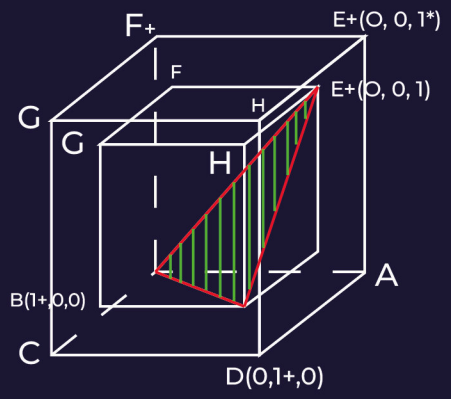
NSS



NEUTROSOPHIC SETS AND SYSTEMS

{Special Issue: Neutrosophic in Latin America, progress and perspectives}

Vol. 52, 2022

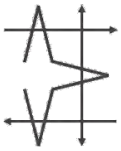
second version

Florentin Smarandache . Mohamed Abdel-Basset
Maikel Leyva Vazquez - Said Broumi

ISSN 2331-6055(print) Editors-in-Chief ISSN 2331-608X(online)

ISSN 2331-6055 (print)

ISSN 2331 – 608X (online)



Neutrosophic Science International Association(NSIA)

Neutrosophic Sets and Systems

second version

An International Journal in Information Science and Engineering

University of New Mexico
United States

ISSN 2331-6055 (print) NSS Editorial Board ISSN 2331 – 608X (online)

University of New Mexico

Neutrosophic Sets and Systems

An International Journal in Information Science and Engineering

Information for Authors and Suscribers

"Neutrosophic Sets and Systems" has been created for publications on advanced studies in neutrosophy, neutrosophic set, neutrosophic logic, neutrosophic probability, neutrosophic statistics that started in 1995 and their applications in any field, such as the neutrosophic structures developed in algebra, geometry, topology, etc.

The submitted papers should be professional, in good English, containing a brief review of a problem and obtained results. Neutrosophy is a new branch of philosophy that studies the origin, nature, and scope of neutralities, as well as their inter actions with different ideational spectra.

This theory considers every notion or idea <A> together with its opposite or negation <antiA> and with their spectrum of neutralities <neutA> in between them (i.e. notions or ideas supporting neither <A> nor <antiA>). The <neutA> and <antiA> ideas together are referred to as <nonA>.

Neutrosophy is a generalization of Hegel's dialectics (the last one is based on <A> and <antiA> only). According to this theory every idea <A> tends to be neutralized and balanced by <antiA> and <nonA> ideas - as a state of equilibrium.

In a classical way <A>, <neutA>, <antiA> are disjoint two by two. But, since in many cases the borders between notions are vague, imprecise, Sorites, it is possible that <A>, <neutA>, <antiA> (and <nonA> of course) have common parts two by two, or even all three of them as well.

Neutrosophic Set and Neutrosophic Logic are generalizations of the fuzzy set and respectively fuzzy logic (especially of intuitionistic fuzzy set and respectively intuitionistic fuzzy logic). In neutrosophic logic a proposition has a degree of truth (T), a degree of indeterminacy (I), and a degree of falsity (F), where T, I, F are standard or non-standard subsets of]-0, 1+[.

Neutrosophic Probability is a generalization of the classical probability and imprecise probability.
Neutrosophic Statistics is a generalization of the classical statistics.
What distinguishes the neutrosophics from other fields is the <neutA>, which means neither <A> nor <antiA>.

<neutA>, which of course depends on <A>, can be indeterminacy, neutrality, tie game, unknown, contradiction, igno- rance, imprecision, etc.

All submissions should be designed in MS Word format using our template file:
http://fs.unm.edu/NSS/NSS-paper-template.doc.

A variety of scientific books in many languages can be downloaded freely from the Digital Library of Science: http://fs.unm.edu/ScienceLibrary.htm.

To submit a paper, mail the file to the Editor-in-Chief. To order printed issues, contact the Editor-in-Chief. This journal is non-commercial, academic edition. It is printed from private donations.
Information about the neutrosophics you get from the UNM website:
http://fs.unm.edu/neutrosophy.htm. The home page of the journal is accessed on http://fs.unm.edu/NSS.

ISSN 2331-6055 (print) NSS Editorial Board ISSN 2331 – 608X (online)

Editors-in-Chief

Associate Editors

Editors

ISSN 2331-6055 (print) NSS Editorial Board ISSN 2331-608X (online)

University of New Mexico

Preface of The Special Issue on Neutrosophic in Latin America, progress and perspectives

The logic of two values, whether Aristotelian or classical symbolist, handles a type of proposition that can be considered unreal. How to judge the truth value of a metaphor, an ambiguous statement or a social phenomenon that is positive from one point of view and negative from another?

The Andean civilization was one of only three civilizations -together with Mesopotamia and Mesoamerica- that emerged autonomously, without any cultural linkage or precedent, as is the case with the other great civilizations: Egyptian, Indian, Chinese, Greek or Roman. In the Andean culture, in this bivalent principle of the lodge of two values, it becomes trivalent, because for the Andean man in a given situation, it is not always "A" or "B", it can be "C". Expressed by the term "Ya". The roots of neutrosophy are already in pre-Columbian American philosophy.

Latin American philosophical currents wonder about the cultural identity of the continent as a result of the encounter of European culture with indigenous cultures. Latin American liberation would consist in the recovery of the lost identity. Secondly, there is the so-called "universalist" interpretation, which integrates the notion of Latin American liberation in the broader context of the integral liberation of humanity.

In this sense, neutrosophy contributes elements to strengthen Latin American philosophy and to focus Smarandache's creation on the solution of social problems and on a new renaissance of philosophy, science and art in Latin America. This special issue serves as a sample of the progress of neutrosophy in the continent in the resolution of social problems and the results of the Latin American Association of Neutrosophical Sciences.

Prof. Maikel Leyva Vázquez PhD.

ISSN 2331-6055 (print) NSS Editorial Board ISSN 2331-608X (online)

University of New Mexico

INDEX

ISSN 2331-6055 (print) NSS Editorial Board ISSN 2331-608X (online)

University of New Mexico

INDEX

INDEX

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Alimony in Students of Legal Age as a Fundamental Right to Education (revisited)

Alex Fabián Solano Moreno[1], Josué Ramón Limaico Mina[2], Diego Vladimir Garcés Mayorga[3], and Paul Orlando Piray Rodríguez[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.alexsolano@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.josuelimaico@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. E-mail: up.diegogarces@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.paulpr13@uniandes.edu.ec

Abstract. The right to food is closely related to the parent-child relationship and constitutes a right of the children and an obligation of the parents. Ecuadorian regulations seek to guarantee studies even when their children become adults and need to continue their academic training. University students are often forced to abandon their studies due to a lack of economic incentives. The objective of this study is to determine the factors that affect the right to education of students when they reach the age of majority and the negative effects caused by the suspension of alimony. As a result, it is obtained using the neutrosophic TOPSIS method to propose the implementation of legal reforms to extend alimony up to 24 years of age.

Keywords: right to food, education, alimony, neutrosophic TOPSIS.

1 Introduction

The alimony has the function of solving the basic needs of food by the obligor. The right to food is an imprescriptible, non-transferable, inalienable, and unattachable right. It is a right that is born and is permanently renewed, as the need for the support of this right changes. This definition includes the essential resources for the subsistence of a person, and the means tending to allow a decent existence [1].

In such virtue, Art. 129 of [2] establishes a logical order of taxes to fulfill this obligation with minors and their exceptions. On the other hand, [3] in Art. 349 regulates this issue in general and introduces the reciprocal nature of the benefit. The Constitution of Ecuador establishes in a guaranteed manner the protection of the rights of children and adolescents within the current Constitutional State of Rights and Social Justice [4].

The State and the family must guarantee the rights of children or adults who are studying up to the age of 21. To protect the right to food, and without leaving them without it because it is a fundamental right, they must acquire a way of life that allows them to have a comprehensive life development, safeguarding the other rights that derive from the aforementioned right [5] [6].

In January, a Legal Reform was proposed to extend the payment of alimony to the age of 24 to support university students. It was cataloged as a big mistake since it is about adults who must learn to earn a living by their own means. The thesis generated controversy and divergent positions. At one extreme are those who claim that this will encourage a generation of irresponsible young people supported by their divorced parents. On the other hand, those who ensure that parents should support their children's university studies, even if they do not live with them [7] [8].

It should be stated that Private Universities receive enormous economic resources from the state even though they are companies destined to make an education business. A faithful example of that is the cost of master's degrees in the country. It is necessary to be objective and observe that they are not minors or adolescents and that they are affected by preventing them from having the power to learn to earn a living by their own means [9] [10].

Economics and education are two fields that maintain a close correlation. Teaching has a fundamental effect on the economic life of people, and, in turn, financial phenomena affect the present and future of education. Among the most prominent problems of school dropout in higher education is that it has been violated by the extinction of alimony to young people who have reached 21 years of age [11].

To analyze the factors that affect the right to education, it is defined as a problem situation: alimony to students over 21 years of age. The main objective of this research is to define the main factors that affect the right to education. Specific objectives: determine the factors that affect the analyzed variable, perform the measurement and modeling of the variable, and finally define the potential alternatives based on eradicating the variables that

affect the fulfillment of the right to education.

2 Materials and methods

2.1 Neutrosophic statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E will occur, the probability that event E will not occur, and the probability of indeterminacy (not knowing whether event E will occur or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$$NP(x) = (T(x), I(x), F(x))$$

Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x. Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [12], neutrosophic estimation, neutrosophic regression, etc.

It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns [13].

Finally, the Neutrosophic Logic [14], the Neutrosophic Sets, and the Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference for study in full development. Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data [15].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers [16], while "I" is the indeterminacy part of the neutrosophic number N. The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable $(\bar{x}_N)$ by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\ \ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ n_N \in [n_l, n_u], \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS), it can be calculated as follows

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N \begin{matrix} \min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix} \\ \left[\max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\right] \end{matrix}, I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is if compared to the other factors. The NCV can be calculated as follows [17].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U] \tag{5}$$

2.2 TOPSIS method

TOPSIS (*Technique for Order Preference by Similarity to Ideal Solution*). This technique is characterized by its effectiveness and the simplicity of its principle in solving multi-criteria decision problems. In the case of TOPSIS, the selection is based on finding the alternative that is closest to the ideal solution and, in turn, is further away from the worst solution. It allows combining several heterogeneous attributes in a single dimensionless index, and this is because the attributes under evaluation are very possibly expressed in different units or scales [18].

TOPSIS is based on the concept that the selected alternative must have the smallest Euclidean distance to an ideal solution and the largest Euclidean distance to an anti-ideal solution. So, the order of preference of the alternatives can be determined through a series of comparisons of these distances. Both solutions, the ideal and the anti-ideal, are fictitious.

The ideal solution is a solution for which all attribute values correspond to the optimal values of each attribute contained in the alternatives; the anti-ideal solution is the solution for which all attribute values correspond to the least desired values of each attribute contained in the alternatives. In this way, TOPSIS provides a solution that is not only the closest to a hypothetically better solution but also the farthest from the hypothetically worse one. The process is described below:

1. Determine the objective and identify the attributes to be evaluated.

2. Prepare a matrix based on the information available on the attributes. Each row corresponds to an alternative and each column to an attribute. The element x_j of the array represents the non-normalized value of the j_{th} attribute for the i_{th} alternative.

3. Calculate the normalized decision matrix R_{ij}. This is obtained by dividing each attribute value x_j by the square root of the sum of the squares of each attribute value x_j. This is represented mathematically by equation (6):

$$Rij = \frac{x_{ij}}{\sqrt{\sum_{m=1}^{k} x_{mj}^2}} \tag{6}$$

4. Determine the relative importance or weight of each attribute with respect to the objective. This gives rise to a set of weights w_j $(for\ j\ =\ 1,2,\dots,J)$ such that $\sum w_j\ =\ 1$. The weights are generally based on expert judgment and should reflect the relative importance assigned to the attributes of evaluated performance. The range of possible values of w_j will only be limited by the ability of the elements of the decision group to distinguish the relative importance of the analyzed performance attributes.

5. Obtain the normalized and weighted matrix V_{ij}. This is done by multiplying each element in the columns of the matrix R_{ij} by its corresponding weight w_j. Therefore, the elements of the normalized and weighted matrix are expressed by equation 7:

6.

$$V_{ij} = w_j * R_{ij} \tag{7}$$

7. Obtain the ideal and anti-ideal solution: The ideal solution can be expressed as (8) and the anti-ideal as (9). V_j^+ indicates the ideal value of the attribute considered among the values of the attributes for the different alternatives, while V_j^- indicates the worst value of the attribute considered among the values of the attributes for the different alternatives [17, 19, 20, 24, 25].

8.

$$V^+ = \left\{V_1^+, V_2^+, V_3^+, \dots., V_j^+\right\} \tag{8}$$

$$V^- = \left\{V_1^-, V_2^-, V_3^-, \dots., V_j^-\right\} \tag{9}$$

9. Calculate the Euclidean distances of each alternative to the ideal and anti-ideal solutions using the following equations:

$$D_i^+ = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^+)^2} \tag{10}$$

$$D_i^- = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^-)^2} \tag{11}$$

10. The relative closeness Pi of a particular alternative to the ideal solution is expressed by (12):

11.

$$P_i = \frac{D_i^-}{(D_i^+ + D_i^-)} \tag{12}$$

12. In this step, a set of alternatives is generated in descending order according to the value of Pi, having as the best alternative the one with the highest value of Pi.
13. In this article, linguistic terms will be associated with SVNN, so that the experts can carry out their evaluations according to the corresponding scale (Table 1).

Linguistic term	SVNN
Very Weak (VW)	(0.10, 0.75, 0.85)
Weak (W)	(0.25, 0.60, 0.80)
Medium Weak (MW)	(0.40, 0.70, 0.50)
Medium (M)	(0.50, 0.40, 0.60)
Medium Strong (MS)	(0.65, 0.30, 0.45)
Strong (S)	(0.80, 0.10, 0.30)
Very Strong (VS)	(0.95, 0.05, 0.05)

Table 1. Linguistic terms according to the strength of the weight in the alternatives. Source: own elaboration.

3 Results

After analyzing the different approaches, the techniques described above are applied as follows. For the right to education and due to the complexity and indeterminacy of the data, it was decided to apply neutrosophic statistics for the modeling of the analyzed variable.

From the processing of the information and the consensus of the experts, the factors that most affect the right to education (Table 2) and the variable to be modeled were determined.

Variable analyzed: right to education, for a sample of n=150 for each factor (f)

Code	Initials	Factors affecting the right to education
a	RLPF	Reform Legal and Political Frameworks
b	PFCE	Provide Free and Compulsory Education
c	EI	Eliminate Inequalities
d	EF	Education Financing
e	LC	Lack of Compromise

Table 2. Determining factors in the right to education. Source: own elaboration

For the development of the statistical study, the neutrosophic frequencies of the determining factors in the right to education are analyzed, mainly in students of legal age. For each factor, an affectation is analyzed in days that make up the set of affectations to ensure that education is for everyone.

Days	Neutrosophic Frequencies				
	RLPF	PFCE	EI	EF	LC
1	[1 ; 2]	[1 ; 2]	[0 ; 0]	[0 ; 0]	[0 ; 1]
2	[1 ; 2]	[0 ; 0]	[0 ; 1]	[0 ; 0]	[0 ; 1]
3	[1 ; 1]	[0 ; 0]	[1 ; 2]	[1 ; 1]	[1 ; 1]
4	[0 ; 0]	[1 ; 1]	[1 ; 2]	[0 ; 1]	[1 ; 1]
5	[1 ; 1]	[1 ; 1]	[0 ; 1]	[0 ; 1]	[1 ; 2]
6	[1 ; 1]	[0 ; 0]	[1 ; 2]	[1 ; 1]	[1 ; 1]
7	[1 ; 1]	[1 ; 2]	[0 ; 1]	[0 ; 0]	[1 ; 1]
8	[0 ; 0]	[0 ; 1]	[1 ; 2]	[0 ; 0]	[1 ; 1]
9	[1 ; 2]	[0 ; 1]	[0 ; 0]	[0 ; 1]	[1 ; 2]
10	[1 ; 2]	[1 ; 1]	[0 ; 1]	[0 ; 0]	[1 ; 1]
11	[1 ; 2]	[0 ; 0]	[0 ; 0]	[0 ; 1]	[0 ; 0]
12	[1 ; 2]	[0 ; 1]	[0 ; 0]	[0 ; 0]	[1 ; 1]
13	[0 ; 0]	[1 ; 1]	[1 ; 1]	[0 ; 0]	[0 ; 0]
14	[1 ; 1]	[0 ; 1]	[1 ; 2]	[0 ; 1]	[0 ; 1]
15	[0 ; 0]	[0 ; 0]	[0 ; 1]	[1 ; 1]	[1 ; 2]

Days	Neutrosophic Frequencies				
	RLPF	PFCE	EI	EF	LC
16	[1 ; 1]	[1 ; 2]	[1 ; 1]	[1 ; 2]	[1 ; 1]
17	[0 ; 0]	[1 ; 1]	[1 ; 1]	[1 ; 2]	[0 ; 1]
18	[1 ; 2]	[0 ; 1]	[0 ; 1]	[0 ; 0]	[0 ; 1]
19	[0 ; 0]	[0 ; 1]	[1 ; 2]	[1 ; 1]	[1 ; 1]
20	[1 ; 1]	[1 ; 1]	[1 ; 1]	[0 ; 1]	[1 ; 2]
0-150	[83 ; 159]	[73 ; 140]	[72 ; 147]	[75 ; 155]	[83 ; 150]

Table 3. Factors that affect the fulfillment of the right to education.

Table 3 studies the factor effects on the fulfillment of the right to education, for 150 days, with an occurrence level of [0; 2] for each factor per day. There is a total indeterminacy level of a=76, b=67, c=75, d=80, e=67, with a representativeness level of [44.66%; 51.61%], on days when 2 affectations per factor were recorded. A 50% higher incidence is observed in *Eliminate Inequalities* and *Provide Free and Compulsory Education*. As a result of the existing indeterminacy, the use of classical statistics is not possible, so the use of neutrosophic statistics is necessary for its greater understanding. [26, 27]

Neutrosophic Statistical Analysis

In the modeling of the data of the affectations that affect education for all young people (Table 4), it will be possible to understand what factor implies a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means are calculated, and for the study of the variations of the affectations, the values of the neutrosophic standard deviation $S_N \in [S_L; S_U]$. To determine which affectation requires a greater incidence in the right to education, the values $CV_N \in [CV_L\ ;\ CV_U]$ are calculated.

