}{S_Q^- - S_Q^*} + (1 - v) \frac{R_{Qj} - R_Q^*}{R_Q^- - R_Q^*} \quad (12)$$

Where:

$$S_Q^* = min_j\ S_{Qj};\ S_Q^- = max_j\ S_{Qj}$$
$$R_Q^* = min_j\ R_{Qj};\ R_Q^- = max_j\ R_{Qj} \quad (13)$$

And $v$is introduced as a weight of the group's maximum utility strategy, while $(1 - v)$, is the weight of individual opposition.

- $v > 0.5$ *Majority vote*
- $v \sim 0.5$ *Vote by consensus*
- $v < 0.5$ *Vote with veto*

III. The alternatives are ordered according to the values of S_Q, R_Q y P_Q (see Figure 2)

$$\begin{bmatrix} S_{Q1} \\ S_{Q2} \\ \vdots \\ S_{Qj} \\ \vdots \\ S_{Qm} \end{bmatrix} \begin{bmatrix} R_{Q1} \\ R_{Q2} \\ \vdots \\ R_{Qj} \\ \vdots \\ R_{Qm} \end{bmatrix} \begin{bmatrix} P_{Q1} \\ P_{Q2} \\ \vdots \\ P_{Qj} \\ \vdots \\ P_{Qm} \end{bmatrix}$$

Figure 2. Matrix according to the values of S_Q, R_Q and P_Q

IV. Determine as a compromise solution the alternative $T_b^{(1)}$ that is best classified according to the value of P_b (according to equation 1), that is, with the value of $P_{b\,min}$, if the following two conditions are met:

a. Condition 1: Acceptable advantage.

$P_b\left(T_b^{(2)}\right) - P_b\left(T_b^{(1)}\right) \geq DP_b$,

Where $T_b^{(2)}$, is the second alternative according to the classification of the values of P_b, and $DP_b = \frac{1}{N-1}$, with N as the number of alternatives.

b. Condition 2: Acceptable stability in the decision process.

The alternative $T_b^{(1)}$ must be the best classified according to the list of values of S_b and/or R_b, this being a stable compromise solution within a decision process.

If one of the conditions is not met, then a set of compromise solutions is proposed, consisting of:

- Alternatives $T_b^{(1)}$ and $T_b^{(2)}$ if condition 2 is not met.
- Alternatives $T_b^{(1)}, T_b^{(2)}, \ldots, T_b^{(m)}$ and if condition 1 is not met, $T_b^{(m)}$ it is determined taking into account the relationship $P_b\left(T_b^{(2)}\right) - P_b\left(T_b^{(1)}\right) \geq DP_b$. These alternatives are considered close to the ideal solution.

3. Results and discussion

The applicability of international treaties and recommendations of human rights organizations in case 38-19-AN is crucial to understanding the context of the decriminalization of abortion for congenital malformations in Ecuador. Evaluating this applicability from the perspective of Neutrosophy implies recognizing the diversity of opinions and perspectives involved in this delicate issue.

1. International Treaties and Human Rights:

Neutral importance: International treaties, once ratified, become part of the Ecuadorian legal framework. The application of these treaties can be seen from a neutral perspective in terms of recognizing the State's commitment to human rights, including those related to reproductive health and human dignity.

Diversity of Neutrosophical Perspectives: Neutrosophy recognizes that interpretations of treaties can be diverse. Some people may see treaties as supporting the decriminalization of abortion in cases of congenital malformations, while others may focus on the protection of the right to life from conception.

2. Recommendations from Human Rights Organizations:

Neutrosophic perspective on recommendations: Recommendations from human rights organizations are evaluated from a neutrosophic perspective [11] , recognizing that these organizations make suggestions based on international standards and the interpretation of human rights.

Role in the decriminalization of abortion for congenital malformations: The specific recommendations regarding the decriminalization of abortion for congenital malformations can be seen as a guide for the State to align itself with international standards. However, there may be a diversity of opinions in the interpretation of the obligatory nature and applicability of these recommendations.