Factors	$\bar{x}_N$	S_N	CV_N
Reform Legal and Political Frameworks	[0.553; 1.06]	[0.126; 0.988]	[0.228; 0.932]
Provide Free and Compulsory Education	[0.487; 0.933]	[0.125; 1,015]	[0.257; 1,088]
Eliminate Inequalities	[0.48; 0.98]	[0.125; 0.965]	[0.26; 0.985]
Education Financing	[0.5; 1,033]	[0.125; 1,028]	[0.25; 0.995]
Lack of Compromise	[0.553; 1]	[0.126; 1,018]	[0.228; 1,018]

Table 4. Neutrosophic statistical analysis of the incidences of education. Source: own elaboration

Table 4 shows that reforming legal and political frameworks has higher incidence values than the other factors. This means that the RLPF factor is, on average, the one that has the most impact on compliance with the rights of older students to education. In affirmation of the value of this factor CV_{No}, is lower compared to the others. This means that the result of RLPF has a negative and more significant impact than other factors on the right to education

Comparative analysis

To determine the associated referent uncertainty measure for $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ and $CV_N \in [CV_L\ ;\ CV_U]$ to the form of neutrosophic numbers (Table 5), it is observed that the CV_N values range from 0.228 to 0.932, with an indeterminacy measure of 75.5. This generates a negative impact on compliance with the reforms to the legal frameworks for better fulfillment of the right to education, as well as its influence on other affectations. The governing bodies are required to focus on a higher level of monitoring of regulations and policies for student training. [21, 22, 23]

Factors	$\bar{x}_N$	S_N	CV_N
RLPF	0.553 + 1.06 I; I ∈ [0; 0; 47.8]	0.126 + 0.988 I; I ∈ [0; 0; 87.2]	0.228 + 0.932 I; I ∈ [0; 0; 75.5]
PFCE	0.487 + 0.933 I; I ∈ [0; 0; 47.8]	0.125 + 1.015 I; I ∈ [0; 0; 87.7]	0.257 + 1.088 I; I ∈ [0; 0; 76.4]
EI	0.48 + 0.98 I; I ∈ [0; 0; 51.0]	0.125 + 0.965 I; I ∈ [0; 0; 87.0]	0.26 + 0.985 I; I ∈ [0; 0; 73.6]

Factors	$\bar{x}_N$	S_N	CV_N
EF	0.5 + 1.033 I; I ∈ [0; 0; 51.6]	0.125 + 1.028 I; I ∈ [0; 0; 87.8]	0.25 + 0.995 I; I ∈ [0; 0; 74.9]
LC	0.553 + 1I; I ∈ [0; 0; 44.7]	0.126 + 1.018 I; I ∈ [0; 0; 87.6]	0.228 + 1.018 I; I ∈ [0; 0; 77.6]

Table 5. Neutrosophic forms with measure of indeterminacy. Source: own elaboration.

TOPSIS analysis

To determine possible alternatives based on using regulations and policies for student training, TOPSIS modeling is used. The strategies to be evaluated are focused on monitoring standards and policies for student training and potentiate the following parameters:

- There is no economic policy in favor of university students over 21 years of age
- Pensions only protect university students up to 21 years of age
- Student desertion from universities
- Change in living standards that facilitated access to universities with the support of parents
- Entry into the labor regime, which limits compliance with permanence in classrooms and university activities
- Cuts on economic aid to the education sector with a negative impact on university students

The results are shown in the following tables:

Alternatives	Submit economic policies	Increase personal income	Maintain pensions until age 24	Equity of resources between universities	Extension of maintenance scholarships to third-level students	Present policies of a social nature
Economic policy	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)	(0.25, 0.60, 0.80)	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)	(0.80, 0.10, 0.30)
Pensions	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.65, 0.30, 0.45)	(0.65, 0.30, 0.45)
Student desertion	(0.95, 0.05, 0.05)	(0.25, 0.60, 0.80)	(0.25, 0.60, 0.80)	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)
Change of standards	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)
Entry into the labor regime	(0.95, 0.05, 0.05)	(0.80, 0.10, 0.30)	(0.25, 0.60, 0.80)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)
Cuts	(0.95, 0.05, 0.05)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)

Table 6. Weights assigned by the experts to each criterion. Source: own elaboration

Alternatives	Submit economic policies	Increase personal income	Maintain pensions until age 24	Equity of resources between universities	Extension of maintenance scholarships to third-level students	Present policies of a social nature
Economic policy	0.12909	0.03907	0.08025	0.01111	0.01252	0.12867
Pensions	0.19466	0.04639	0.04494	0.01676	0.01888	0.16339
Student desertion	0.19466	0.01367	0.04494	0.01676	0.01888	0.19402
Change of standards	0.12909	0.00781	0.02568	0.01411	0.00318	0.03268
Entry into the labor regime	0.19466	0.03907	0.04494	0.00282	0.00318	0.03268
Cuts	0.19466	0.03077	0.08025	0.00282	0.00318	0.03268

Table 7. Weighted normalized matrix. Source: own elaboration.

Alternative	d-	d+	Ri	Order
Economic policy	0.05099	0.06597	0.43595	5
Pensions	0.11550	0	1	1
Student desertion	0.11198	0.03272	0.77387	4
Change of standards	0.04739	0.07607	0.38385	6
Entry into the labor regime	0.11391	0.00732	0.93957	2
Cuts	0.11265	0.01562	0.87818	3

Table 8. Matrix of the distances and calculation of the Ri for each alternative. Source: own elaboration.

From the results obtained, it is preferred to promote alternative 1, relative to alimony or alternative 2, entry into the labor regime, depending on the deficiency to be eradicated. Third-level students, once they reach the age of majority, are often forced to drop out and others look for work and end up leaving the university because their economic solvency does not allow them to continue their university studies.

- Propose a legal reform to the governing bodies and the State with the proposal to extend up to 24 years the payment of alimony to support college students
- Propose aid programs for university students over 21 years of age, who are backed by a difficult economic situation.

Conclusion

The right to education is often violated due to the effectiveness of the application of current legal regulations. In Ecuador, there is a need to design a reform proposal, which introduces the suspension of alimony after 24 years. The Government must encourage and indicate to the governing bodies in the legal field the revision of the current legislation. It is necessary to protect students of legal age, whose parents suspend their alimony when they turn 21 regardless of whether they pursue a university course.

Propose reforms on alimony and aid programs for university students over 21 years of age, who are facing a difficult economic situation and are still pursuing higher education.

The method applied seeks to promote alternatives to improve the educational situation in Ecuador. The need to extend alimony up to 24 years of age is formulated so that all young people have the right not only to education and a university degree but also to a job and a decent life.

References

[1] C. R. P. Diaz and Z. M. d. C. O. Ordoñez, "Análisis Jurídico del Derecho de Alimentos en los Menores de Edad y su Aplicación en las Unidades Judiciales de la Familia, Mujer, Niñez y Adolescencia del Cantón Quito," Proyecto de Investigación previo a la obtención del Título de: ABOGADO, Universidad Central del Ecuador. Facultad de Jurisprudencia, Ciencias Políticas y Sociales Carrera de Derecho, 2016.

[2] E. A. N. Constituyente, "Código Orgánico de la Niñez y Adolescencia," ed: Gobierno del Ecuador, 2017.

[3] E. A. N. Constituyente, "Código Civil del Ecuador," ed: Gobierno del Ecuador, 2015.

[4] Ecuador Asamblea Nacional Constituyente, "Constitución de la República del Ecuador," ed: Gobierno del Ecuador, 2008.

[5] V. MEIER and M. WREDE. (2010) Pensions, fertility, and education. Journal of Pension Economics & Finance. 75-93. Available: https://www.cambridge.org/core/journals/journal-of-pension-economics-and-finance/article/abs/pensions-fertility-and-education/844789D2B4070DD2C793F2F1BC9ECB84

[6] G. Peñafiel. (2020). Las pensiones alimenticias a las que tienen derecho los hijos. Available: https://gvn.com.ec/2020/11/11/pensiones-alimenticias-derecho-hijos/

[7] Siru Myllykoski-Laine, Liisa Postareff, and M. M. H. Vilppu. (2022) Building a framework of a supportive pedagogical culture for teaching and pedagogical development in higher education. Higher Education. Available: https://link.springer.com/article/10.1007/s10734-022-00873-1

[8] E. Especialista. (2022) Pensión alimenticia: ¿hay que pagar los estudios de grado y posgrado? El Universo. Revista Electrónica. Available: https://www.eluniverso.com/larevista/el-especialista/pension-alimenticia-hay-que-pagar-los-estudios-de-grado-y-posgrado-nota/

[9] Claire Englund, A. D. Olofsson, and L. Price. (2018) The influence of sociocultural and structural contexts in academic change and development in higher education. Higher Education. 1051-1069. Available: https://link.springer.com/article/10.1007/s10734-018-0254-1,

[10] S. Debets, H. Prast, M. Rossi, and A. v. Soest. (2022) Pension communication, knowledge, and behaviour. Journal of Pension Economics & Finance. 99-118. Available: https://www.cambridge.org/core/journals/journal-of-pension-economics-and-finance/article/pension-communication-knowledge-and-behaviour/5B104E1720447452631F2BAEE04444EF

[11] R. Kickert, M. Meeuwisse, Stegers-Jager, K.M., P. P. &, and L. R. Arends. (2022) Curricular fit perspective on motivation in higher education. 729-745. Available: https://link.springer.com/article/10.1007/s10734-021-

00699-3
[12] F. Smarandache, An introduction to the Neutrosophic probability applied in quantum physics: Infinite Study, 2000.
[13] W. B. Vasantha, I. Kandasamy, and F. Smarandache, "Algebraic Structure of Neutrosophic Duplets in Neutrosophic Rings < Z U I>,< Q U I> and < R U I.> " Neutrosophic Sets and Systems, vol. 23, pp. 85-95, 2018.
[14] Pérez-Teruel, Neutrosophic logic for mental model elicitation and analysis.: Neutrosophic Sets and Systems, 2012.
[15] F. Smarandache, Neutrosophy, a new Branch of Philosophy: Infinite Study, 2002.
[16] W. V. Kandasamy and F. Smarandache, "Fuzzy Neutrosophic Models for Social Scientists.," Education Publisher Inc., (2013)
[17] F. Smarandache, "A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Infinite Study.," 2005.
[18] R. G. Ortega, M. L. Vázquez, J. A. S. Figueiredo, &, and A. Guijarro-Rodriguez. (2018) Sinos river basin social-environmental prospective assessment of water quality management using fuzzy cognitive maps and neutrosophic AHP-TOPSIS. Neutrosophic Sets and Systems. 160–171. Available: http://fs.unm.edu/NSS2/index.php/111/article/view/408
[19] Salazar, O. L. A., Gallegos, S. B. G., & Abarca, L. V. R. "Incidencia de la seguridad jurídica y análisis del cobro mediante la tercería coadyuvante en la legislación ecuatoriana". Universidad y Sociedad, vol. 14 no. 5, pp 541-551, 2022.
[20] Gómez, F. M. E., Manzano, R. L. M., & Manzo, A. D. M. "Estrategias en la lucha contra el sicariato en Ecuador". Universidad y Sociedad, vol. 14 no. 5, pp 552-563, 2022.
[21] Barragán, F. D. V., Arroyo, G. F. V., & Verdezoto, M. I. M. "Identificación de factores determinantes en la carencia de educación sexual y reproductiva en la comunidad San José, Cantón de Arajuno". Universidad y Sociedad, vol. 14 no. 5, pp 564-576, 2022.
[22] Carballido, R. M., Matos, M. A., Paronyan, H., & Eduardo, C. L. K. "Movilidad forzada y mendicidad infantil desde el contexto de la ciudad de santo domingo Ecuador". Universidad y Sociedad, vol. 14 no. 5, pp 587-594, 2022.
[23] Blacio, J. H. A., López, N. E. B., Burbano, I. P. T., & Hernández, F. M. P. "Análisis social de la devolución del impuesto al valor agregado a los adultos mayores en el cantón de santo domingo". Universidad y Sociedad, vol. 14 no. 5, pp 595-602, 2022.
[24] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.
[25] González, I. A., Fernández, A. J. R., & Ricardo, J. E. "Violación del derecho a la salud: caso Albán Cornejo Vs Ecuador". Universidad Y Sociedad, vol. 13 no. S2, pp 60-65, 2021.
[26] Acuña, B. P., & Von Feigenblatt, O. F. "La lengua y la literatura en el aula del futuro enmarcado en el aprendizaje personalizado. In Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones" (pp. 13-24). Ediciones Octaedro, 2022.
[27] von Feigenblatt, O. F., Calderon, R. D., & MacDonald, T. "The Case for an Eclectic and Flexible Leadership Research Agenda: Dealing with Social Justice and Diversity in the 21st Century Workplace". Centro Sur, vol. 6 no. 1, pp 130-142, 2022.

Received: August 01, 2022. **Accepted:** October 01, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2020
University of New Mexico

Analysis of the Legal Treatment of Perfidy

Merly Claribel Moran Giler[1], Alexandra Dolores Molina Manzo[2], Nelson Francisco Freire Sánchez[3], and Rene Estalin Portilla Paguay[4]

[1] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador. E-mail: uq.merlymg82@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.alexandramolina@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.nelsonfreire@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.renepp25@uniandes.edu.ec

Abstract. Labor perfidy in Ecuador is a real current problem. There are irregularities in the labor sector that can affect the labor rights of workers, which perpetuates deception and ignorance on the part of those affected. Knowing the causes and consequences of labor perfidy allows projecting solutions to reduce its effect on the working society. The analysis of preliminary studies and surveys defines certain levels of indeterminacy in the answers obtained by a group of lawyers and workers. This integration between neutrosophic sets allows us to reflect, through the representation of neutrosophic statistics, the level of deterioration of the factors that intervene in the violation of labor rights. Consequently, the existing indeterminacy forces carry out the modeling of each element of the group studied to analyze the levels of associated deterioration in Ecuador. As a result, it is defined to propose strategies focused on restructuring regulations to mitigate their impact on the working society of Ecuador.

Keywords: labor perfidy, hiring, deception, rights.

1 Introduction

Perfidy is established as a concept that has been used to denominate a breach of trust or deception, infidelity, or a fault that consists of the infringement or violation of an alleged commitment assumed by two previously established parties [1]. In a general way, it is defined as a form of deception in which the act of a person in good faith is directly compromised. It produces an obvious violation of the rights of the people affected by this action, with adverse effects as it is the deception produced intentionally by the employer towards the worker. This implies a violation of constitutional rights, which may result in the establishment of fines or sanctions for the employer and the worker, and adverse effects on his life, employment, and economic stability.

1.1 Analysis of the Concepts

Below are the basic concepts related to the topic in question:

- Guarantees: It can be defined as a legal mechanism to ensure or protect the commitment of a certain obligation that must be fulfilled on time [2]. These guarantees may consist of obtaining the advantage of being liable for the obligation. A guarantee is a mechanism through which it is intended to provide greater protection or security for the fulfillment of the fundamental constitutional rights of all human beings. It is implied that they can be fulfilled effectively.
- Contract: A legal relationship whose purpose is the paid provision of services of an economic nature, whether industrial, commercial, or agricultural. More technically, it can be defined as follows: the one whose purpose is the continued provision of private services and economic nature, and for which one of the parties gives a remuneration or reward in exchange for enjoying or using [3], under its dependence or direction, of the professional activity of the other party [4]. The employment contract can be defined as a solemn and bilateral act carried out between two parties called employer and worker. It will establish the necessary conditions to enter into an employment relationship, which also typifies the will of both parties to acquire and provide a job, in exchange for fair remuneration proportional to their activity [5].
- Obligation: An obligation can be defined as an act that grants responsibility to fulfill an action immediately and for which one has the right to fulfill, by avoiding its transgression, and being able to be responsible for an act of a debtor towards a creditor. Any legal relationship can be

understood as an obligation by which one of the parties undertakes to make a certain provision to the other which, in correspondence, holds a personal or credit right over the debtor to demand compliance. In addition to responding to the obligated subject with his assets in case of non-compliance.

- Violation of rights: The violation consists of an action or omission established in the legal norm, as a condition of the sanction. It should be stated that it is also a breach of a rule, principle, guarantee, or constitutional right. The violation of rights can be defined as those acts in which rights or guarantees established in constitutional rights are violated. These produce harmful effects on the people who are the object of this act, for which it may be subject to sanctions or fines.
- Job insecurity: Job insecurity is based on the conditions that a workplace must have to function without causing accidents. These can harm workers, considering that each company or employer must have a contingency plan and security measures in case of misfortune or natural disaster. Therefore, the term occupational safety is understood as those sets of techniques and procedures whose purpose is to avoid, eliminate or minimize the risks that may cause the materialization of accidents at work. This means avoiding injuries and serious effects caused by agents or products of a dangerous nature [6].
- Work accident: according to Ecuadorian legislation, it is considered any physical injury caused by misfortune or accident within the workplace. It can be produced by the worker himself due to his lack of experience or training in the development of a function or by a third person when performing a job in a bad way, or by handling machinery incorrectly, which can produce injuries and deterioration of the physical condition, and the shortening of the period of life that depends on the condition of the accident.

1.2 Characteristics of labor perfidy

In general, perfidy, when considered as a concept that is used to name a deception or how it violates an alleged commitment, can be distinguished from other actions by considering the following characteristics:

- The dishonorable and reprehensible attitude: In most cases can constitute a crime or betrayal of a person's trust because it can be considered an intentional act and, according to the laws, this act is sanctioned by fines or penalties and custodial sentences. The ignoble attitude is about the actions carried out to cause damage by omission and reproduces the worker or the person involved to commit an error that is foreseen and from which the employer will benefit. A reason why this action can also constitute a crime.
- Violation of rights (International Humanitarian Law prohibits perfidy as a method to be used in international war conflicts): This characteristic is not entirely linked to labor law, since it speaks of human rights, in the case of war conflicts in times of war, in which, according to the doctrine, it is an act in which one deceives another with the concept of peace and action contrary to which one lives together is carried out to maintain peace.
- The abuse of trust: this characteristic is configured when the employer does not respect the rights of the worker, imposing himself or taking advantage of the respect or determination given by the worker at the time of establishing his employment relationship, for which this falls into labor perfidy. The breach of trust is determined as a criminal type that is contemplated in fraud. This means that those patrimonial injuries that are produced by fraud, are also considered an infraction in which the abuse of trust is denoted. An existing lawful legal relationship between the perpetrator and the corresponding victim; in which the subject considered passive gives his will of free signature, and then the active subject abuses the expressed good faith that has been delivered to him, violates any action raised in an unjustified manner.
  The abuse of trust by the worker in the case of perfidy is directly related to the abuse of the will of the worker, who trusts his employer. The disappointment of any situation in which the worker himself may be affected is facilitated.

In general, the characteristics that constitute perfidy are basic concepts to be able to mention the deception of one person to another in the performance of daily acts in which one of them can be harmed, where the harmful effects on both labor relations and the life of one of these subjects of rights [7]. Therefore, its investigative treatment is needed, for this, the present study defines the problem situation as the increase in infractions of labor rights by the employer in Ecuador. For its resolution, the main objective is to analyze the levels of deterioration of labor rights by employers in Ecuador.

2 Methods

2.1 Neutrosophic Statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E will occur, the probability that event E will not occur, and the probability of indeterminacy (not knowing whether event E will occur or not). In classical probability $n_{sup} \leq 1$, while in neutrosophic probability $n_{sup} \leq 3+$.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x))$. Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x. Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [8], neutrosophic estimation, neutrosophic regression, etc.

It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them. Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns [9].

Finally, the Neutrosophic Logic [10], the Neutrosophic Sets, and the Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a novel study reference in full development. Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data [11, 21, 22, 23, 24].

Neutrosophic Numbers are numbers of the form N = a + bI, where a and b are real or complex numbers [12, 14, 15, 16,17], while "I" is the indeterminate part of the neutrosophic number N. The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable $(\bar{x}_N)$ by the formula:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\ \ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ n_N \in [n_l, n_u], \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS), it can be calculated as follows

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N \begin{matrix} \min\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \\ \left\lfloor \max\begin{pmatrix} (a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U) \end{pmatrix} \right\rfloor \end{matrix}, I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N} (X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (CVN) measures the consistency of the variable. The lower the value of the CVN, the more consistent the performance of the factor is if compared to the other factors. The CVN can be calculated as follows [13, 18, 19, 20].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U] \tag{5}$$

The Neutrosophic Argumentation coefficient evaluates the criteria through Linguistic Terms with SVNN of consensus of justification of the expert opinion, (see Table 1).

Linguistic term	SVNN
No Deterioration (ND)	(1,0.05,0)
Almost No Deterioration (AND)	(0.95,0.12,0.15)
Very Low Deterioration (VLD)	(0.85,0.15,0.25)
Low Deterioration (LD)	(0.75,0.3,0.4)
Slight Deterioration (SD)	(0.65,0.35,0.5)
Deteriorated (D)	(0.55,0.45,0.53)
Mildly Deteriorated (MD)	(0.49,0.5,0.55)
Severely Deteriorated (SD)	(0.3,0.75,0.8)
Very Deteriorated (VD)	(0.25,0.8,0.85)
High Deterioration (HD)	(0.15,0.9,0.95)
Extremely Deteriorated (ED)	(0,0.95,1)

Table 1. Linguistic terms that represent the weight of the factors

3 Results

3.1 data collection

Statistics allows for analyzing situations in which random components contribute significantly to the variability of the data obtained. To measure the levels of risks associated with the treacherous, indeterminate random components are presented. The impossibility of measuring some determinants in labor rights is defined in the variability of responses of the surveys, similar to each other, that participated in the study.

3.2 Development of the Method

For the neutrosophic statistical modeling, the experts select five factors that prevail in the neutrosophic sets (elements associated with the violation of labor rights), based on defining the variable to be studied (Table 2).

Variable	Coding	Sample Factor	Scale
Levels of violation of labor rights by the employer in Ecuador	IDLE	[45;203]	$[0;\ 1], \forall\ F_n$ RCD = 0 (false) RCD = 1 (True) DCR $\neq 0.5$ (Existing indeterminacy in IDLE)

Table 2. Characteristics of the variable. Source: own elaboration

It should be considered that the recommendations are subject to constant updates motivated by advances in the investigation of perfidy and the contributions of statistical information in university studies.

Factor	Root causes	Degree	Relationship between factor and set	Scale	Element Decision Acceptance Range
F1	Lack of prevention of occupational diseases and accidents	P	Neutrosophic set: (Occupational Health; accidents)	[0; 1]	Subset: • Index at risk of getting sick (high, medium, low, or null) • Level to be injured (high, medium, low, or none)
F2	Insecurity of the worker for the performance of his work activity	I	Neutrosophic set: (Job security, job performance)	[0; 1]	Subset: • Job security index (high, medium, low, or null) • Job performance (low, medium, high)
F3	Non-compliance with labor obligations by employers	O	Neutrosophic set: (Contractual obligations; violation of labor rights)	[0; 1]	Subset: • Contract compliance (low, medium, high) • Presence of the infraction (yes, sometimes, no)
F4	Lack of guarantees for the fulfillment of fundamental rights	G	Neutrosophic set: (Labor and contractual guarantee)	[0; 1]	Subset: • Labor guarantee: contractual guarantee (complies with some parameters or does not comply)
F5	Ignorance of the fundamental rights of the worker	C	Neutrosophic set: (knowledge; disclosure)	[0; 1]	Subset: • Unawareness; disclosure (high, medium, low, or none)

Table 3. Factors that give rise to the violation of labor rights. Source: own elaboration

For the development of the neutrosophic statistical study, it is recommended by the experts to analyze the levels of deterioration of the elements associated with labor rights in Ecuador. Studies in risk conditions are associated, based on the statistical bases and the surveys carried out (Table 4).

No.	F1	F2	F3	F4	F5
1	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]
2	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]
3	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]
4	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
5	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0,0.95,1)]
6	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
7	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
8	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]
9	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
10	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]
11	[(0,0.95,1);(0.49,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0,0.95,1);(0.49,0.5,0.55)]
12	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
13	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
14	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
5	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0,0.95,1);(0.15,0.9,0.95)]
16	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
17	[(0,0.95,1);(0.25,0.8,0.85)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]
18	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]
19	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]
20	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
21	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
22	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
23	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]

24	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]
25	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]
26	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]
27	[(0,0.95,1);(0.25,0.8,0.85)]	[(0,0.95,1);(0,0.95,1)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]
28	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
29	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0,0.95,1);(0.15,0.9,0.95)]
30	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]
31	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
32	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]
33	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]
34	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
35	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
36	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]
37	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]
38	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
39	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
40	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]
41	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]
42	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]
43	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0,0.95,1);(0,0.95,1)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]
44	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]
45	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0.15,0.9,0.95)]
46	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]
47	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
48	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]

49	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]
50	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
51	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]
52	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]
53	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
54	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]
55	[(0,0.95,1);(0,0.95,1)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
56	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
57	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0,0.95,1);(0.49,0.5,0.55)]
58	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
59	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
60	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
61	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
62	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
63	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
64	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
65	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0,0.95,1);(0.15,0.9,0.95)]
66	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]
67	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
68	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]
69	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
70	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]
71	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
72	[(0,0.95,1);(0.25,0.8,0.85)]	[(0,0.95,1);(0,0.95,1)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]
73	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0,0.95,1);(0.15,0.9,0.95)]

74	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0,0.95,1);(0,0.95,1)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
75	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0,0.95,1);(0.49,0.5,0.55)]
76	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]
77	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
78	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]
79	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
80	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]
1-80	**[(0.3,0.75,0.8);(0.55,0.45,0.53)]**	**[(0.3,0.75,0.8);(0.49,0.5,0.55)]**	**[(0.25,0.8,0.85);(0.49,0.5,0.55)]**	**[(0.25,0.8,0.85);(0.3,0.75,0.8)]**	**[(0.3,0.75,0.8);(0.49,0.5,0.55)]**

Table 4. IDLE neutrosophic frequency. Source: own elaboration

For the development of the statistical study, the neutrosophic frequencies of the factors are analyzed to determine the *level of infraction of labor rights by the employer in Ecuador*, associated with risk conditions and labor guarantees. For each factor, a sample of the elements associated with the subset visualized by the group of experts is analyzed. The analysis of the sample that makes up the groups analyzed in the study with respect to determining the relationship between the deterioration of labor rights and the associated risk condition (Table 4).

For the modeling, it is decided to take each term to a neutrosophic number according to equation (1). Table 4 analyzes the IDLE level for a sample of [37; 80] workers and lawyers engaged in labor activity in Ecuador for each factor analyzed. Of the neutrosophic frequencies, it can be observed with a level of response in the weight of the factors, from the neutrosophic linguistic terms represented between $[0;\ 1]$. For each risk condition reviewed with a total indeterminacy level of $P = 19.8, I = 19.8, O = 20.9, G = 17.5, C = 20.1$, and with a representativeness level of $[46.05\%;\ 51.48\%]$, on the days that both workers and lawyers are evaluated, in relation to more than one risk condition.

The preliminary results of the tracking have an indeterminate level close to 0.5 in F_1. The result diagnoses the deterioration of each factor that affects the appearance of violations of the labor law of the employees according to the sample analyzed:

- The disease prevention index is severely deteriorated, while the level of workplace accidents is impaired for the interaction of the subsets analyzed.
- The worker's safety is in a severely deteriorated state in the face of a moderately deteriorated level of performance in their work activity.
- The level of contractual obligation is very deteriorated with moderately deteriorated in the violations of labor rights.
- The impact on labor and contractual guarantee It is very deteriorated with a slight influence on some institutions to a severely deterioration state.
- The lack of knowledge of the fundamental rights of the worker is severely deteriorated in the new environment that surrounds them, while there is a moderate deterioration in the disclosure of the rights of the workers.

Given the existing levels of indeterminacy, the use of classical statistics is not possible, so it is necessary to use neutrosophic statistics for a better understanding of interrelated neutrosophic sets.

3.3 Neutrosophic Statistical Analysis

The modeling of data on the level of deterioration existing in the factors associated with the origin of violations of labor rights and guarantees shows that factor 1 requires studies with a level of depth. To determine the level of incidence between the causes and conditions of occupational risk, it is necessary to analyze the means (Table 5). To understand what factor implies a representative mean, $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means are calculated for the study of the variations of the affectations, and the values of the standard neutrosophic deviation $S_N \in [S_L; S_U]$. To determine which factor requires a higher level of accuracy at the time of diagnosing each subset, therefore, the $CV_N \in [CV_L\ ;\ CV_U]$ values are calculated.

Factors	$\bar{x}_N$	S_N	CV_N
Lack of prevention of occupational diseases and accidents	0.29 + 0.538 I	0.015 + 0.331 I	0.052 + 0.615 I
Insecurity of the worker for the performance of his work activity	0.255 + 0.503 I	0.018 + 0.36 I	0.071 + 0.716 I
Non-compliance with labor obligations by employers	0.246 + 0.508 I	0.015 + 0.327 I	0.061 + 0.644 I
Lack of guarantees for the fulfillment of fundamental rights	0.239 + 0.458 I	0.015 + 0.298 I	0.063 + 0.651 I
Ignorance of the fundamental rights of the worker	0.264 + 0.515 I	0.015 + 0.342 I	0.057 + 0.664 I

Table 5. Neutrosophic statistical analysis of the IDLE level. Source: own elaboration

Table 5 shows the factors that affect the conditions of infringement of labor rights by the employer and the associated level of indeterminacy. So, it is necessary to analyze the status of workers and propose solutions to reduce violations of labor rights and guarantees. This means that the level of risk associated with this situation is more common and easier to detect, but there are levels of uncertainty to analyze. On the other hand, the analysis of CV_{NO} for these factors is lower for the factors of *lack of prevention of occupational diseases and accidents and non-compliance with labor obligations by employers*.

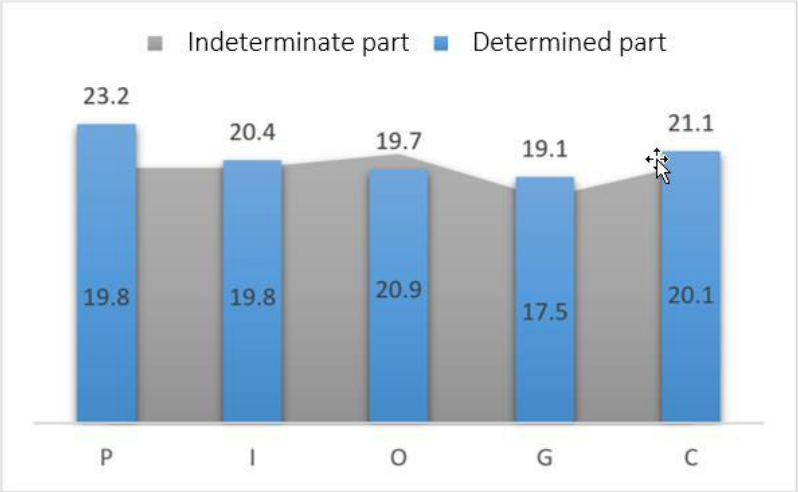


Figure 1. Neutrosophic bar graph of the DPEA. Source: own elaboration

The neutrosophic set for the lack of prevention of occupational diseases and accidents and the breach of work obligations by employers derives with a greater frequency from the analyzed studies. It is visualized that, for levels of ignorance of the fundamental rights of the worker, where the knowledge and disclosure are defined in a contradictory way and the conditions of risk in labor rights (Figure 1).

3.4 Comparative Analysis

To determine the associated referent indeterminacy measure for $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ and $CV_N \in [CV_L\ ;\ CV_U]$ to the form of neutrosophic numbers (Table 6). In the results obtained, it is observed that the values CV_N range from 0.052 to 0.071 with the measure of indeterminacy of [0.615; 0.716] generated by a sample of [100; 203] questionnaires and statistical information, obtained from 80 workers and lawyers.

From the results expected by the neutrosophic statistical study, it can be seen that:

The lack of prevention of occupational diseases and accidents causes a risk index of over 21.3% of those surveyed. The status of the analyzed factor is between severely deteriorated and deteriorated for a frequency of [23.2; 43].

The insecurity of the worker for the performance of his work activity presents an index of safety and job performance of 19.9% of those surveyed. While the factor status is between severely impaired and moderately impaired for a frequency of [20.4; 40.2].

The non-compliance with labor obligations by employers presents a level of labor infractions and contractual breaches of 20.1%. Therefore, the factor is between highly impaired and moderately impaired for a frequency of [19.7; 40.6].

The lack of guarantees for the fulfillment of fundamental rights presents a level of achievement of 18.2% of those surveyed. Therefore, the factor is very impaired to severely impaired with a frequency of [19.1; 36.6].

Ignorance of the fundamental rights of the worker presents a level of ignorance and disclosure of 20.4% of those surveyed. Therefore, the factor is between severely impaired and moderately impaired with a frequency of [21.1; 41.2].

For violations of labor rights by the employer, they increase with the deterioration of the factors analyzed. For these factors, more in-depth studies are required to track down the potential causes, such as the mitigation of the consequences that affect the fulfillment of labor rights. It is vital, for the analysis of statistical studies referring to the subject where the contradictions and indeterminacies are diversified in various degrees of weight in neutrosophic terms, to obtain a level of consensus of the specialists within the analyzed element of the neutrosophic set.

Factors	$\bar{x}_N$	S_N	CV_N
F1	0.29 + 0.538 I;I ∈ [0,0.461]	0.015 + 0.331I;I ∈ [0,0.955]	0.052 + 0.615 I;I ∈ [0,0.915]
F2	0.255 + 0.503I;I ∈ [0,0.493]	0.018 + 0.36I;I ∈ [0,0.950]	0.071 + 0.716 I;I ∈ [0,0.901]
F3	0.246 + 0.508 I;I ∈ [0,0.516]	0.015 + 0.327 I;I ∈ [0,0.954]	0.061 + 0.644 I;I ∈ [0,0.905]

F4	0.239 + 0.458 I;I ∈ [0,0.478]	0.015 + 0.298 I;I ∈ [0,0.950]	0.063 + 0.651 I;I ∈ [0,0.903]
F5	0.264 + 0.515 I;I ∈ [0,0.487]	0.015 + 0.342I;I ∈ [0,0.956]	0.057 + 0.664 I;I ∈ [0,0.914]

Table 6: Neutrosophic forms with the measure of indeterminacy. Source: own elaboration

6 Discussion

Partial Solutions

From the results obtained in the study, it is proposed to promote alternatives to minimize violations of labor rights committed by the employer. The variants presented allow the actions to be taken depending on the level of indeterminacy and acceptance of the levels in each range and for the tracking and prevention of *violations of labor rights by the employer.* Therefore, you want:

- Regularize and process a control system for perfidy, where the judicial system establishes entities and authorities responsible for regulating or punishing problems arising from poor labor relations between the parties involved in an employment contract. The labor inspector, the judge, and the labor inspectorate itself must carry out a procedure to sanction said actions.
- Inspectors are required to receive complaints arising from labor relations problems. Settlements are practiced when an employment relationship is terminated or when eviction or notice of termination of the contract is presented, either individually or collectively.
- The labor inspectorate as a judicial entity dependent on the public sector is in charge of receiving complaints related to labor problems that have no solution in labor relations. In addition, it acts as a body dependent on the Ministry of Labor, in charge of handling cases related to labor matters in Ecuador.
- Labor inspectors have a fundamental duty or objective to ensure effective compliance with the obligations imposed by law on workers and employers who are under a dependency employment relationship by signing an employment contract. To comply with the obligation to ensure compliance with hygiene and safety provisions in the workplace.
- Add the correct fulfillment of those obligations that the law imposes on both the employer and the worker. In addition, deny or grant requests for approval are imposed by the worker or the employer. Also impose the ends established in the norms of the Labor Code, carry out inspections in workplaces to be able to verify compliance with the dislocations of the Labor Code and in addition to the constitutional, legal, or regulatory norms in labor matters.

Conclusion

Labor Perfidy is applied in the action of hiring a worker, the same that is made visible in deception and acting in bad faith on the part of the employer. The need to get a job to support their homes and the lack of information and training makes workers, when starting an employment relationship, fall into this violation of rights since most workers do not know which authorities to contact in these cases.

The modeling showed the ignorance of the fundamental rights of the workers. As analyzed, the issue is not as well known in the social environment since most of the surveyed population has not heard about this problem and the danger that workers run when signing blank documents.

The violation of workers' rights is a very common problem in the labor sector. It is necessary to reform that adjusts to the principles and constitutional and legal rights of the worker, as is the case of Labor Perfidy. Therefore, the labor inspector is considered essential for the judicial and public systems to be able to carry out inspections of labor activities and to address power to ensure compliance with labor standards.

References

[1] M. A. Ch, H. S. Shaukat, &, and M. Iqbal, "Impact on job satisfaction and organizational pride through evaluation of perceived organizational CSR: A structural equation modelling. Journal of, 8(1), 50–70. ," *Management Sciences,* vol. 8, pp. 50-70, 2021.

[2] Tamás Gyulavári and E. Menegatti. (2022) Who Regulates Employment? Trends in the Hierarchy of Labour Law Sources.

International Journal of Comparative Labour Law and Industrial Relations. 31-52. Available: https://kluwerlawonline.com/journalarticle/International+Journal+of+Comparative+Labour+Law+and+Industrial+Relations/38.1/IJCL2022002

[3] M. T. Al-Zoubi, & and K. M. Al-Tkhayneh, "Employees' perception of Corporate Social Responsibility (CSR) and its effect on job satisfaction. Journal of, 10(1), 67–81," Social Research & Policy, vol. 10, pp. 67-81, 2019.

[4] J. Brandl. (2022) Frames of reference in managing employment from the perspective of economics of conventions. *Industrial Relations: A Journal of Economy and Society*. Available: https://onlinelibrary.wiley.com/doi/full/10.1111/irel.12305

[5] M. Biagi. (2000) The Impact of European Employment Strategy on the Role of Labour Law and Industrial Relations. International Journal of Comparative Labour Law and Industrial Relations. 155-173. Available: https://heinonline.org/HOL/LandingPage?handle=hein.kluwer/cllir0016&div=21&id=&page=

[6] B. Kunerth, & and R. Mosley, "Applying employer brand management to employee engagement.," Strategic HR Review, vol. 10, pp. 19-26, 2011.

[7] S. Herrmann and C. Nagel. (2022) Early Careers of Graduates from Private and Public Universities in Germany: A Comparison of Income Differences Regarding the First Employment. Research in Higher Education. Available: https://link.springer.com/article/10.1007/s11162-022-09698-4

[8] F. Smarandache, An introduction to the Neutrosophic probability applied in quantum physics: Infinite Study, 2000.

[9] W. B. Vasantha, I. Kandasamy, and F. Smarandache, "Algebraic Structure of Neutrosophic Duplets in Neutrosophic Rings < Z U I>,< Q U I> and < R U I.> " Neutrosophic Sets and Systems, vol. 23, pp. 85-95, 2018.

[10] Pérez-Teruel, Neutrosophic logic for mental model elicitation and analysis.: Neutrosophic Sets and Systems, 2012.

[11] F. Smarandache, Neutrosophy, a new Branch of Philosophy: Infinite Study, 2002.

[12] W. V. Kandasamy and F. Smarandache, "Fuzzy Neutrosophic Models for Social Scientists.," Education Publisher Inc., (2013)

[13] F. Smarandache, "A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Infinite Study.," 2005.

[14] A Sánchez Garrido, & A. J. Peñafiel Salazar. (2022). La acupuntura como terapia coadyuvante en el fortalecimiento del sistema inmunológico contra el covid-19. Revista Universidad y Sociedad, Vol. 14 Num. 2, pp- 188-191, 2022.

[15] R. Martínez Martínez, C. D. Castañeda Guillot, & I. Pimienta Concepción. "Microbiota intestinal y diabetes". Universidad y Sociedad, Vol. 14 Num. 2, pp- 158-163, 2022.