3. Diversity of perspectives in case 38-19-AN:

Recognition of Neutrosophy: In the analysis of case 38-19-AN, Neutrosophy allows for the recognition of the diversity of perspectives regarding the applicability of treaties and recommendations. Some may argue that these obligations must be strictly adhered to, while others may advocate for more flexible or contextualized interpretations.

Importance in legal and social debate: Neutrosophy stresses the importance of considering all perspectives in legal and social debate. It recognises that different parties may have legitimate and divergent interpretations of the applicability of treaties and recommendations.

Once the different approaches have been analyzed, the techniques mentioned above will be applied. The AHP neutrosophic methodology is applied to determine the relevant criteria and subcriteria in the analysis of case 38-19-AN on the decriminalization of abortion due to congenital malformations in Ecuador, as well as the relevant indeterminacies (see Tables 5 to 8).

Table 5: Relevant criteria and sub criteria in the analysis of case 38-19-AN. Source: Own elaboration.

Code	**Criteria**	**Sub criteria**
Chief Information Officer	Compliance with international obligations.	Ratification of treaties, compliance reviews and recommendations from organizations.
PHR	Protection of human rights.	Reproductive rights, women's autonomy, fetal rights.
VLA	Political and legislative feasibility.	Political support, feasibility of implementation, existing legal framework.
YEAH	Social impact.	Public education, health services, social acceptance.
EC	Ethical considerations.	Human dignity, disability perspective, morality of abortion.

Table 6: Neutrosophic AHP paired matrix. Source: Own elaboration.

Criteria	**Chief Information Officer**	**PHR**	**VLA**	**YEAH**	**EC**
Chief Information Officer	**〈 (1,1,1);0.50,0.50,0.50 〉**	〈 (6,7,8);0,90,0,10,0,10 〉	〈 (6,7,8);0,90,0,10,0,10 〉	〈 (2,3,4);0.30,0.75,0.70 〉	〈 (2,3,4);0.30,0.75,0.70 〉
PHR	〈 (6,7,8);0,90,0,10,0,10 〉	**〈 (1,1,1);0.50,0.50,0.50 〉**	〈 (4,5,6);0.80,0.15,0.20 〉	〈 (1,1,1);0.50,0.50,0.50 〉	〈 (2,3,4);0.30,0.75,0.70 〉
VLA	〈 (6,7,8);0,90,0,10,0,10 〉	〈 (4,5,6);0.80,0.15,0.20 〉	**〈 (1,1,1);0.50,0.50,0.50 〉**	〈 (2,3,4);0.30,0.75,0.70 〉	〈 (2,3,4);0.30,0.75,0.70 〉
YEAH	〈 (2,3,4);0.30,0.75,0.70 〉	〈 (1,1,1);0.50,0.50,0.50 〉	〈 (2,3,4);0.30,0.75,0.70 〉	**〈 (1,1,1);0.50,0.50,0.50 〉**	〈 (1,1,1);0.50,0.50,0.50 〉
EC	〈 (2,3,4);0.30,0.75,0.70 〉	〈 (2,3,4);0.30,0.75,0.70 〉	〈 (2,3,4);0.30,0.75,0.70 〉	〈 (1,1,1);0.50,0.50,0.50 〉	**〈 (1,1,1);0.50,0.50,0.50 〉**
Addition	**1**	**1**	**1**	**1**	**1**

Table 7: Determination of the weights of the criteria when applying the Neutrosophic AHP method.

Criteria	**Chief Information Officer**	**PHR**	**VLA**	**YEAH**	**EC**	**WEIGHT**
Chief Information Officer	0.51	0.73	0.37	0.47	0.36	**0.49**
PHR	0.07	0.10	0.26	0.16	0.36	**0.19**
VLA	0.07	0.02	0.05	0.05	0.04	**0.05**

YEAH	0.17	0.10	0.16	0.16	0.12	**0.14**
EC	0.17	0.03	0.16	0.16	0.12	**0.13**

Table 8: Analysis of the consistency of the paired matrix. Source: own elaboration.