[16] C M. Méndez Cabrita, M. G. Gordón Martínez, M. R. Dávila Castillo, & J. R.Cadena Morillo. "El derecho natural convergente y la justificación ética del derecho". Universidad y Sociedad, Vol. 14 Num. 2, pp- 120-123, 2022.

[17] K. L. Baque Villanueva, A. M. Izquierdo Morán, & D. A. Viteri Intriago. "Estructura metodológica de plan estratégico para mejorar las ventas en las Mipymes del cantón Quevedo". Universidad y Sociedad, Vol. 14 Num. 2, pp- 66-74, 2022.

[18] I E. Montenegro Bósquez, D. F. Granja Zurita, M. R. Aguilar Martínez, & D. P. Gordillo Cevallos. "Las aclaraciones a testigos por parte de los jueces penales en las audiencias de juicio, un análisis desde el estándar de prueba". Universidad y Sociedad, Vol. 14 Num. 2, pp- 51-56, 2022.

[19] W A Cacpata Calle, T. L Bautista Sierra, A. S. Gil Betancourt & E. B. Prado Calderón. "Admisibilidad y eficacia de la acción extraordinaria de protección en Santo Domingo de los Tsáchilas". Universidad y Sociedad, Vol. 14 Num. S2, pp- 498-505, 2022.

[20] D. F. Tixi Torres, J. X. Iglesia Quintana, L. X. Cangas Oña, & C. A. Bonilla Villa. "El elemento descriptivo cohabitación, en relación con el núcleo familiar en materia de violencia intrafamiliar. Universidad y Sociedad, Vol. 14 Num. S2, pp- 493-497, 2022.

[21] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018

[22] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.

[23] von Feigenblatt, O. F. "Education, culture, and underdevelopment: Haiti's tragic failure". Universidad y Sociedad, vol. 14 no. 3, pp 604-611, 2022.

[24] von Feigenblatt, O. F., Peña-Acuña, B., & Cardoso-Pulido, M. J. "Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones". Ediciones Octaedro, 2022.

Received: August 01, 2022. Accepted: October 01, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Limiting Factors of Extenuating Circumstances Using Neutrosophic 2-Tuple (revisited)

Diego Fabricio Tixi Torres[1], Carlos Gilberto Rosero Martinez[2], Ned Vito Quevedo Arnaiz[3], and Jorge Gabriel Del Pozo Carrasco[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.diegotixi@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Tulcán, Ecuador. E-mail: ut.carlosrosero@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.nedquevedo@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador. E-mail: uq.jorgedc77@uniandes.edu.ec

Abstract. Every court is responsible for applying the law under the principles of fairness, justice, ethical-legal, and human value because it cannot be forgotten that every criminal is a human being. The foregoing is the reason why the application of extenuating circumstances acquires a particular complexity. Currently, in Ecuador, certain situations cause mismanagement of justice due to the lack of understanding and assimilation of mitigating circumstances. This is adopted as a problem situation, while the main objective of the investigation is to analyze the limiting factors in the application of extenuating circumstances using the 2-Tuple model in its neutrosophic extension.

Keywords: Extenuating circumstances, limiting factors, neutrosophic 2-tuple model, Neutrosophy.

1 Introduction

Extenuating circumstances are those that reduce the penalty of the crime with attention to some requirements established in the law. In its application, the verification of the behavior of the aggressor after having committed the harmful action prevails [1]. Which is compatible with the provisions of article 45 of the Organic Integral Penal Code (OIPC) of the Republic of Ecuador [2]. It has been possible to verify that there have been cases where people are prosecuted for an infraction that they did not want to commit and without neglecting what is established by the OIPC, the mitigating circumstances must be evaluated. This allows a fairer sentence to be obtained and the individual to be rehabilitated and reintegrated into society [1, 3, 4].

According to article 54 of the OIPC, the judge must individualize the sentence for each person, even if there are several responsible for the same infraction. To do this, the following aspects must be observed or considered:

- The circumstances of the punishable act, extenuating and aggravating circumstances.
- The needs and special or conditions of the victim.
- The seriousness of the violation of their rights.
- The degree of participation and all the circumstances that limit criminal responsibility (article 54 of the OIPC).

The preceding implies the adequacy of the sentence to the personality of the offender to whom it is applied, this is how the need to apply the sanction according to the actor and his personality can be evidenced. What considers the circumstances that serve as support to set the penalty within the framework of Criminal Law. In such a way that the factors taken into account in the phase of individualization of the sentence are multiple, thus: the conduct or precedent of the crime, the surrounding circumstances under which the crime was committed, time, manner, place, etc., and even the same criminal record that in practice is put into consideration before the judge seeking to determine and identify the dangerousness of the offender, as well as economic, social, family factors, etc. [5-7].

As well as all the circumstances that limit criminal responsibility so that justice is applied in its maximum expression. To guarantee that all legal systems tend to justice and equity. Therefore, every court is responsible for applying the law under the principles of fairness, justice, ethical-legal, and human value, because it cannot be forgotten that every criminal is a human being. The foregoing is the reason why the application of mitigating circumstances acquires a particular complexity [3, 8].

According to [3], it is important to verify the nature of the crime. It establishes a certain number of typologies for which it is necessary to consider several circumstances. However, it is important to mention that typicity refers to the type that in this case would be the crime that according to [3] has a triple function:

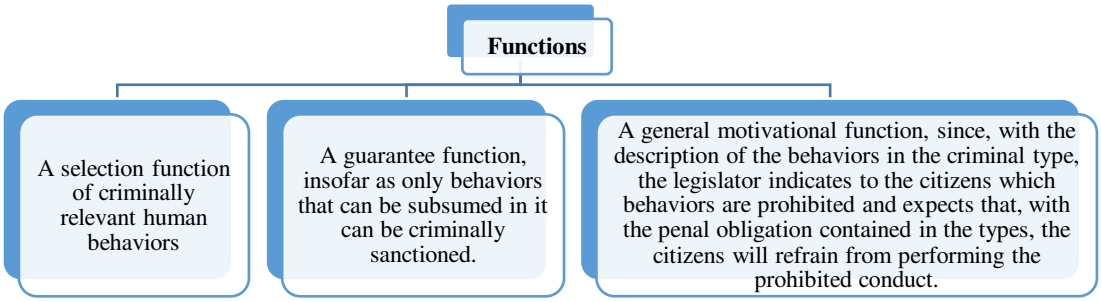


Figure 1: Triple role of mitigating circumstances. Adapted from [3].

Today certain situations cause mismanagement of justice due to a lack of understanding and assimilation of extenuating circumstances. Mostly it can be verified that this is due to [1, 3-5]:

a) its non-application exists by failing to observe evidence considered as mitigating circumstances,

b) misuse them, as a means to reduce the sentence of a dangerous person, even though sufficient elements are exposed for conviction.

According to the above, it can be said that the present investigation adopts the above as a problem situation. For this reason, the main objective of the investigation is to analyze the limiting factors in its application. For its resolution, it is proposed to apply the 2-Tuple model in its neutrosophic extension. It is chosen for the way of modeling the uncertainty of this problem by incorporating other modern approaches such as CWW (Computing With Words) for the treatment of imprecision and uncertainty.

The CWW deals with the words and propositions of a natural language as its main objects of computation, for example: "small", "big", "expensive", "very possible" or even more complex phrases such as "tomorrow will be sunny, but not very cold". The main inspiration of the CWW is the human ability to perform several different tasks such as (walking in the street, playing soccer, riding a bicycle, understanding a conversation, making decisions, etc.) without the need for the explicit use of measurements or calculations [9, 10].

Hence it is explicit why this method was selected over a statistical one because many of the direct opinions that could be collected are not reliable since they depend on the subjective opinion of the respondents. That is why the help of experts is essential because they are specialists in the subject and have wide access to opinions, which allows them to determine the true state of the opinion of those surveyed more accurately.

2 Materials and Methods

2.1 CWW

The CWW is a methodology that allows calculation and reasoning processes to be carried out using linguistic terms instead of numbers exclusively. This methodology allows creating and enriching decision models in which vague and imprecise information is represented through linguistic variables using linguistic terms. This makes it more natural for people to communicate. These processes have been carried out in fuzzy decision-making using different models, which are the following:

- Semantic Model: operations are performed using fuzzy arithmetic.
- Symbolic Model: the operations are carried out on the indices of the linguistic labels.
- Linguistic 2-tuple-based Model: it operates in a domain of linguistic expression, but treats it as a continuous universe, gaining precision in the results. The use of the 2-tuple-based model has made it possible to address decision-making problems defined in complex contexts that classical models cannot deal with, due to their limitations.

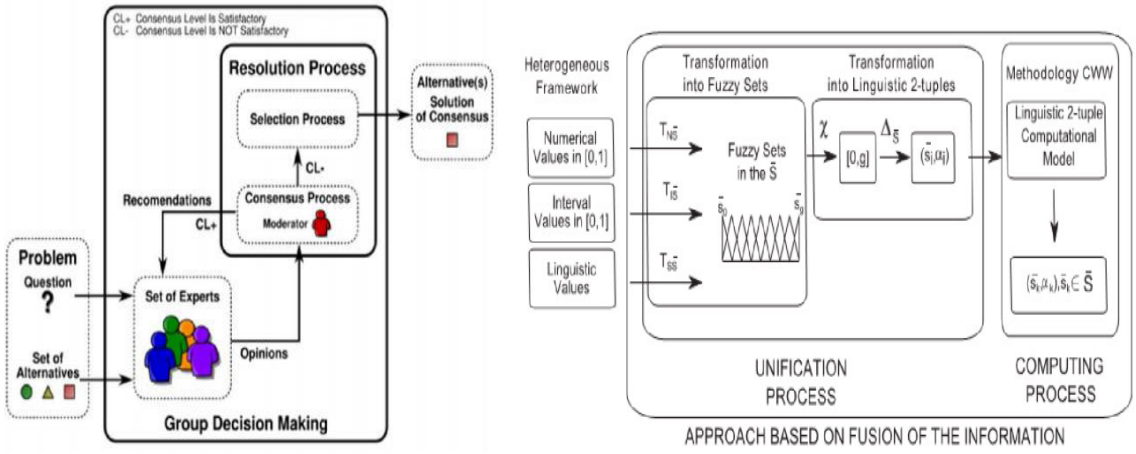


Figure 2: General scheme of a consensus-based group decision-making process and an approach based on the fusion of information into linguistic values [11-13].

The 2-tuple linguistic representation model allows computing processes with words without loss of information, based on the concept of symbolic translation. In this article, this method is used within the framework of neutrosophic sets. This combination enriches the result of decision-making, this concept is known as the Set of 2-tuple Linguistic Neutrosophic Numbers. The advantage of such a combination is that the falsehood and indeterminacy criteria can be included independently.

2.2 Neutrosophy applied to the 2-tuple CWW model

Definition 1. Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x): X \to]-0,1^+[$, that satisfy the condition: $-0 \leq \inf u_A(x) + inf r_A(x) + inf v_A(x) \leq sup u_A(x) + \sup r_A(x) + sup v_A(x) \leq 3^+ \; para \; todo \; x \in X$, where $u_A(x), r_A(x) \; and \; v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively, and their images are standard or nonstandard subsets of $]-0,1^+[$.

Definition 2. Let X be a universe of discourse. A Single Value Neutrosophic Set (SVNS) A on X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \tag{1}$$

Where $u_A, r_A, v_A: X \to [0,1]$ satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3 \; for \; all \; x \in X. u_A(x), r_A(x), v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively. For convenience, a *Single Value Neutrosophic Number* (SVNN) will be expressed as A = (a, b, c), where a, b, c ∈ [0,1] and satisfies 0 ≤ a + b + c ≤ 3.

Definition 3. Let $S = \{s_0, s_1, \dots, s_t\}$ be a set of linguistic terms and a value in the granularity interval of S. The *Symbolic Translation* of a linguistic term s_i, is a number in the interval [−0.5; 0.5) that expresses the difference of information between a quantity of information expressed by the value $\beta \in [0,t]$, obtained in a symbolic operation and the closest integer value $i \in \{0, \dots, t\}$, which indicates the index of the closest linguistic label s_i in S.

Definition 4. Let $S = \{s_0, s_1, \dots, s_t\}$ be a set of linguistic terms and a value that represents the result of a symbolic operation, then the *linguistic 2-tuple* (2TL) that expresses the information equivalent to β, is obtained using the following function:

$$\Delta: [0,t] \to S * [-0.5;0.5)$$

$$\Delta(\beta) = (s_i, \alpha), con \begin{cases} s_i, i = round(\beta) \\ \alpha = \beta - 1, \alpha \in [-0.5;0.5) \end{cases} \tag{2}$$

Where *round* is the usual rounding operator, s_i is the label with the index closest to β and α is the value of the symbolic translation. It should be noted that $\Delta^{-1}: \langle S\rangle \to [0,t]$ is defined as $\Delta^{-1}: \langle s_i, \alpha\rangle = i + a$. In this way, a linguistic 2-tuple $\langle S\rangle$ is identified with its numerical value in $[0,t]$.

Definition 5. Suppose $S = \{s_0, s_1, \dots, s_t\}$ is a 2TL with odd cardinality t + 1. $(s_T, a), (s_I, b), (s_F, c) \in L \; and \; a, b, c \in [0,t]$ are defined where $(s_T, a), (s_I, b), (s_F, c) \in L$ express independently the degree of truth, degree of indeterminacy, and degree of falsehood by 2TL, respectively, then a *2-tuple Neutrosophic Linguistic Numbers Set* (NLNS2T) is defined as follows:

$$l_j = \left\{\left(s_{T_j}, a\right), \left(s_{I_j}, b\right), \left(s_{F_j}, c\right)\right\} \tag{3}$$

Where $0 \leq \Delta^{-1}\left(s_{T_j}, a\right) \leq t, 0 \leq \Delta^{-1}\left(s_{I_j}, b\right) \leq t, 0 \leq \Delta^{-1}\left(s_{F_j}, a\right) \leq t \; y \; 0 \leq \Delta^{-1}\left(s_{T_j}, a\right) +$

$\Delta^{-1}\left(s_{I_j}, b\right) + \Delta^{-1}\left(s_{F_j}, a\right) \leq 3$.

The score and precision function allow to classify the NLNS2T as shown below:

Let $l_j = \left\{\left(s_{T_j}, a\right), \left(s_{I_j}, b\right), \left(s_{F_j}, c\right)\right\}$ be a NLNS2T on L, the score and precision function on l_1 is defined as follows:

$$S(l_1) = \left\{\frac{2t + \Delta^{-1}\left(s_{T_1}, a\right) - \Delta^{-1}\left(s_{I_1}, b\right) - \Delta^{-1}\left(s_{F_1}, c\right)}{3}\right\}, \Delta^{-1}(S(l_1)) \in [0, t] \tag{4}$$

$$H(l_1) = \Delta\left\{\frac{t + \Delta^{-1}\left(s_{T_1}, a\right) - \Delta^{-1}\left(s_{F_1}, c\right)}{2}\right\}, \Delta^{-1}(H(l_1)) \in [0, t] \tag{5}$$

$$MAP(l_1, l_2, \ldots, l_n) = \sum_{j=1}^{n} w_j l_j = \begin{matrix} \Delta\left(t\left(1 - \prod_{j=1}^{n}\left(1 - \frac{\Delta^{-1}(s_{T_J}, a_j)}{t}\right)^{w_j}\right)\right), \\ \left(\Delta\left(t\prod_{j=1}^{n}\left(\frac{\Delta^{-1}(s_{I_J}, b_j)}{t}\right)^{w_j}\right), \Delta\left(t\prod_{j=1}^{n}\left(\frac{\Delta^{-1}(s_{F_J}, c_j)}{t}\right)^{w_j}\right)\right. \end{matrix} \tag{6}$$

$$MGP(l_1, l_2, \ldots, l_n) = \sum_{j=1}^{n} l_j^{w_j} \begin{matrix} \Delta\left(t\prod_{j=1}^{n}\left(\frac{\Delta^{-1}\left(s_{T_J}, a_j\right)}{t}\right)^{w_j}\right), \Delta\left(t\left(1 - \prod_{j=1}^{n}\left(1 - \frac{\Delta^{-1}\left(s_{I_J}, b_j\right)}{t}\right)^{w_j}\right)\right), \\ \left.\Delta\left(t\left(1 - \prod_{j=1}^{n}\left(1 - \frac{\Delta^{-1}(s_{F_J}, c_j)}{t}\right)^{w_j}\right)\right)\right. \end{matrix} \tag{7}$$

Definition 6. Given a set of NLNS2T, $l_j = \left\{\left(s_{T_j}, a\right), \left(s_{I_j}, b\right), \left(s_{F_j}, c\right)\right\}$, (j = 1, 2,…, n) with a vector of weights that satisfies the conditions y = 1, then we have the following two aggregation operators, which are the *Weighted Arithmetic Mean of Linguistic Neutrosophic Numbers of 2-tuple* (WAMLNN2T) and the *Weighted Geometric Mean of 2-tuple Linguistic Neutrosophic Numbers* (WGMLNN2T).

2.3 Procedure to resolve the objective

a) Select
   1) Experts: experts with more than 3 years of experience in the courts of the Republic will be chosen so that the following condition is met: $K = \{k_1, k_2, \ldots, k_n\}(n \geq 2)$. Each one will be assigned a weight such that $w_i \in [0,1]\ y\ \sum_{j=1}^{n} w_i = 1$. Provided that the will to participate in the exercise voluntarily is expressed.
   2) Decision criteria such that $C = \{c_1, c_2, \ldots, c_m\}(m \geq 2)$.

b) Assign linguistic scale
c) Evaluate by criteria assigning, through equation 6, the result of the evaluation of each of the criteria by each expert consulted. To then perform the total aggregation with a weight ratio such that $w_i = \frac{1}{m}$ on the results of each criterion.
d) Apply the score function or the precision function to assess the results from a numerical value from equations 4 and 5.

3 Results and Discussion

It is exposed as a problem to analyze the incorrect inapplicability of the mitigating circumstances, so the limiting factors of this situation are understood as input variables. To determine these factors, a survey was conducted among the selected experts. [23, 24]

For the selection of the group of experts, a competency validation survey was applied through self-assessments, on an ascending scale from 1 to 10:

- Degree of knowledge that said potential expert possesses about the subject
- Degree of influence of each of the sources of argumentation

The processing of the form was based on the calculation of the rating factor of the experts through the following mathematical expression:

$$K = \frac{FA + GC}{2} = \frac{\frac{SI + EP + IR + FB}{4} + GC}{2} \quad (8)$$

Where:
Si= Intuition
PS= Practical experience
IR= Research conducted
BC= Consultation of bibliographic sources
DK: Degree of knowledge (1-10)

7 experts were consulted for the exercise and their skills were checked as described below using equation 8:
K Value and Classification
8-10 High
5-7 Medium
1-4 Low

Of the 10 interviewees, only a group of 3 experts composed of a judge, defense attorney, and prosecutor were selected for a total (k=3), therefore $w_i = \frac{1}{3}, for\ i = 3$.

From the surveys applied, it was possible to determine the limiting factors of the correct inapplicability of the mitigating circumstances. According to the criteria of the experts consulted, these are:

a) Corruption between the actors of the judicial system that favors non-observance or not at convenience.
b) Lack of knowledge about who should request its application.
c) No belief in their effectiveness due to their typification.
d) Need to streamline the process: they are usually downplayed and ignored due to violation of the principle of innocence since it is assumed that everyone is guilty of having committed a crime
e) Misidentification of the accused and/or the investigation of the fact prevents the visualization of the same within the process.