Criteria	**A x Weight**	**Approximate Eigenvalues**	
Chief Information Officer	2.98	6.083966105	The analysis of the consistency of the method showed that its eigenvalue is 8.83, CI=0.10 and CR=0.09, which confirms that the exercise was correct.
PHR	1.03	5.361019817	
VLA	0.25	5.145918245	
YEAH	0.77	5.406747757	
EC	0.64	4.999384268	
Eigenvalue = 5.399407239			

According to the AHP analysis, the criteria are prioritized as follows: Compliance with international obligations, Protection of human rights, Social impact, Ethical considerations, Political and legislative feasibility. Therefore, Vikor's neutrosophic method is applied.

By using the VIKOR methodology from a neutrosophic perspective, we seek to achieve an equitable and efficient evaluation of the alternatives for action in case 38-19-AN, thus providing a solid basis for informed decision-making in the context of the decriminalization of abortion for congenital malformations in Ecuador.

Analysis of alternatives:

- ❖ Implementation of comprehensive support policies (A1): This stands out for addressing various dimensions, including the needs of affected women and fetuses. However, it could face resistance in terms of political and legislative viability.
- ❖ Full decriminalization of abortion (A2): While it stands out for addressing reproductive autonomy and human rights, it faces resistance on ethical and moral grounds, as well as potential challenges in terms of social acceptance and political viability.
- ❖ Partial decriminalization with medical and ethical criteria (A3): Seeks a balance by considering ethical and moral aspects, but can generate controversies in terms of reproductive rights and access to health services.
- ❖ Maintaining existing legislation (A4): This approach, while respecting certain ethical and moral principles, may be insufficient to address the needs of women and the fundamental rights involved, depending on the criteria and sub-criteria assessed.

Once the weights of each criterion have been defined according to the AHP method, each alternative is evaluated for each criterion. In this way, the ranking of alternatives is obtained, and thus the compromise solution or solutions that come closest to the solution are determined (see Tables 9 to 12). These compromise solutions must be aligned with the neutrosophic values, respecting the diversity of opinions and seeking an approach that maximizes general well-being.

Table 9: Neutrosophic normalization of the decision matrix. Source: Own elaboration.

	Chief Information Officer	**PHR**	**VLA**	**YEAH**	**EC**
Weight	**(0.91,0.15,0.11)**	**(0.5,0.55,0.4)**	**(0.11,0.9,0.94)**	**(0,3,0,8,0,7)**	**(0,3,0,8,0,7)**
FJ	**Maximum**	**Maximum**	**Maximum**	**min.**	**Maximum**
A1	(0.74,0.31,0.32)	(0.34,0.71,0.72)	(0.64,0.41,0.42)	(0.64,0.41,0.42)	(0.44, 0.61, 0.62)
A2	(0.74,0.31,0.32)	(0.54,0.51,0.52)	(0.24,0.81,0.82)	(0.44, 0.61, 0.62)	(0.34,0.71,0.72)

A3	(0.34,0.71,0.72)	(0.64,0.41,0.42)	(0.24,0.81,0.82)	(0.44, 0.61, 0.62)	(0.54,0.51,0.52)
A4	(0.34,0.71,0.72)	(0.34,0.71,0.72)	(0.44, 0.61, 0.62)	(0.24,0.81,0.82)	(0.34,0.71,0.72)
Better f_{Qi}^{*}	**(0.74,0.31,0.32)**	**(0.64,0.41,0.42)**	**(0.64,0.41,0.42)**	**(0.24,0.81,0.82)**	**(0.54,0.51,0.52)**
Worse f_{Qi}^{-}	**(0.34,0.71,0.72)**	**(0.34,0.71,0.72)**	**(0.24,0.81,0.82)**	**(0.64,0.41,0.42)**	**(0.34,0.71,0.72)**

Table 10: Measure of utility S_{Qj} and regretR_{Qj} of each program. Source: own elaboration.

Alt.	**C1**	**C2**	**C3**	**C4**	**C5**	S_j	R_j
A1	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	**(0.34,0.71, 0.72)**	**(0,0,95,1)**
A2	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	**(0.24,0.81, 0.82)**	**(0,0,95,1)**
A3	(0.34,0.71, 0.72)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	**(0.44, 0.61, 0.62)**	**(0.34,0.71, 0.72)**
A4	(0.44, 0.61, 0.62)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	(0,0,95,1)	**(0.74,0.31, 0.32)**	**(0.44, 0.61, 0.62)**

Table 11: Index $P_{Qj}$of each program. Source: own elaboration.