A linguistic scale consisting of the following was selected: $S = \{s_0 = Very\ Bad, s_1 = Bad, s_2 = Regular, s_3 = Good, s_4 = Very\ Good"\}$, which was processed in Octave 4.2.1. The following tables show the results of the application of the method.

Factors	Lawyer	Judge	Attorney
Corruption	<(s2, 0), (s1, 0), (s1, 0)>	<(s1, 0), (s2, 0), (s1, 0)>	<(s2, 0), (s1, 0), (s0, 0)>
Individualization	<(s1, 0), (s1, 0), (s1, 0)>	<(s0, 0), (s1, 0), (s3, 0)>	<(s1, 0), (s1, 0), (s2, 0)>
Effectiveness	<(s2, 0), (s1, 0), (s3, 0)>	<(s1, 0), (s1, 0), (s2, 0)>	<(s0, 0), (s1, 0), (s1, 0)>
Streamlining	<(s1, 0), (s1, 0), (s1, 0)>	<(s0, 0), (s1, 0), (s3, 0)>	<(s1, 0), (s1, 0), (s2, 0)>
Identification	<(s0, 0), (s1, 0), (s3, 0)>	<(s0, 0), (s1, 0), (s1, 0)>	<(s0, 0), (s0, 0), (s3, 0)>

Table 1: Evaluation. Source: own elaboration.

Factors	Added Criteria
Corruption	<(s2;0.42), (s1;0.23), (s2;0.07)>
Individualization	< (s1;-0.30), (s1; 0), (s3; 0)>
Effectiveness	< (s1; 0.12), (s1; 0), (s3; 0)>
Streamlining	<(s1;-0.31), (s1;0), (s3;-0.38)>
Identification	<(s0, 0), (s0, 0), (s3, 0)>

Table 2: Joint criteria of the experts. Source: Own elaboration.

Factors	Scoring Function
Corruption	(s2; 0.36)
Individualization	(s2; -0.42)
Effectiveness	(s2; -0.30)
Streamlining	(s2; -0.31)
Identification	(s1; -0.34)

Table 3: Scoring function. Source: own elaboration.

The factors can be sorted as follows:

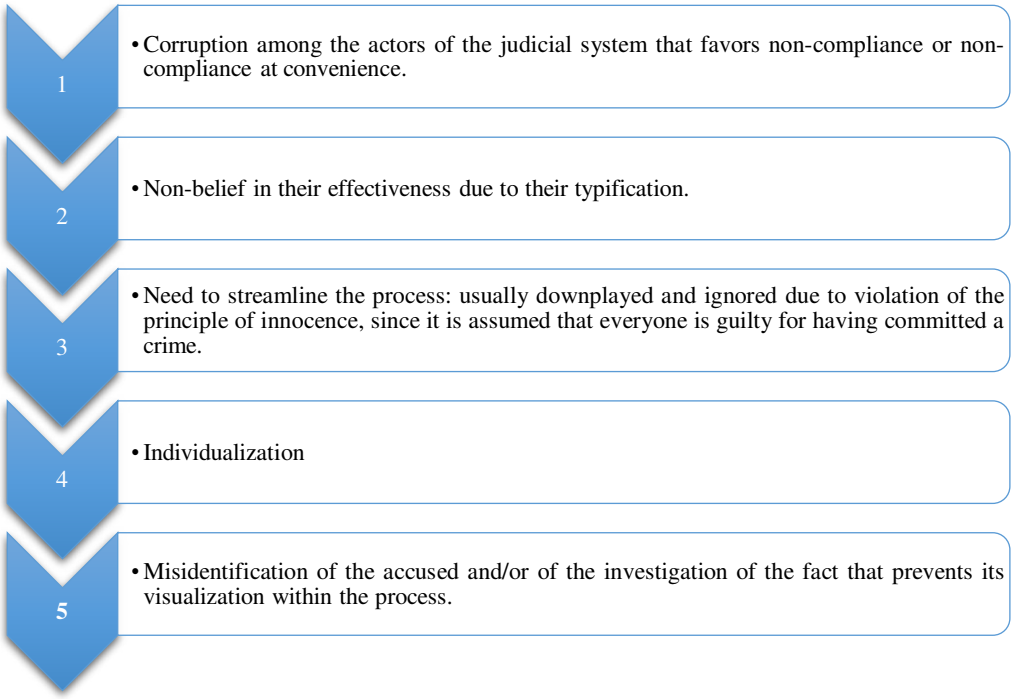


Figure 3. Order of importance of the factors according to the results. Source: own elaboration.

In accordance with the results, it can be said that for the experts consulted, the main reasons why the analyzed phenomenon is faced, are the presence of corruption and the lack of effectiveness in the typification. Therefore, the need to make improvements in eliminating these situations is essential. [14, 15, 16]

As can be seen in Table 3, in general, all the proposed factors are not favorably evaluated, most of them are exposed as regular. What offers a not very encouraging panorama for the implementation of Due Process. Although the correct attitude of those who impose justice is indeed the first step to guarantee due process, in such a way that there is the right to defense, presentation of evidence, and other actions that the defense attorney could present as an extenuating factor on the infraction committed; is the responsibility of all the correct application of the law.

The Ecuadorian State is characterized as a state of rights and justice, which is fully stated in the Constitution of the Republic, so that under no circumstances can a right be violated. Therefore, there is a need to improve both the training of students on this subject, as well as the postgraduate training of the actors of the justice system as corrective measures. All this is to achieve an equitable judicial system where justice is imposed in an egalitarian manner. [17, 18, 19, 20]

Regarding politics and corruption, the actions must come from the highest hierarchy, according to the criteria of the experts on the subject in question. The social, legal, technological, and ecological factors in that order have a much lower hierarchy, and are similar in values, in the analysis; but their strategies are pillars for the development of a long-term plan for the full recovery of due process in the closure of public service premises. [21, 22]

In addition, it is necessary to pay attention to individualization. It is a matter of adapting the penalty, provided for in the norm, to a specific case so that it is truly fair and effective. When applying the sentence, it is the judge who must consider a series of circumstances not explicitly provided for in the law, which affect the greater or lesser severity of the act, and which are susceptible to generalization. Although it is the defense attorney who proposes mitigating causes, the role of the judge is fundamental. Therefore, training activities are also needed in this area.

Conclusion

Fuzzy logic has grown rapidly due to its ability to solve problems related to the uncertainty of information or knowledge of experts. In addition, it provides a formal method for the expression of knowledge in a form understandable by humans. The variant presented to create a computational model allows decisions to be made in the definition of improvement actions. With the use of the CWW merged with Neutrosophy, an accurate mathematical tool is achieved in the treatment of qualitative information and the subjectivity of evaluation by experts. Its experimental evaluation through this case demonstrated a satisfactory performance of the system, exhibiting the advantage of using this intelligent system to speed up the work time of the evaluators in this area.

The management of extenuating circumstances requires a continuous analysis in the search for justice through the means available for it. Some of the factors that prevent a correct development of what is established in the case of mitigating circumstances were determined. It was found that the Ecuadorian State must work more deeply on this issue, both in training strategies and in the management of the authorities of the judicial system. Control mechanisms must be established for the processes to guarantee compliance with due process.

It is recommended to conduct an analysis of other legislation to determine points in common or other aspects of interest that may present themselves as opportunities for improvement. Legislations such as the Spanish, Colombian, and Argentine could be models of comparison, for which it is exhorted to research this subject.

References

[1] S. D. Espinoza Sanchez, "Las circunstancias atenuantes de la infracción en el delito de tentativa de homicidio," *Universidad Regional Autónoma de Los Andes "UNIANDES",* Tesis 2017.
[2] Ecuador Asamblea Nacional, R. d. Ecuador, Ed. Código Orgánico Integral Penal, 2014 ed. Registro Oficial del Organo del Gobierno del Ecuador, 2014, p. 144.
[3] Á. A. Suárez Santos, "La aplicabilidad de las circunstancias atenuantes de la infracción penal," Universidad Regional Autónoma de Los Andes "UNIANDES", Tesis 2019.
[4] G. G. Guillin Barcia, "El juzgamiento de personas vulnerables en la tentativa de homicidio," Universidad Regional Autónoma de Los Andes "UNIANDES", tesis 2018.
[5] M. E. G. Santos, R. E. A. González, C. E. P. Paucar, and I. J. D. Basurto, "Mapeo conceptual como herramienta para comprender circunstancias atenuantes en las tentativas de homicidios," *Estudios del Desarrollo Social: Cuba y América Latina,* vol. 8, pp. 48-60, 2020.
[6] SCIELO. "La motivación en la enseñanza en línea." SCIELO. http://scielo.sld.cu/scielo.php (Accessed.
[7] J. Estupiñán Ricardo, V. M. Vaca Rosado., J. Piedra Fernández, and S. Mantilla Martínez. (2020) Importancia de la investigación jurídica para la formación de los profesionales del Derecho en Ecuador. Revista Dilemas Contemporáneos: Educación, Política y Valores. 1-25. Available: http://www.dilemascontemporaneoseducacionpoliticayvalores.com/
[8] V. Vásquez and H. Javier, "La Corte Constitucional del Ecuador y su facultad de interpretación," 2022.
[9] L. A. Zadeh, "Fuzzy logic = computing with words," IEEE Transactions on Fuzzy Systems, vol. 4, no. 2, pp. 103-111, 1996.
[10] J. T. Rickard, J. Aisbett, and R. R. Yager, "Computing With Words in fuzzy cognitive maps," in Fuzzy Information Processing Society (NAFIPS) held jointly with 2015 5th World Conference on Soft Computing (WConSC), 2015 Annual Conference of the North American, 2015: IEEE, pp. 1-6.
[11] M. Espinilla, R. De Andrés, F. Marínez, and L. Martínez, " A 360–degree performance appraisal model dealing with heterogeneous information and dependent criteria," *Information Sciences,* vol. 222, pp. 459-471, 2013, doi: 10.1016/j.ins.2012.08.015.
[12] M. Espinilla, I. Palomares, and L. Martínez, "A comparative study of heterogeneous decision analysis approach applied to sustainable energy evaluation. ," International journal of uncertainty, fuzziness and knowledge-based systems, vol. 20, no. 1, pp. 159-174, 2012.
[13] F. Herrera, E. H. Viedma, and p.-. , "Linguistic decision analysis: Steps for solving decision problems under linguistic information.," Fuzzy Sets and Systems, vol. 115, pp. 67-82, 2000.
[14] J. M. Puetate Paucar, M. A. Guambo Llerena & M.E. España Heredia. "Analysis of the level of risk in the crime of tax evasion from a judicial perspective in Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 127-137, 2022.
[15] R. C. Ilaquiche Licta, T. E. González Macas, A. K Bucaran Caicedo & G. S. Manaces Easud. "La aplicación de la pena máxima en pueblos y nacionalidades indígenas en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 118-126, 2022.
[16] F. D. Vilamarin Barragán, N. G. Freile Cartagena, G. F. Vinueza Arroyo & J. R. Limaico Mina. "Inobservancia a los derechos humanos: migración irregular de grupos vulnerables a Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 108-117, 2022.
[17] F. E. Álvarez Álvarez, R. C. Ilaquiche Licta, S. F. Fiallos Bonilla & V. J. Hernandez Alvarado. "Procedimientos disciplinarios a servidores judiciales: vulneración de derechos constitucionales". Universidad y Sociedad, vol. 14 no. S4, pp 98-107, 2022.
[18] E. G. Olalla Chávez, W. R. Paredes Navarrete, G. P. León Burgos & S. B. Esparza Pijal. "Análisis del ingreso y posesión de teléfonos celulares en centros de privación de libertad de Santo Domingo-Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 89-97, 2022.

[19] Y. G. Calva Vega, C. D. Cedeño Moreira, J. C. Nevarez Moncayo & O. F. Villacrés Duche. "Delitos de femicidio: reparación integral para los niños (as) y adolescentes". Universidad y Sociedad, vol. 14 no. S4, pp 81-88, 2022.
[20] Y. A. Crespo Mejía, K. E. Carrión León, J. A. Paredes López & M.E. Infante Miranda. "Etapas del proceso penal: importancia de la defensa material y técnica". Universidad y Sociedad, vol. 14 no. S4, pp 70-80, 2022.
[21] Ricardo, J. E., Villalva, M. I. M., Padilla, Z. A. O., & Hurtado, L. A. C. "Filosofía de la comunicación, complemento necesario en el aprendizaje de las Ciencias Sociales". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 3 no. 2, pp 39-52, 2018.
[22] García, J. M. B., Ricardo, J. E., & Villalva, I. M. "Acciones didácticas para la autorrealización física integral de los estudiantes de carreras agropecuarias". Didasc@ lia: Didáctica y Educación, vol. 7 no. 2, pp 57-66, 2016
[23] von Feigenblatt, OF, Pardo, P. & Cooper, M. "Corporativismo y autoritarismo benévolo: antídotos viables contra el populismo". Revista de perspectivas alternativas en las ciencias sociales. Vol. 11 no. 1, pp 95-98, 2021.
[24] Von Feigenblatt, O. F. "Honor, Loyalty, and Merit: The Cultura Contemporary of the Spanish Nobility". Ediciones Octaedro, 2022.

Received: August 02, 2022. **Accepted:** October 02, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Success Factors in the Joint Custody Process to Guarantee the Well-being of the Minor

Carmen Marina Méndez Cabrita[1], Cesar Eduardo Ochoa Díaz[2], Leonardo Toapanta Jiménez[3], And Mónica Alexandra Salame Ortiz[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.carmenmmc56@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.cesarochoa@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.leonardotoapanta@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.monicasalame@uniandes.edu.ec

Abstract. Joint or shared custody is a process that arises from divorce when there are children in common. This process is channeled by lawyers and judges, who are the deciding figure in the process. This pursues as its main objective, the superior well-being of the minor, granting equal responsibilities to both parents. In the case of Ecuador itself, the preponderant power is granted to the mother, as legal guardian. In the present investigation, the implications that this process could have on the emotional stability of the minor, as well as the role of the psychologist in the process is analyzed. A survey was applied to a group of parents. Then, possible solutions were proposed that intend to favor the well-being of the minor during the custody process to which they will be subjected. These proposals were handled through expert consultation and processed using the CRITIC multi-criteria decision method with RATIO.

Keywords: joint custody, superior well-being of the minor, emotional stability, CRITIC with RATIO.

1 Introduction

Joint custody arises for the first time, in the state of California in the United States in the year 1979, however, by 1967 in the state of North Carolina a statute on the custody regime was approved that applied the "joint custody" [1]. In effect, for purposes of regulating what is also called “tenure”, after the divorce joint custody could be chosen if in this way the interest of the child was better ensured. It is through this legal figure that minors could maintain coexistence with both parents, through alternate or successive periods, a time within which the obligations and attributions that arise from paternity are exercised. Under this scheme, it was only discussed which parent the child would live with and which one would be in charge of the minor's care on a daily basis. [2]. The Ecuadorian State guarantees and recognizes that the right to care exists from the very moment of conception, in this sense, children have the right to enjoy family life, as stated in Article 45 of the Magna Carta of Ecuador where, logically, further development is required regarding the scope of this right and its content in the infra-constitutional regulations to optimize its practical application [3].

This is the case of the Code of Childhood and Adolescence, (CONA in Spanish), which, despite starting to ratify the principles, rights, and guarantees established in the Constitution related to the complementarity in parental activities, later promotes the maternal preference for tenure, establishing roles of care and attention to the mother and relegating fathers in the upbringing of children as a simple provider of resources. This aspect was of recent attention by the Constitutional Court that ordered the declaration of unconstitutionality of numerals 2 and 4 of Article 106 of the CONA through Judgment No. 28-15-IN since it is not consistent with the distribution of obligations towards the children as stated in Article 69, numeral 1 of the Constitution, where it is indicated that parents must ensure the upbringing, care, education, promotion and protection of the rights of their offspring together [3][4].

It can be considered that the general interest of the minor is to achieve evolutionary development from childhood to adulthood, and it must be taken into account by all those who intervene in any act or circumstance during this period. The idea is that all the measures that are adopted with respect to the minor are oriented to the protection of his interest, which of course supposes that with these measures the minor reaches an integral development. To achieve these objectives, it must be taken into account that the decision adopted may affect him or her and that it must be assumed, taking into account these purposes, with preference over other particular interests of the parents [5].

The criteria that are usually considered when establishing the best interests of the minor are the wishes, opinions, and feelings of the minor himself according to his maturity. It is about the satisfaction of their basic or vital needs, whether psychic, emotional, or through material goods, as well as those that affect their education and training, and all those alterations of the environment that may affect the development and the formation of the minor. In turn, his identity, religion, orientation, and sexual identity or language will be preserved, in addition to non-discrimination for any condition [6].

It is significant to note that there have been frequent cases in which parental authority has been granted to the mother, for thinking that the minor may be better off with her, a situation that has not been much debated since in high percentages this idea relies on being true. However, the possibility that the father may also be optimal and qualified to exercise that right is not taken into consideration, thus questioning the effectiveness of the law against the legal approach, and whether it should improve its equitable perception [7].

Along with rights, parents share obligations by having the same level of responsibilities, for this reason, it is convenient to assess in conditions of equivalence who is conferred parental authority over the minor. The criteria outlined in article 106 of the CONA are questioned in Judgment 28-15-IN/21 of the Constitutional Court, debating the need to consider equal conditions with respect to both parents, without giving preference to the mother so that she obtains parental authority. Meanwhile, it is discussed whether custody in favor of the mother violates the principle of parental co-responsibility regarding the fact that both parents are suitable for the care of the child. [8].

Within this procedure, parental authority has been immersed under the assumption of the best interests of the child, understanding that it integrates the stability of the minor. In turn, justice operators are called upon to assess the positive or negative impact of whoever is going to obtain parental authority. Certainly, "there is no room for any kind of supposition, nor, on the contrary, any kind of custom that the parents personally have ingrained, so they must leave the child in total dedication and freedom to guarantee his well-being" [9].

A great responsibility falls on the competent judge since it is in their hands to give priority to the best interests of the minor. Relevant aspects of parental authority denote the correlation to the family to ensure a sense of union that provides for both parents to share time with the minor. In this way, it is possible to balance the harmony that the minor needs to ensure his emotional stability. It is of the utmost importance that what is expressed before the family must be “effective for the minor since it is their first school based on learning where the son or daughter will be able to give way to the full development of what is being analyzed about the personality” [10, 11].

Shared custody is positive for the child's life, but it will depend a lot on the relationship between the parents. If the relationship is peaceful without measuring violence, the psychological formation of the child will be positive. If the relationship is bad, the psychological effects on the minor will be negative, then they will be positive as long as the parents have a good relationship focusing clearly on the well-being of the minor since it is a Constitutional right to safeguard the best interests of the child [12].

For positive effects to be obtained from shared custody, the parents must have a good relationship, transmitting this to their children, if this is not the case, the parents together with the children have to carry out psychological therapies so that they can establish a healthy environment that will favor the family. The parents must go through psychological therapy even if they have reached a conciliatory agreement in an extrajudicial conciliation center since by not being evaluated they fail to comply with what was agreed, that is why when evaluating the parents it will be known what is the purpose of wanting the possession of their children. It is also necessary that the children receive therapies so that they live in a healthy environment with food protection and affection; there is a constitutional right that protects them in the best interests of the child [13, 22, 23].

Analyzing the revised texts to carry out the present investigation, it is important to remark on the need for the inclusion of the figure of the psychologist in the legal process of joint custody. The work of accompanying and advising him in the process could prevent future alterations in minors. Therefore, for this research we set the following objectives:

1.1 General objective

Highlight the importance of the work of the psychologist during the joint custody process as a possible success factor in the process.