Alt	S_{Qj}	R_{Qj}	v	P_{Qj}	**Hierarchy**	For the classification of the alternatives, it is evaluated for v ~ 0.5 (Consensus voting)
A1	(0.34,0.71,0.72)	(0,0,95,1)	0.5	(0,0,95,1)	**2**	
A2	(0.24,0.81,0.82)	(0,0,95,1)		(0,0,95,1)	**1**	
A3	(0.44, 0.61, 0.62)	(0.34,0.71,0.72)		(0.54,0.51,0.52)	**3**	
A4	(0.74,0.31,0.32)	(0.44, 0.61, 0.62)		(1,0,0)	**4**	

Table 12: Acceptable advantage condition. Source: Own elaboration.

Alt	$P_b\,(a'')$	**Hierarchy**	$P_b\,(a')$	**north**	$P_b\,(a'') - P_b\,(a')$	DP_b	$Q_b\,(a'') - P_b\,(a') \geq DP_b$
A1	0.15	2	0.00	4	0.15	0.2	**Failure**
A2	0.00	1			0.00		**Failure**
A3	0.63	3			0.63		**Passes**
A4	1.00	4			1.00		**Passes**

The acceptable advantage condition is met by alternative 3. Therefore, alternatives 1 and 2 are defined as part of the compromise solution group. While Alternative 2 is the best ranked for the index P_{b_j}. It must be defined whether it is the best ranked according to the list of values of $S_b$and/or R_b. To do this, Figure 3 shows a representation of $S_{bj}, R_{bj}$and P_{bj}.

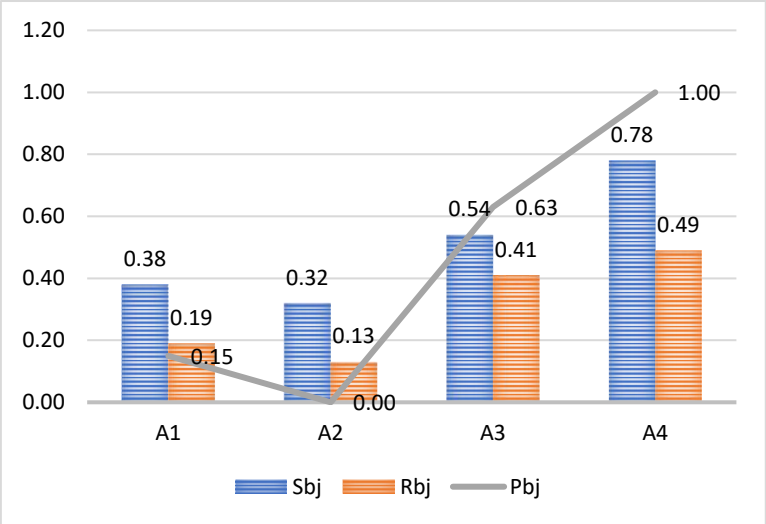

Figure 3. Analysis of $S_{bj}, R_{bj}$and P_{bj}. Source: own elaboration.

The graph shows that Alternative 2 is at the minimum of the values. $S_{bj}, R_{bj}$and P_{bj}. Therefore, it meets the second condition of being ranked higher inP_{bj} and is also the best ranked by $S_{bj}$and R_{bj} with a value of (0.32, 0.13). Where the *full decriminalization alternative* stood out as the most balanced in terms of compliance with the established criteria, closely followed by the *implementation of comprehensive support policies.* The other two alternatives are less favorable in this context. Therefore, the following action plan is proposed for the best alternative:

Best alternative: *Comprehensive Support (Total decriminalization)*

Integrated action plan:

I.Legislative amendments:

- Propose amendments to the Comprehensive Organic Criminal Code (COIP) to fully decriminalize abortion due to congenital malformations.
- Establish specific clauses that address the different situations related to serious malformations and respect reproductive rights.