1.2 Specific objectives

1. Evaluate the parents' perception of the process to obtain joint custody.
2. Know the work of the psychologist in the process to ensure the emotional well-being of the minor.
3. Propose solutions regarding the issue to guarantee emotional stability and the superior well-being of the minor.

2 Materials and methods

The study responds to a non-experimental correlational design because the research will be carried out without manipulating the variables; which implies the collection of data at a specific and unique time [14, 17, 18, 19]. The current research work is characterized by a holistic approach since basic statistics and legal hermeneutics will be used. To determine the sample to be studied, the following operation was performed:
Sample:

$$n = \frac{Z^2 pqN}{E^2(N-1) + Z^2 pq} \quad (1)$$

Expert validation

For the selection of the group of experts, a competency validation survey was applied which is executed through self-assessments, on a scale ascending from 1 to 10:

- ✓ Degree of knowledge that the potential expert possesses about the subject
- ✓ Degree of influence that each of the sources of argumentation

The processing of the form was based on the calculation of the rating factor of the experts through the following mathematical expression:

$$K = \frac{FA + GC}{2} = \frac{\left(\frac{SI + EP + IR + FB}{4} + GC\right)}{2} \quad (2)$$

Where:
Si= Intuition
PS= Practical experience
IR= Research conducted
FB= Consultation of bibliographic sources
CG: Degree of knowledge (1-10)

2.1 Data Processing

Descriptive statistics for data processing, with graphs and statistical tables as instruments.

CRITIC valuation model with RATIO

The valuation model proposed is made up of the CRITIC (Criteria Importance Through Intercriteria Correlation) methods [15] and the Valuation Ratio [16, 20, 21] and consists of the following steps:

- ✓ First step. Selection of comparable alternatives
- ✓ Second step. Selection of the explanatory criteria of the value
- ✓ Third step. Weighting of criteria using CRITIC
- ✓ Fourth step. Weighting of alternatives
- ✓ Fifth step. Valuation Ratio Calculation
- ✓ Sixth Step. Calculation of the value of the target alternative

Each of the steps that make up the valuation process is described in greater detail below.

1. First step. Selection of comparable alternatives: Once the alternative to be valued has been selected, the first point is to determine the comparable alternatives, which must be similar and, therefore, comparable to the alternative to be valued.
2. Second step. Selection of the explanatory criteria of the value: The criteria to be used in the comparison process are selected and the database is created. As mentioned, the proposed assessment methodology is based on the comparison of alternatives.
3. Third step. Weighting of criteria using CRITIC: The weight or importance of the different criteria is weighted, by applying CRITIC. It does not seem reasonable to think that all the selected variables or criteria have the same importance or influence when determining the value of the alternatives. It is therefore necessary to objectively assign a weight to each of the criteria selected in the previous step. CRITIC [16] is a criteria weighting method that defines their importance utilizing (3), based on their values normalized by the range.

$$w_i = S_i * \rangle \ \rangle (1 - r_{ik}) \quad (3)$$

Where:

w_j = weight or weighting of criterion j
s_j = standard deviation of criterion j
$r_{j,k}$ = Correlation coefficient between criteria j and k
The obtained weights (w_j) are normalized by the sum. Applying CRITIC, a criterion has greater weight the greater its standard deviation and the lesser correlation it maintains with the other criteria.

4. Fourth step. Weighting of alternatives: Once the weight w_j of each of the criteria is obtained, the weighting of the different alternatives is calculated using (4):

$$x_i = \sum_{j=1}^{n} w_j * c_{ij} \tag{4}$$

Where
x_i is the weight of alternative $\underline{i}$,
w_j is the weight of criterion j,
c_{ij} is the value of criterion j for alternative i

5. Fifth step. Valuation Ratio Calculation: The Valuation Ratio is a methodology proposed in the International Valuation Standards (1997) whose mathematical expression is (5). In our case, the numerator is the sum of the values of the comparable alternatives, or another type of parameter linked to it and the denominator is the sum of the weights of the comparable alternatives obtained in the previous step (fourth step).

$$RV = \frac{\sum_{i=!}^{n} V_i}{\sum_{i=!}^{n} x_i} \tag{5}$$

Where
RV=Valuation Ratio
V_i=Value of the alternative i
x_i = Weight of the alternative i obtained with CRITIC
The Valuation Ratio indicates the value of the alternatives per weighting unit.

6. Sixth Step. Calculation of the value of the target alternative: The value of the target alternative is calculated through the product of the ratio obtained in (5) by the weighting to be valued obtained by applying (4).

2.2 Description of the methodology

1. Data entry. The sources of information used in the study were:
   - ✓ Surveys: a survey with closed questions was developed, and then applied to the parents to obtain information about their perception of the process of joint custody and to evaluate aspects concerning the importance of the figure of the psychologist in the process. In addition, they were applied to the experts, for the selection of the group that will be part of the decision-making process.
   - ✓ Documentary review: theses, documents, and statutes referring to the subject were reviewed to provide relevant data to the investigation.

2. Information processing:
   - ✓ The calculation was made for the selection of the sample
   - ✓ Then the survey was applied to the selected sample
   - ✓ For the processing of the information, the professional statistical processing system and its qualitative analysis were used.
   - ✓ Selection of the group of experts
   - ✓ Application of the CRITIC method with RATIO to the results expressed by the selected experts

3. State results
4. Recommend possible solutions to the issue addressed

3 Results and Discussion

The investigation was carried out in the city of Cuenca, to calculate the sample size the following exercise was

carried out.

Calculation of sample size

(For the estimation of proportions, under the assumption that p=q=50%)

- ✓ Maximum allowed margin of error: 10.0%
- ✓ Population size: 25
- ✓ Size for a confidence level of 95%: 20

A survey was developed and applied to 20 parents who participated in the shared custody process, to assess their perception of the process. The sample was selected from the total number of cases treated in Cuenca, in 10 months. The results obtained from this survey are listed below.

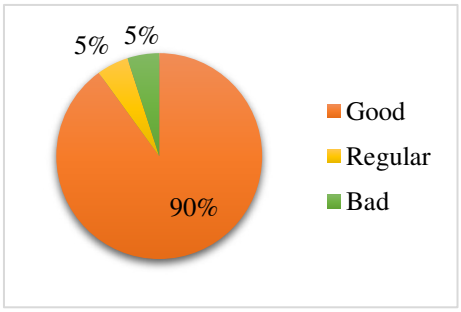


Figure 1: Question 1. What do you think about joint custody? Source: own elaboration.

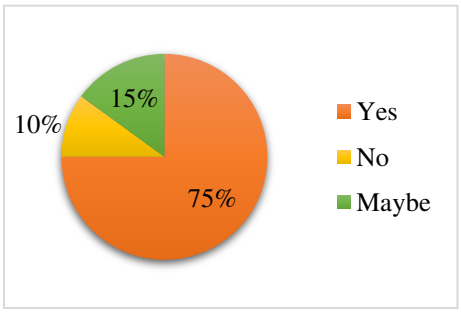


Figure 2: Question 2. Did both parents have the same rights in the process? Source: own elaboration

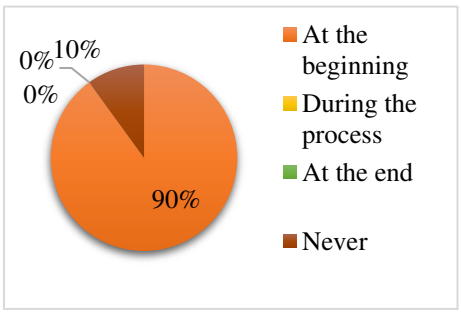


Figure 3: Question 3. Was your child evaluated by a psychologist in the process? Source: own elaboration

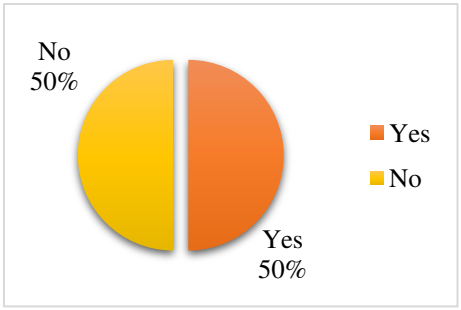


Figure 4: Question 4. The lawyer in his decision process took into account the diagnosis issued by the psychologist. Source: own elaboration

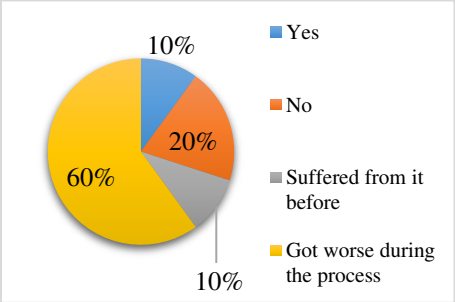


Figure 5: Question 5. Did your child suffer from any emotional disturbance before the process? Source: own elaboration

The results of the analysis of the graphs show that:

- ✓ 90% of the surveyed sample considers that joint custody is generally good.
- ✓ Regarding figure 2, which answers the second question of the questionnaire, 75% of the parents state that do not have equal rights during the process and in the judge's decision-making.
- ✓ In 90% of the cases, the psychologist evaluated the minor only at the beginning of the process, having a single contact with the minor, for evaluative purposes, data that was obtained from question 3.
- ✓ Figure 4, corresponding to question 4, reflects that in 50% of the cases the lawyer took into account the opinion of the psychologist for the process.
- ✓ Figure 5 shows that of the minors in question, 60% presented aggravation of emotional disturbances caused by the divorce of their parents, 10% had it before, 20% of the cases did not suffer from them and 10% reported that they did.

When jointly analyzing the results of the parents' survey, it can be affirmed that the parents consider that the process, in general, is good, but equal rights are not granted to both parents. The results also show the need for the work of the psychologist during the process, where social workers could also be included. After carrying out the surveys to the parents, possible solutions to the analyzed topic were proposed, for which it was necessary to consult a group of experts. The results of the expert selection process and the consultation carried out are presented below. [24, 25]

Processing of the survey for the selection of experts

For this procedure, there are 12 experts, from 4 different specialties: social workers, family lawyers, judges, and psychologists. It began with the tabulation of the results in the Microsoft Excel 2019 tool, where the average results of the qualifications given by the respondents are exposed. See table 1.

Sources of argumentation (FA)	**Degree of influence of the sources of argumentation**		
	High	**Medium**	**Low**
Intuition (Si)	10	5	1
Practical Experience (PE)	10	5	1
Research conducted (IR)	10	5	1
Consultation of bibliographic sources (FB)	10	5	1

Table 1: Degree of knowledge. Source: own elaboration

K-value	**Classification**
8-10	High
5-7	Medium
1-4	Low

Table 2: CG (degree of knowledge). Source: own elaboration. Note: It will be graded from 1-10.

Experts	**CG**	**SI**	**EP**	**IR**	**FB**	**K**	**Qualification**
Expert 1	7	10	10	5	10	7,875	Medium
Expert 2	6	5	10	5	5	6,125	Medium

Expert 3	5	5	5	1	5	4.5	Medium
Expert 4	8	10	10	5	10	8,375	High
Expert 5	9	10	10	5	10	8,875	High
Expert 6	6	5	5	1	5	5	Medium
Expert 7	9	10	10	10	10	9.5	High
Expert 8	10	10	10	5	10	9,375	High
Expert 9	8	10	10	5	10	8,375	High
Expert 10	10	10	10	10	10	10	High
Expert 11	10	10	10	10	10	10	High
Expert 12	9	10	10	5	10	8,875	High

Table 3: Result of the qualification of experts according to their degree of knowledge. Source: own elaboration

For the calculation, the mathematical expression number (3) was used. As can be seen from the proposed experts, they are all at a medium and high level. Of these, 30% of the candidates have medium competence and 70% high, choosing these for the application, so it can be stated that in general the coefficient of competence presented high values. Therefore, they are validated as decision-makers in the investigation. The group of selected experts was presented with the following alternatives to consider, those that seek to achieve the superior well-being of the minor during and after the shared custody process: [28, 29]

1) Give equal importance in granting custody to both parents.
2) Provide follow-up by a psychologist during the joint custody process and later if the case requires so.
3) For the granting of custody, consider the person closest to the child emotionally.
4) Establish with both parents the need for consistency in educational methods in both homes.
5) Provide the minor with the possibility of choosing the person with whom they want to live if they can decide.
6) If the parents do not meet the requirements for the custody of the minor, grant it to a trained close relative.
7) Establish schedules for visits, outings, and meetings with the other parent.
8) Guarantee the economic stability of the minor by both parents.

Which will be evaluated according to the following criteria:

1. Emotional stability
2. Affective well-being
3. Consistency of educational methods
4. Security
5. Satisfaction of basic needs
6. School stability

This procedure was performed using the CRITIC with RATIO method. The results of the decision-making process, which was carried out by consulting each of the 4 groups of experts separately, are presented in the tables below. Then take the preferred alternative for each group and define the possible solutions.

Alternatives	**Criterion 1**	**Criterion 2**	**Criterion 3**	**Criterion 4**	**Criterion 5**	**Criterion 6**
Alternative 1	15.3	1.08	4.33	1.5	14	1
Alternative 2	19	20	18	6.78	19	17.9
Alternative 3	8.7	1.98	2.53	5.6	2	4.5
Alternative 4	9	4.6	1.65	1	1	1
Alternative 5	5.4	7.1	2.33	18.9	1	23
Alternative 6	3.2	4.12	1.21	11.8	1	2
Alternative 7	7.1	3.52	2.1	7.9	1	8.9
Alternative 8	10	3.24	0.98	17	1	1

Table 4: Decision matrix. Source: own elaboration

Alternatives	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Alternative 1	0.7658228	0.0000000	0.1968273	0.0279330	0.7222222	0.0000000
Alternative 2	1,0000000	1,0000000	1,0000000	0.3229050	1,0000000	1,0000000
Alternative 3	0.3481013	0.0475687	0.0910693	0.2569832	0.0555556	0.2071006
Alternative 4	0.3670886	0.1860465	0.0393655	0.0000000	0.0000000	0.0000000
Alternative 5	0.1392405	0.3181818	0.0793184	1,0000000	0.0000000	0.0769231
Alternative 6	0.0000000	0.1606765	0.0135135	0.6033520	0.0000000	0.0591716
Alternative 7	0.2468354	0.1289641	0.0658049	0.3854749	0.0000000	0.4674556
Alternative 8	0.4303797	0.1141649	0.0000000	0.8938547	0.0000000	0.0000000

Table 5: Normalization matrix by range. Source: own elaboration

Alternatives	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Deviation	0.306	0.299	0.313	0.346362858	0.37577081	0.32806569

Table 6: Deviation. Source: own elaboration

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Criterion 1	1	0.552	0.799	-0.455	0.913	0.563
Criterion 2	0.552	1	0.914	0.058839798	0.63184331	0.84276679
Criterion 3	0.799	0.914	1	-0.211824227	0.86849741	0.87693071
Criterion 4	-0.455202482	0.058839798	-0.211824227	1	-0.40174971	-0.13318151
Criterion 5	0.912968364	0.631843315	0.868497405	-0.401749708	1	0.61764989
Criterion 6	0.562760701	0.842766794	0.87693071	-0.133181507	0.61764989	1

Table 7: Correlation matrix. Source: own elaboration

	Weight	Normalized weight
Criterion 1	0.8043	0.1410
Criterion 2	0.5983	0.1049
Criterion 3	0.5488	0.0962
Criterion 4	2.1277	0.3731
Criterion 5	0.8909	0.1562
Criterion 6	0.7326	0.1285
Total	5,7026	1,0000

Table 8: Weights of each criterion. Source: own elaboration

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Alternative 1	0.7658	0.0000	0.1968	0.0279	0.7222	0.0000
Alternative 2	1,0000	1,0000	1,0000	0.3229	1,0000	1,0000
Alternative 3	0.3481	0.0476	0.0911	0.2570	0.0556	0.2071
Alternative 4	0.3671	0.1860	0.0394	0.0000	0.0000	0.0000
Alternative 5	0.1392	0.3182	0.0793	1,0000	0.0000	0.0769
Alternative 6	0.0000	0.1607	0.0135	0.6034	0.0000	0.0592
Alternative 7	0.2468	0.1290	0.0658	0.3855	0.0000	0.4675
Alternative 8	0.4304	0.1142	0.0000	0.8939	0.0000	0.0000

Table 9: Weighting of variables. Source: own elaboration

	Weighing	Normalized Weighting	Ranking of the alternatives
Alternative 1	0.2502	0.0953	6
Alternative 2	0.7474	0.2846	1
Alternative 3	0.1940	0.0739	7
Alternative 4	0.0751	0.0286	8
Alternative 5	0.4437	0.1690	2
Alternative 6	0.2509	0.0955	5
Alternative 7	0.2586	0.0985	4
Alternative 8	0.4062	0.1547	3

Table 10: Ranking of the alternatives. Source: own elaboration

The first group of experts consulted, made up of social workers, and selected alternative 2: provide follow-up by a psychologist during the joint custody process, and later if the case requires so. Taking into consideration this proposal, the fact that the separation process of the parents could, to some extent, cause psychological alterations in the minor in question. The results of the consultation with the second group of experts, made up of lawyers, are set out below. In this case, the table corresponding to the weighting of the variables and ranking of the alternatives, described in Step 6 of the applied method, will be presented. [26, 27]

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Alternative 1	0.5455	0.0750	0.3750	0.3889	0.0722	0.0000
Alternative 2	0.2727	0.8333	0.6591	0.5556	0.5000	0.0556
Alternative 3	0.2455	0.4500	0.3864	0.0000	0.0000	0.0000
Alternative 4	0.0182	0.3333	0.3693	0.5556	0.2944	0.0000
Alternative 5	0.0000	0.3333	0.1193	0.5000	0.5000	0.5000
Alternative 6	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
Alternative 7	0.5455	0.0000	0.3864	0.3222	0.3889	0.0833
Alternative 8	0.1818	0.1667	0.0000	0.2000	0.2778	0.0000

Table 11: Weighting of variables. Group of experts 2. Source: own elaboration

	Weighing	Normalized Weighting	Ranking of the alternatives
Alternative 1	0.2521	0.0876	4
Alternative 2	0.4699	0.1633	2
Alternative 3	0.2014	0.0700	7
Alternative 4	0.2342	0.0814	6
Alternative 5	0.2989	0.1038	3
Alternative 6	1,0000	0.3475	1
Alternative 7	0.2849	0.0990	5
Alternative 8	0.1367	0.0475	8

Table 12: Ranking of the alternatives. Source: own elaboration

For the second group of experts, the appropriate alternative is 6, in case the parents do not meet the requirements, for the care and custody of the minor, give it to a trained close relative. The consultation of the third group of experts: made up of judges, shows the following results:

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Alternative 1	1,0000	1,0000	0.7778	1,0000	1,0000	1,0000
Alternative 2	0.9306	1,0000	1,0000	0.7368	0.5202	0.6278
Alternative 3	0.0000	0.0556	0.1389	0.0000	0.0636	0.0611
Alternative 4	0.8611	1,0000	0.9444	0.8526	0.0000	0.0000
Alternative 5	0.2778	0.4056	0.0667	0.7368	0.0000	0.0000
Alternative 6	0.4514	0.4444	0.0167	0.1842	0.0000	0.0000

Alternative 7	0.2361	0.0000	0.1389	0.0000	0.0809	0.0000
Alternative 8	0.3750	0.5611	0.0000	0.4158	0.8671	0.0000

Table 13: Weighting of variables. Group of experts 3. Source: own elaboration

	Weighing	Normalized Weighting	Ranking of the alternatives
Alternative 1	0.9593	0.3079	1
Alternative 2	0.7615	0.2444	2
Alternative 3	0.0596	0.0191	8
Alternative 4	0.5175	0.1661	4
Alternative 5	0.2038	0.0654	6
Alternative 6	0.1339	0.0430	7
Alternative 7	0.0723	0.0232	3
Alternative 8	0.4077	0.1309	5

Table 14: Ranking of the alternatives. Source: own elaboration

For the third group of experts, alternative 1 was selected: give equal importance to granting custody to both parents. They allege that the state protects the mother as the legal guardian of the children, but sometimes she does not adequately fulfill her role and therefore does not favor the psychological well-being of the minor. Thus, it is necessary to grant the same possibility to the father figure.

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6
Alternative 1	0.5000	0.2200	0.5455	0.6154	1,0000	0.6059
Alternative 2	1,0000	1,0000	1,0000	1,0000	0.6000	1,0000
Alternative 3	0.1700	0.3400	0.3864	0.0000	0.0000	0.0000
Alternative 4	0.0000	0.2000	0.3750	0.5385	0.5333	0.4647
Alternative 5	0.0000	0.5000	0.0000	0.6923	0.6000	0.5294
Alternative 6	0.0000	0.6000	0.4318	0.5538	0.5333	0.3000
Alternative 7	0.2400	0.0000	0.3182	0.4615	0.4667	0.0882
Alternative 8	0.6000	0.0000	0.2614	0.3846	0.4000	0.3882

Table 15: Weighting of variables. Group of experts 4 made up of psychologists. Source: own elaboration.

	Weighing	Normalized Weighting	Ranking of the alternatives
Alternative 1	0.5711	0.1718	2
Alternative 2	0.9231	0.2776	1
Alternative 3	0.1659	0.0499	6
Alternative 4	0.3190	0.0959	5
Alternative 5	0.3620	0.1089	8
Alternative 6	0.3934	0.1183	4
Alternative 7	0.2550	0.0767	7
Alternative 8	0.3355	0.1009	3

Table 16: Ranking of alternatives

In this case, the experts from the fourth group considered that the second alternative could be a success factor in the joint custody process since the advice of a mental health professional could contribute to improving the child's alterations. Many times, these alterations are derived from the process itself, other times they are happening and are aggravated in the process. Therefore, in addition to taking into account the criteria and measures taken by a lawyer, the help of a psychologist are important in all cases. They unanimously considered that there are few social workers in multidisciplinary groups to psychologically assess parents due to the discrepancy or lack of communication they have.

Our National Legislation in force must incorporate requirements, procedures, and mechanisms for joint custody with the objective that citizens know what type of tenure is appropriate for their family environment. In addition, the parents must know what to do to achieve shared custody, forgetting about the judicial provisions and focusing on improving relations between them. These parameters will allow the magistrates to evaluate the parents in psychological therapies and determine how they are physically, psychologically, and economically with the

purpose that they do not breach the judicial mandate. Thus promoting understanding and harmony in both parents so that they do not affect their children and they maintain a healthy relationship hand in hand with their parents. [13].

Among the important measures to keep in mind in the joint custody process, are the psychological therapies that both parents and children must receive, as well as their physical and mental evaluation. In addition to determining the mental, physical and economic conditions of both parents who will share custody. Therefore, a multidisciplinary team must participate together with psychologists so that parents are constantly evaluated. It is important to highlight, according to the results obtained in the investigation, the need for the active participation of the figure of a psychologist, not only as an evaluator of the process but also as a professional who accompanies the process. Making it possible for both parents to receive relevant guidance on the management of their children in this new stage that begins for everyone. The work of this professional is not only diagnostic but guidance and advice, in addition to providing the relevant treatments if necessary.

Conclusions

The parents who participated in the study expressed dissatisfaction with the joint custody process. In most cases, they state that the minor was not given care by specialists. Through the application of the CRITIC method with RATIO, it was possible to obtain that the possible success factors in the joint custody process could be: involve the psychologist in the process and provide follow-up by this professional after it is concluded, so that their guidance and contributions can be valid in the process, pursuing the superior well-being of the minor and their emotional balance.

At the same level of decision, alternative 1 was selected: give equal importance to granting custody to both parents. Sometimes, because it is stipulated that the mother be the one who takes care of the children, her inability to do so is not considered. Depriving the father of the right to legal guardianship could be a failure of justice, considering that in many cases the father figure has a better capacity to assume the role. Therefore, it is recommended to consider these results to guarantee success in the process. More in-depth research is needed to define and be able to make the right decision for the judge.

References

[1] L. Fischel-Wolovick, *Traumatic divorce and separation: The impact of domestic violence and substance abuse in custody and divorce*: Oxford University Press, 2018.

[2] A. Steinbach, L. Augustijn, and G. Corkadi, "Joint physical custody and adolescents' life satisfaction in 37 North American and European countries," *Family process,* vol. 60, pp. 145-158, 2021.

[3] A. A. C. Posso, C. J. L. Chapeta, M. L. S. Iñiguez, and A. F. G. Gordillo, *Use of Neutrosophy to analyze problems related to the joint custody of children and adolescents after marriage* dissolution: Infinite Study, 2019.

[4] A. Baude, S. Drapeau, V. Lachance, and H. Ivers, "Adjustment of children in joint custody and associated variables: A systematic review," *Journal of child custody,* vol. 16, pp. 313-338, 2019.

[5] M. V. Greiner, A. Duncan, K. Nause, K. Flinchum, and S. J. Beal, "Child welfare experiences with automated medical data sharing for children in protective custody," *Children and Youth Services Review,* vol. 136, p. 106453, 2022.

[6] L. Canzutti, "(Co-) Producing liminality: Cambodia and Vietnam's 'shared custody'of the Vietnamese diaspora in Cambodia," *Political Geography,* vol. 71, pp. 26-35, 2019.

[7] M. Ortega-Gaspar, A. Moreno-Mínguez, and A. López-Narbona, "Impact of Joint Physical Custody and Best Interest of the Child: Reflections from a Critical Review of Empirical Studies," *Journal of Divorce & Remarriage,* vol. 63, pp. 101-119, 2022.

[8] S. A. Brocker and L. Augustijn, "Adolescent self-esteem, parent-child relationships, and joint physical custody," Journal of Family Trauma, Child Custody & Child Development, pp. 1-19, 2022.

[9] A. Steinbach, "Children's and parents' well-being in joint physical custody: A literature review," Family Process, vol. 58, pp. 353-369, 2019.

[10] J. Turunen, A. Norell-Clarke, and C. Hagquist, "How do children and adolescents of separated parents sleep? An investigation of custody arrangements, sleep habits, sleep problems, and sleep duration in Sweden," Sleep Health, vol. 7, pp. 716-722, 2021.

[11] A. T. O'Neill, K. Bussey, C. J. Lennings, and K. M. Seidler, "The views of psychologists, lawyers, and judges on key components and the quality of child custody evaluations in Australia," Family Court Review, vol. 56, pp. 64-78, 2018.

[12] A. M. Caulley, "Equal Isn't Always Equitable: Reforming the Use of Joint Custody Presumptions in Judicial Child Custody Determinations," BU Pub. Int. LJ, vol. 27, p. 403, 2018.

[13] L. Merla and B. Nobels, "Children negotiating their place through space in multi-local, joint physical custody arrangements," in Families in Motion: Ebbing and Flowing Through Space and Time, ed: Emerald Publishing Limited, 2019.

[14] R. a. M. Hernández-Sampieri, C., Investigation methodology. The quantitative, qualitative and mixed routes. México: Editorial Mc Graw Hill Education, 2018.

[15] M. Žižović, B. Miljković, and D. Marinković, "Objective methods for determining criteria weight coefficients: A modification of the CRITIC method," *Decision Making: Applications in Management and Engineering,* vol. 3, pp. 149-161, 2020.

[16] S. Wang, G. Wei, J. Lu, J. Wu, C. Wei, and X. Chen, "GRP and CRITIC method for probabilistic uncertain linguistic MAGDM and its application to site selection of hospital constructions," *Soft Computing* vol. 26, pp. 237-251, 2022.
[17] S. E. Bonilla Veloz & M. Y. M. Y. Muñoz Medina. "Diseño de dieta para el tratamiento de enfermedades mentales en Ambato". Universidad y Sociedad, vol. 14 no. S2, pp 285-289, 2022.
[18] D. M. Sandoval Malquín & D. M. Sandoval Pozo. "El Cuadro de Mando Integral como herramienta de planificación financiera para la Compañía de Transporte de Carga Contrancarchi SA". Universidad y Sociedad, vol. 14 no. S2, pp 277-284, 2022.
[19] D. M. Sandoval Malquín & D. M. Sandoval Pozo. "Estrategias financieras en tiempo de crisis para las Pymes de la ciudad de Tulcán". Universidad y Sociedad, vol. 14 no. S2, pp 268-276, 2022.
[20] J. A. Viteri Rodríguez, G. C. Romero Paredes & E. S. Cocha Chicaiza. "Uso de ordenadores electrónicos como factor predisponente para el desarrollo de astenopia". Universidad y Sociedad, vol. 14 no. S2, pp 259-267, 2022.
[21] Y. Rodriguez Cuéllar & L. N. Espinoza Pire. "Las manifestaciones bucales en pacientes adultos con asma y su manejo odontológico". Universidad y Sociedad, vol. 14 no. S2, pp 252-258, 2022.
[22] D. Peña Suárez, N.D. Silva Álvarez & G. R. Navas Espín. "Análisis de la cartera vencida y su incidencia en la liquidez del Banco Pichincha en Puyo". Universidad y Sociedad, vol. 14 no. S2, pp 244-251, 2022.
[23] D. Peña Suárez, N.D. Silva Álvarez & G. R. Navas Espín. "La auditoría y su incidencia en la gestión de la calidad en los procesos de elaboración de confites y snacks". Universidad y Sociedad, vol. 14 no. S2, pp 237-243, 2022.
[24] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[25] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.
[26] von Feigenblatt, O. F., Pardo, P., & Cooper, M. "Sufficiency Economy Philosophy (SEP): Thailand's Emic Approach to Governance and Development as Evidence of an Asian-value Oriented Inclusive Leadership Management Philosophy". Journal of Asia Pacific Studies, vol. 6. No. 2, pp 289-300, 2021.
[27] von Feigenblatt, O., Pardo, P., & Cooper, M. "The "Bad Students" Movement and Human Rights in Contemporary Thailand". Ciencias Sociales y Económicas, vol. 5 no. 1, pp 156-176, 2021.
[28] von Feigenblatt, OF, Pardo, P. & Cooper, M. "Corporativismo y autoritarismo benévolo: antídotos viables contra el populismo". Revista de perspectivas alternativas en las ciencias sociales. Vol. 11 no. 1, pp 95-98, 2021.
[29] Von Feigenblatt, O. F. "Honor, Loyalty, and Merit: The Cultura Contemporary of the Spanish Nobility". Ediciones Octaedro, 2022.

Received: August 02, 2022. **Accepted:** October 03, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Application of Compensatory Fuzzy Logic to a Legal Analysis of Abandonment of Causes

Alex Fabián Solano Moreno[1], Alipio Absalon Cadena Posso[2], Danilo Rafael Andrade Santamaría[3], And Yanhet Lucía Valverde Torres[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.alexsolano@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.alipiocadena@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. E-mail: up.daniloandrade@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.yanhetvalverde@uniandes.edu.ec

Abstract. The Constitution of Ecuador designs a Constitutional State of rights and justice in which the maximum duty of the State is to respect and enforce respect for human rights. The rights to formal and material equality are guaranteed, so that the rights may be exercised, promoted, and demanded individually or collectively before the competent authorities. When a process is declared abandoned, these civil rights are violated. There are numerous reasons to declare a process abandoned. The present investigation was given the task of investigating these reasons, which were found through consultation with experts and the application of Compensatory Fuzzy Logic. From the analysis of the results, a solution proposal was derived to improve the satisfaction of the population in this regard which was processed by the TOPSIS method.

Keywords: abandonment of causes, Compensatory Fuzzy Logic, TOPSIS, solution strategies.

1 Introduction

The Ecuadorian civil procedural rule has an extensive historical background, but its origin was based on the guidelines of the Spanish monarchy, giving the process the characteristics of parsimonious, written, and solemn; in 1863 the Code of Civil Procedure was issued for the first time, which was replaced by the Code of Civil Procedure of 1938. After this, there were some reforms but from the end of the dictatorship in the years of 1976. Ecuador had a great change in its political structure since at last, the winds of democracy arrived in the country that allowed the constituent power to be the one to elect its president, with this new stage of democratic governments that were ruling the country it was also accompanied by the birth of new laws and reforms in other legal bodies [1].

The institution of abandonment in our country has undergone some variations over time and procedural reforms, which is why our repealed Code of Civil Procedure of the year 1987 was established, among other details, and according to the last reform that this same code underwent in 2005, the institution of abandonment came to establish eighteen months counted from the last diligence carried out in the trial, or from the last petition or claim. For a century and a half, this procedural rule remained in force, which was characterized by being a slow, formal, and bureaucratic model that produced a great breakdown in our civil legal system, for which a radical change was imminent both in its structure and in users and legal professionals [2].

The declaration of abandonment of processes when referring to its first characteristic indicates that a judicial process begins from the moment the claim is filed with the competent judicial unit. It must be promoted by the parties, otherwise, the same regulations establish the term for it to be archived. The second characteristic mentioned in previous lines establishes that the judge is the authority that must be aware of which causes are being promoted and which are not so that in this way he can make the corresponding calculation of the time in which the process remained static and declare its abandonment. Even the defendant can request the judge in writing to declare the abandonment and file the process because it has remained without processing for more than eighty days; finally, the third characteristic mentions that once the cause is declared abandoned, the plaintiff will not be able to file a new lawsuit on the same action that was intended in the filed process [3, 4].

Legal effects of abandonment according to the General Organic Code of Processes [1, 5]

By declaring the abandonment of cases by the administrators of justice, legal consequences are produced that, directly, end up affecting the rights and interests of the person who went before the judicial bodies to have a right restored or recognized. Once the declaration of abandonment proceeds, the plaintiff will not be able to propose a

new claim on the same fact, object and person, as determined in article 249, second paragraph of the General Organic Code of Processes (hereinafter COGEP).

With the aforementioned regulations, not only is the free access to justice being limited to citizens or individuals but, in turn, it is violating other Constitutional rights, such as, for example, property rights and the rights of the obligations to give or do. Additionally, constitutional principles such as; effective judicial protection, legal certainty, and the right to equality.

Every judicial process is initiated solely with the purpose that the interested person receives from the Judges the reason or the denial of the facts that are claimed in their claim. That is why in this new procedural system that is applied in Ecuador, the sentences or resolutions are issued orally in the same Hearing, with the declaration of abandonment, due to the failure to appear at the Hearing as established in article 87, number 1 of the COGEP, violates the rights of the procedural parties and that is why the Constitution establishes it in its Article 168, number 6.

It can be stated that the declaration of abandonment of causes is a way of terminating a judicial process. The inconvenience arises at the time of considering the limitation of access to justice through a new one so that the right is recognized, which entails a serious legal consequence, at the time of declaring the abandonment of the case due to the failure to appear at the hearing by the actor. The abandonment of a process does not provide a solution to a dispute, does not provide a solution to the conflict, nor does it recognize or restore a right, even though this declaration takes the form of res judicata.

When analyzing in light of the constitutional norm and comparative law the legal effects caused by the declaration of the abandonment of causes according to the COGEP. This legal body directs the procedures that must be followed in the trials to solve the legal conflicts that occur between civilians, in relation to the abandonment of causes, in chapter V, of articles 245, 246, 247, and 248, it is determined that the abandonment of causes proceeds when the extra parties cease to pursue the same during the term of eighty days, counted from the date of the last ruling. In addition, one of the most drastic legal effects that this declaration of abandonment, made by the judge, produces is that a new claim cannot be filed, in the case of the first instance.

The understanding of the procedural details and basic concepts to take into account regarding the abandonment of the causes and as well as its effects typified in the General Organic Code of Processes. Since today certain constitutional principles are violated such as:

- Effective judicial protection: Effective judicial protection is found as a right of protection in article 75 of the Constitution of the Republic which says: that every person has the right to free access to justice and effective, impartial, and expeditious protection of their rights and interests, subject to the principles of immediacy and speed; in no case will he be helpless. Failure to comply with judicial resolutions will be sanctioned by law.
- Legal security: it is the protection and confidence that the State will respect all the rights of its citizens, the right to freedom, private property, freedom of expression, and due process, among others, precisely because of the existence of a Prior public norm that imposes, allows or prohibits, and to which not only must the public power adapt its action, but must also inexorably apply it.
- Equality of rights: When citing the legal modalities of the principle of equality, it says that there are four; the first, the principle of equality in the strict sense, being considered as a value or principle, citing, as manifest from the innumerable examples that could be given, the declarations of Human Rights and the various International Treaties.
- Right to Access to Justice: Access to Justice is equal opportunities that people have to access formal and informal legal resources that generate, apply or interpret laws and normative regulations with a special impact on the social and economic well-being of people. Access to Justice is a fundamental and conditional human right of the Constitutional State of Rights so that all citizens can know and exercise their rights and obligations without any discrimination, ensuring that their legal disputes are treated and resolved in an effective and timely manner.

The present investigation defined the research problem: What are the factors or reasons that frequently lead to the abandonment of causes? To answer the question posed, the following research objectives were planned:

1) Determine what are the frequent reasons for abandoning cases
2) State the results and process them

Propose alternative solutions to the issue to improve the state of satisfaction of the population with respect to legal processes.

2 Methods

In the investigation, a mixed modality was utilized, with the use of qualitative and quantitative methodology. It was developed under the descriptive model, trying to illustrate the phenomenon analyzed from different positions.

Theoretical methods such as Analytical-Synthetic were used: the one that allowed to inspect documents and establish conclusions regarding the subject of study. In addition, the Inductive-Deductive method was also applied: this research method allows for logical reasoning. While the inductive method starts from specific premises to reach general aspects, the deductive method is the opposite, since it starts from the generic until reaching the particular aspects. However, both methods are essential in the construction of knowledge. The empirical methods used were the survey, applied to the selected sample of law professionals. For the selection of the sample to be used, the following operation was carried out:

Sample:

$$n = \frac{Z^2 pqN}{E^2(N-1)+Z^2 pq} \quad (1)$$

Information processing methods

Compensatory fuzzy logic (CFL): was created by the multidisciplinary scientific group Business Management in Uncertainty: Research and Services (GEMINIS) of the José Antonio Echeverría Higher Polytechnic Institute (ISPJAE), in Havana, Cuba. Dr. Rafael Espín Andrade, a full professor of the ISPJAE, is one of its most representative leaders. CFL constitutes a branch of Fuzzy Logic. It is a new multivalent system that breaks with the traditional axiomatics of this type of system to achieve semantically better behavior than classical systems [6-9].

In processes that require decision-making, the exchange with experts leads to obtaining complex and subtle formulations that require compound predicates. The truth values obtained on these composite predicates must be sensitive to changes in the truth values of the basic predicates. This need is satisfied with the use of the CFL, which renounces compliance with the classical properties of conjunction and disjunction, opposing these with the idea that the increase or decrease in the value of the conjunction or the disjunction caused by the change in the truth value of one of its components, can be "compensated" with the corresponding decrease or increase in the other. An increase or decrease in the truth value of the conjunction or disjunction as a result of a change in the truth value of one component may be offset by the increase or decrease in another component. This notion makes CFL a sensible logic [6-9].