II.Strategies for implementing recommendations:

- Create an inter-institutional working group with representatives from the National Assembly, the Executive and human rights organizations to oversee the implementation of the recommendations.
- Establish clear and measurable timelines to ensure effective implementation of legislative amendments and recommendations of human rights committees.

III.Education and awareness programs:

- Develop national educational campaigns to inform about legislative changes and reproductive rights.
- Collaborate with civil society organizations, educational institutions and health professionals to disseminate accurate information and promote awareness about the complete decriminalization of abortion for congenital malformations.

IV.Monitoring and evaluation:

- Establish a monitoring and evaluation system to measure the impact of legislative changes and implemented strategies.
- Conduct periodic reviews to ensure proper implementation of recommendations and adjust the action plan as necessary.

V.Inclusion of diverse perspectives:

- Encourage the active participation of diverse stakeholders, including women's organizations, human rights groups and communities, in the planning and implementation of the action plan.

VI.International coordination:

- Collaborate with international organizations and other nations that have addressed similar issues to exchange experiences, good practices and lessons learned.

This integrated action plan aims to effectively address the full decriminalization of abortion for congenital malformations. It incorporates legislative changes, implementation strategies and awareness-raising programs in a coordinated and sustainable manner.

The prioritization of reproductive rights in the AHP analysis underscores the importance of empowering women in decisions related to their reproductive health. The decriminalization of abortion for congenital malformations supports the idea that women should have the capacity to make informed decisions about continuing or terminating a pregnancy affected by malformations. This critical assessment reveals that, while priorities have been identified, effective policy implementation will require a balanced approach that considers the diverse ethical, moral, and social perspectives present in Ecuadorian society. Furthermore, it highlights the need for a holistic approach that considers individual rights, international obligations, and social implications.

4. Conclusion

The decriminalization of abortion for congenital malformations in Ecuador poses the challenge of balancing women's rights with the country's international responsibilities. The neutrosophic solution emphasizes the need to find a middle ground that respects women's reproductive autonomy while complying with international human rights obligations and standards. Any approach to decriminalizing abortion for congenital malformations must be comprehensive. This involves considering not only legal and ethical aspects, but also the effective implementation of comprehensive support policies as part of the commitments made to the Vikor method. Key factors such as public education, health services and social acceptance are essential to comprehensively address the complexities of this issue. A permanent dialogue is necessary to raise awareness in Ecuadorian society about the decriminalization of abortion for congenital malformations. The neutrosophic analysis highlights the diversity of ethical and moral perspectives, reinforcing the importance of continuing education to foster understanding and empathy in decision-making related to reproductive health.

Funding: “This research did not receive external funding”

Conflicts of interest: “The authors declare that they have no conflict of interest.”

References

[1]M. Van Gerwen et al. , "Association of the timing of chemotherapy in pregnancy with congenital malformations", JAMA network open, vol. 4, no. 6, pp. e2113180-e2113180, 2021.

[2]FVB Muñoz, MGC Sandoval, EPC Ochoa, SAH Sánchez and EVZ Vinueza, "Socioeconomic and health consequences of adolescent pregnancies in Ecuador in the period 2015-2021", HIV Nursing, vol. 23, no. 3, pp. 1733–1738, 2023.

[3] C. O'Brien and M. Newport, "Prioritizing women's choice, consent, and bodily autonomy: from a violence continuum to women-centered reproductive care," Social Science & Medicine, vol. 333, no. September pp. 2–6, 01/09/2023.

[4] M S. Broumi, F. Smarandache, and M. Dhar, “Multi-criteria decision making using neutrosophic AHP and VIKOR methods for supplier selection,” Neutrosophic Sets and Systems, vol. 41, no. 1, pp. 87–102, 2021.

[5] Crespo Berti, L. A., Haro Terán, L. F., Esparza Pijal, S. B., & Benavides Morillo, R. A. (2024). Métodos AHP y TOPSIS para la estimación del ordenamiento jurídico positivo penal ecuatoriano vigente desde el foco de la imputación subjetiva. Neutrosophic Computing and Machine Learning, 34, 213–222.

[6] I. Canco, D. Kruja, and T. Iancu, "AHP, a Reliable Method for Quality Decision Making: A Case Study in Business," Sustainability, Vol. 13, No. 24, pp. 2–7, 2021.

[7] Chakraborty, A. Banik, B. Broumi, S. Salahshour, S. (2022). Graded Mean Integral Distance Measure and VIKOR Strategy Based MCDM Skill in Trapezoidal Neutrosophic Number. International Journal of Neutrosophic Science, 18(2), 210-226. DOI: https://doi.org/10.54216/IJNS.180205

[8]E. González Caballero, M. Leyva Vázquez and F. Smarandache, "On neutrosophic uninorms", Neutrosophic Sets and Systems, vol. 45, no. 2021, pp. 340-348, 2021.

[9] A. Abdel-Basset, L. Gunasekaran, and M. Mostafa, “An integrated neutrosophic AHP-VIKOR approach for sustainable development project selection,” Sustainability, vol. 14, no. 2, pp. 389–405, 2022. DOI: https://doi.org/10.3390/su14020389.

[10]DM Ramírez Guerra, YM Gordo Gómez, LJ Cevallos Torres and FGP Ortiz., "Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment.", Journal of International Journal of Neutrosophic Science, vol. 19, no. 1, pp. 389-402, 2022.

[11] M. Leyva-Vazquez, J. Estupinan, and F. Smarandache, “Neutrosophic in Latin America, advances and perspectives” Neutrosophic Computing and Machine Learning, vol. 14, no. 2020, pp. 1-7, 2020.

[12] González-Caballero, E., Leyva-Vázquez, M. Y., Batista-Hernández, N., & Smarandache, F. (2024). NeutroGeometry and Fractal Geometry. Neutrosophic Sets and Systems, 71(1), 2.

[13] Reales-Chacón, L. J., de Ustáriz, M. E. L., Ustáriz-Fajardo, F. J., Luna, A. C. P., Bonilla-Ayala, G. J., Djabayan-Djibeyan, P., ... & Valdiviezo-Maygua, M. A. (2024). Study of the Efficacy of Neural Mobilizations to Improve Sensory and Functional Responses of Lower Extremities in Older Adults with Diabetic Peripheral Neuropathy Using Plithogenic n-SuperHyperGraphs. Neutrosophic Sets and Systems, 74, 1-12.

[14] Ricardo, JE, Poma, MEL, Argüello, AM, Pazmiño, ADAN, Estévez, LM, & Batista, N. ¨Neutrosophic model to determine the degree of understanding of higher education students in Ecuador¨. Neutrosophic sets and systems, no. 26, pp. 54-61, 2019.
[15] De la Cantera, D. H., Quiroz, R. C., Queija, M. L., Gonzalez, J. R., & Vazquez, M. Y. L. (2024). Analyzing Interdisciplinary Education in General Medi cine Using Smarandache's Multivalued Logic Hypothesis Theory and Plithogenic Probability. Neutrosophic Sets and Systems, 70, 369-377.
[16] Ricardo, JE, Fernández, AJ, & Vázquez, MY ¨Compensatory fuzzy logic with single-valued neutrosophic numbers in the analysis of university strategic management¨. International Journal of Neutrosophic Sciences (IJNS), vol 18 num 4, 2022.
[17] H. Garg and R. Rani, "A novel neutrosophic AHP-VIKOR decision-making approach with an application in renewable energy selection," Soft Computing, vol. 26, no. 5, pp. 2057–2075, 2022. DOI: https://doi.org/10.1007/s00500-021-05896-8.
[18] A. Salama and M. El-Dahshan, "An integrated decision support system using neutrosophic AHP and VIKOR for smart city planning," Complex & Intelligent Systems, vol. 8, no. 2, pp. 1125–1140, 2022. DOI: https://doi.org/10.1007/s40747-021-00529-4.
[19] P. K. Singh and S. K. Pal, "A neutrosophic multi-criteria decision-making approach based on AHP and VIKOR for evaluating healthcare management strategies," Journal of Ambient Intelligence and Humanized Computing, vol. 13, no. 4, pp. 5642–5660, 2022. DOI: https://doi.org/10.1007/s12652-021-03218-5.