In essence, a predicate is a function of the universe X on the interval [0,1], and the operations of conjunction, disjunction, negation, and implication are defined in such a way that being restricted to the domain (0,1) [10] Boolean Logic is obtained. They, along with other operators, guarantee the effective combination of intangible elements valued through experts considering categorical scales of veracity, with quantitative information, which provides truth values through conveniently defined predicates based on such information. [24, 25]

The predicates can be represented in different ways, one of them is trees. For example, a predicate can be represented using a general tree (to avoid associativity) where each node can be an operator. This variant is being implemented due to its recursive and potentially descriptive character. [26, 27, 28, 29] The formulation of a predicate can be as follows: if it is an element *X*, to meet condition A, it must first meet requirements B and C, then the definition of simple predicates will be:

1. *EB(x):* Element *X* meets requirement B.

2. EC*(x):* element *X* meets requirement C.

Then the compound predicate is defined as:

A(x): element *X* satisfies condition A.

The translation of this predicate into calculus language is $A(x) = EB(x) \wedge EC(x)$. The CFL is formed by a quartet of continuous operators: conjunction (c), disjunction (d), fuzzy strict order (o), and negation (n), the first two go from [0,1] to n in [0,1], o goes from [0,1] 2 to [0,1] and n from [0,1] to [0,1], which satisfy the following axioms:

1. Min $(x_1, x_2, \dots, x_n) \leq c(x_1, x_2, \dots, x_n) \leq \max(x_1, x_2, \dots, x_n)$(Compesation Axiom)
2. $c(x_1, x_2, \dots, x_i, \dots, x_j, \dots, x_n) = c(x_1, x_2, \dots, x_i, \dots, x_j, \dots, x_n)$(Axiom of Commutativity or Symmetry)
3. If $x_1 = y_1, x_2 = y_2, \dots, x_{i-1} = y_{i-1}, x_{i+1} = y_{i+1}, \dots, x_n = y_n$, such that neither is zero, $yx_i > y_i$, then $c(x_1, x_2, \dots, x_n) > c(y_1, y_2, \dots, y_n)$ (Strict Growth Axiom)
4. If $x_1 = 0$ for some *i,* then $c(x_1, x_2, \dots, x_n) = 0$ (Veto´s Axiom)
5. If $o(x, y) \geq 0.5$ and $i(y, z) \geq 0.5$, then $o(x, z) \geq \max\{o(x, y), o(y, z)\}$ (Axiom of Transitivity Diffuse).
6. $n(c(x_1, x_2, \dots, x_n)) = d(n(x_1), n(x_2), \dots, n(x_n)).n(d(x_1, x_2, \dots, x_n)) = c(n(c(x_1), n(x_2), \dots, n(x_n))$ (De Morgan´s Laws)

From the axioms proposed above, we have the following properties:

1. Min $(x_1, x_2, \dots, x_n) \leq d(x_1, x_2, \dots, x_n) \leq \max(x_1, x_2, \dots, x_n)$(Compesation Property)
2. $d(x_1, x_2, \dots, x_i, \dots, x_j, \dots, x_n) = d(x_1, x_2, \dots, x_i, \dots, x_j, \dots, x_n)$ (Property of Commutativity or Symmetry
3. If $x_1 = y_1, x_2 = y_2, \dots, x_{i-1} = y_{i-1}, x_{i+1} = y_{i+1}, \dots, x_n = y_n$, such that neither is zero y$x_i > y_i$, then $d(x_1, x_2, \dots, x_n) > d(y_1, y_2, \dots, y_n)$ (Strict Growth Property)
4. If $x_1 = 1$ for some *I,* then $d(x_1, x_2, \dots, x_n) = 1$ (Veto Ownership)
5. $c(x_1, x_2, \dots, x_n) = d(x_1, x_2, \dots, x_n) = x$ (Idempotency Property)

The use of sigmoidal membership functions for increasing or decreasing functions is recommended for modeling vagueness. This is also achieved through linguistic variables, which allows for taking advantage of the knowledge of the experts. These linguistic variables are based on scales such as the one shown in Table 1.

Truth value	Category
0	Fake
0.1	Almost fake
0.2	Pretty fake
0.3	Something fake
0.4	More false than true
0.5	As true as false
0.6	More true than false
0.7	Something real
0.8	True enough
0.9	Almost true
1	Real

Table 1: Scales of linguistic variables. Source: [9]

Considering that CFL can take any truth value within a set of values that oscillate between two extremes, absolute truth, and total falsity. This tool allows us to represent a management model through a non-linear mathematical model, which the authors of this research consider that it is of great importance.

TOPSIS method

The TOPSIS method is a compensatory strategy method, which allows the ordering of a finite set of decision alternatives. Yoon and Hwang developed the TOPSIS method based on the concept that a given alternative should be located the shortest distance from a positive (ideal) ideal solution and the greatest distance from a negative ideal solution (anti-ideal) [11, 12, 17, 18]. TOPSIS defines an index called Similarity (or relative proximity) to the ideal solution by combining the proximity to the ideal solution and the distance from the anti-ideal solution [13, 14, 19, 20]. The alternative that is located as close as possible to the maximum similarity to the positive ideal solution is selected. It can assume values between 0 and 1: if the alternative is closer to the ideal point, it will be closer to 1, on the contrary, if it is closer to the anti-ideal point, its value will be closer to 0. For the methodology of the technique see [15, 21, 22, 23].

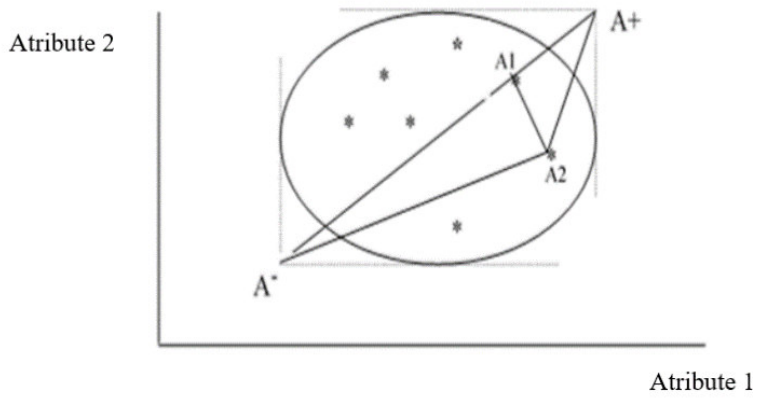


Figure 1: Euclidean distance to the ideal and anti-ideal in a two-dimensional space. Source: [16].

3 Results and Discussion

For the analysis of the possible reasons that lead to the abandonment of causes, the present case study was carried out, for which documents that could provide significant data were reviewed. In addition, an interview was carried out and brainstorming was carried out with a group of lawyers and judges, to corroborate the information consulted. It was evaluated from a qualitative point of view. Among the causes found, the following could be cited:

1. Processes canceled for a term of 18 months
2. Priority to other judicial processes
3. Lack of the actor's technical defender to the audiences
4. Lack of commitment to the work to be done
5. Difficulty in following up on demand
6. Failure to attend the hearing due to the Covid 19 quarantine
7. Failure to pursue the parties
8. Failure to appear
9. Lack of resources to solve the process

The sample consisted of 25 legal professionals, for the selection of the sample the following criteria were taken:

1. That the professionals that integrate it have actively participated in legal processes of Abandonment of Causes
2. Have more than 5 years of experience in cases of this type
3. They were asked to express criteria based on the experience of the last year of work (2021)

Application of Compensatory Fuzzy Logic

For the analysis of the causes that lead to the abandonment of causes, it was found in the bibliography consulted, possible causes that at different levels influence the process, then the following steps were carried out:

1. Analyze by applying Compensatory Fuzzy Logic:

    a) Statement of simple and compound predicates

    b) Development of the decision tree

    c) Calculus of simple and compound predicates

    d) Determination of the state through linguistic terms.

The results are shown below:

Simple and compound predicates	Calculation expressions
Abandonment of Causes	$\boldsymbol{CA(X) = IL(X) \wedge EL(X)}$
Internal level	$IL(X) = JLc_{1-4}(X)$
External level	$EL(X) = Dc_{1-3}(X) \wedge Ac_{1-2}(X)$
Judges and Lawyers causes	$JLc_{1-4}(X) = JLc_1(X) \wedge JLc_2(X) \wedge JLc_3(X) \wedge JLc_4(X)$
Plaintiff Causes	$Dc_{1-3}(X) = Dc(X) \wedge Dc_2(X) \wedge Dc_3(X)$
Defendant causes	$Ac_{1-2}(X) = Ac_1(X) \wedge Ac_2(X)$
$\boldsymbol{JLc_1(X)}$	Processes canceled for a term of 18 months
$\boldsymbol{JLc_2(X)}$	Priority to other judicial processes
$\boldsymbol{JLc_3(X)}$	Lack of the actor's technical defender to the audiences
$\boldsymbol{JLc_4(X)}$	Lack of commitment to the work to be done
$\boldsymbol{Dc_1(X)}$	Difficulty in following up on demand
$\boldsymbol{Dc_2(X)}$	Failure to attend the hearing due to the Covid 19 quarantine
$\boldsymbol{Dc_3(X)}$	Failure to pursue the parties
$\boldsymbol{Ac_1(X)}$	Failure to appear
$\boldsymbol{Ac_2(X)}$	Lack of resources to solve the process

Table 2: Predicates and calculation expressions. Source: own elaboration

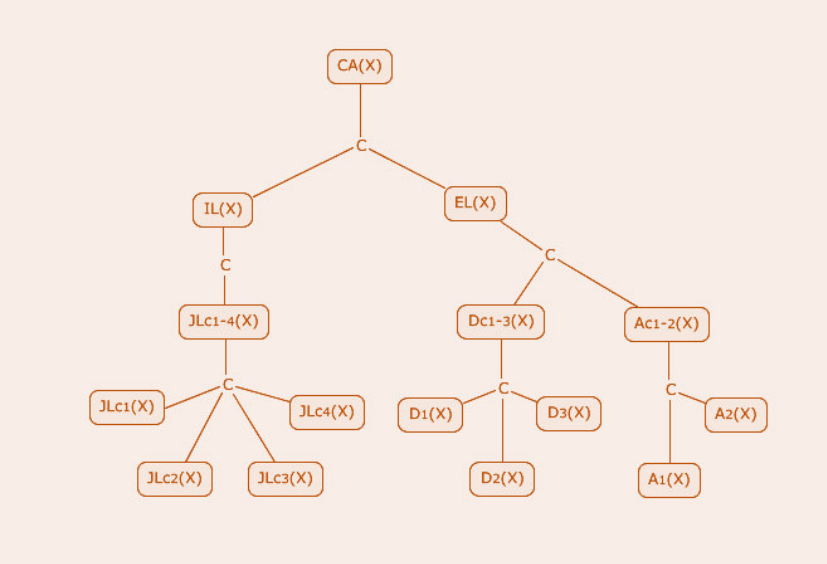


Figure 2: Tree of predicates. Source: own elaboration

Next, the calculation of the predicates by groups of experts using the scales in Table 1 and the mathematical operators in Table 2:

Simple predicates	E1	E 2	E 3	E4	E5	E6	E7
$JLc_1(X)$	0.5	0.4	0.6	0.4	0.5	0.4	0.4
$JLc_2(X)$	0.5	0.5	0.6	0.5	0.5	0.6	0.6
$JLc_3(X)$	0.5	0.5	0.6	0.4	0.5	0.5	0.5
$JLc_4(X)$	0.5	0.4	0.6	0.6	0.4	0.4	0.4
$Dc_1(X)$	0.5	0.4	0.6	0.6	0.5	0.4	0.4
$Dc_2(X)$	0.9	0.7	0.9	0.7	0.9	0.7	0.7
$Dc_3(X)$	0.9	0.7	0.9	0.7	0.9	0.7	0.8
$Ac_1(X)$	0.9	0.7	0.9	0.7	0.9	0.6	0.7
$Ac_2(X)$	0.9	0.7	0.9	0.7	0.9	0.7	0.7

Table 3: Assessment of the Group 1 experts. Source: own elaboration

Simple predicates	E1	E 2	E 3	E4	E5	E6	E7
$JLc_1(X)$	0.4	0.9	0.3	0.9	0.2	0.5	0.5
$JLc_2(X)$	0.9	0.5	0.6	0.5	0.9	0.8	0.9
$JLc_3(X)$	0.6	0.5	0.6	0.4	0.5	0.5	0.5
$JLc_4(X)$	0.9	0.7	0.6	0.9	0.4	0.4	0.9
$Dc_1(X)$	0.9	0.9	0.6	0.7	0.9	0.5	0.4
$Dc_2(X)$	0.4	0.7	0.4	0.7	0.9	0.4	0.5
$Dc_3(X)$	0.5	0.5	0.9	0.8	0.8	0.7	0.5
$Ac_1(X)$	0.9	0.7	0.6	0.7	0.9	0.6	0.7
$Ac_2(X)$	0.9	0.7	0.9	0.7	0.9	0.7	0.7

Table 4: Evaluation of the Group 2 experts. Source: own elaboration

Simple predicates	E1	E 2	E 3	E4	E5	E6	E7
$JLc_1(X)$	0.5	0.5	0.6	0.5	0.7	0.6	0.6
$JLc_2(X)$	0.7	0.3	0.5	0.5	0.6	0.4	0.5
$JLc_3(X)$	0.8	0.5	0.5	0.5	0.5	0.5	0.5
$JLc_4(X)$	0.9	0.9	0.8	0.9	0.6	0.5	0.9
$Dc_1(X)$	0.9	0.9	0.9	0.8	0.9	0.6	0.8
$Dc_2(X)$	0.3	0.5	0.4	0.4	0.5	0.4	0.5
$Dc_3(X)$	0.7	0.7	0.5	0.5	0.5	0.7	0.6
$Ac_1(X)$	0.9	0.7	0.6	0.7	0.9	0.6	0.7
$Ac_2(X)$	0.6	0.6	0.8	0.9	0.6	0.6	0.7

Table 5: Assessment of the Group 3 experts. Source: own elaboration

Simple predicates	Mean by groups		
	Group 1	Group 2	Group 3
$JLc_1(X)$	0.457	0.529	0.571
$JLc_2(X)$	0.543	0.729	0.500
$JLc_3(X)$	0.500	0.514	0.543
$JLc_4(X)$	0.471	0.686	0.786
$Dc_1(X)$	0.486	0.700	0.829
$Dc_2(X)$	0.786	0.571	0.429
$Dc_3(X)$	0.800	0.671	0.600
$Ac_1(X)$	0.771	0.729	0.729
$Ac_2(X)$	0.786	0.786	0.686

Table 6: Calculation of the weighted means of the rating of the experts of the 3 groups. Source: own elaboration

SP	Mode	Mean	Truth value	Category
$JLc_1(X)$	0.600	0.519	0.642	More true than false
$JLc_2(X)$	0.633	0.590	0.647	More true than false
$JLc_3(X)$	0.500	0.519	0.504	As true as false
$JLc_4(X)$	0.733	0.647	0.733	Almost true
$Dc_1(X)$	0.733	0.671	0.738	Almost true
$Dc_2(X)$	0.533	0.595	0.538	As true as false
$Dc_3(X)$	0.700	0.690	0.633	More true than false
$Ac_1(X)$	0.766	0.743	0.743	Almost true
$Ac_2(X)$	0.666	0.752	0.752	pretty true

Table 7: Calculation of the predicates according to their truth values. Source: own elaboration

Compound predicates	Truth value
AC(X)	Something real
IL(X)	Pretty true
EL(X)	Almost true
JLc(X)	Pretty true
DC(X)	More true than false
Ac(X)	as true as false

Table 8: Truth values of compound predicates. Source: own elaboration

After obtaining the results of the analysis of causes through the CFL, a solution proposal was made to improve the satisfaction of the population and the quality of the processes. The possible solution alternatives proposed were the following:

1. Provide training to legal professionals so that they can carry out their work more effectively.
2. Apply judicial measures such as fines, or others, to the party causing non-attendance at the hearings.
3. Carry out outreach campaigns on the laws and rights of citizens when establishing a lawsuit, as well as informing about the term of completion of the processes.
4. Frequently encourage legal professionals who comply with their cases on time
5. Increase the number of premises willing to carry out the trials, as well as the offices to process the processes, to guarantee promptness in the services

Which will be evaluated under the following criteria:

1. Quality of services to the population
2. Commitment to the task by judges and lawyers
3. Resource economy

Alternatives/Criteria	Criterion 1	Criterion 2	Criterion 3
Alternative 1	0.249574	0.110000	0.020203
Alternative 2	0.249574	0.066000	0.020203
Alternative 3	0.249574	0.088000	0.020203
Alternative 4	0.415956	0.110000	0.025254
Alternative 5	0.415956	0.110000	0.025254

Table 9: Weighted Normalized Matrix. Source: own elaboration

Alternatives	D+	D-	Ri	Hierarchy order
Alternative 1	0.027683117	0.16638244	0.20914293	3
Alternative 2	0.029619117	0.17210205	1.9614E-06	1
Alternative 3	0.028167117	0.16783062	0.11589279	2
Alternative 4	0	0	1	4
Alternative 5	0	0	1	5

Table 10: Calculation of relative proximity to the ideal solution and order. Source: own elaboration

As a proposed alternative, after consulting experts, the following was left: apply judicial measures such as fines, or others, to the party causing non-attendance at the hearings.

Conclusions

The results obtained made it possible to verify that the experts of the consulted groups agree that most of the simple predicates have a high level of significance and presence within the process of abandoning causes. Therefore, it is necessary to develop actions that can serve as a solution to this problem, and in this way, improve the level of satisfaction of the population regarding the processes of abandonment of causes, guaranteeing the principles of good living.

From the analysis of the compound predicates, it can be concluded that the internal level factors, qualified as quite true, are the ones that fundamentally exert important negative effects in terms of the analysis of the reasons for which the causes are abandoned. Because it is the legal authorities that must take measures in this regard to comply with due process.

Within the solution proposals, to reduce the abandonment of cases, taken to expert consultation, the alternative of applying fines or other measures to people who cause non-attendance at trial was selected. Because this cause was found as one of the possible mitigating factors. In addition to providing training to those involved in legal processes.

References

[1] L. I. Barahona Tapia, M. E. España Herrería, J. M. Macías Bermúdez, and L. M. Ochoa Escobar, "Evaluation of the level of satisfaction with the process of abandonment of causes in two communities of Babahoyo," Conrado, vol. 18, pp. 116-127, 2022.

[2] J. A. Fuentes, "UPDATE: The Basic Structure of the Ecuadorian Legal System and Legal Research," in Global Lex, ed: Hauser Global Law School Program, New York University School of Law, 2021.
[3] M. C. Mungan, "Abandoned criminal attempts : An economic analysis," Alabama Law Review, vol. 67, pp. 1-43, 2015.
[4] J. J. Deborah and G. M. Moncla, "Abandonment: An Evolving Concept of Liberative PrescriptionAbandonment: An Evolving Concept of " *Louisiana Law Review,* vol. 63, pp. 342-379, 2003.
[5] R. González Salas and M. M. Vidal del Río, "Analysis of the abandonment of cases and its legal effects, from the perspective of comparative law, with the use of Diffuse Cognitive Maps," *Revista Universidad y Sociedad,* vol. 13, pp. 114-124, 2021.
[6] R. L. Maldonado Manzano, J. J. Cellán Palacios, and F. M. Estrella Gómez, "Evaluation of the Effectiveness in the National Social Rehabilitation System using Neutrosophy and Compensatory Operators.," *Neutrosophic Sets & Systems,* vol. 44, pp. 299-307, 2021.
[7] E. L. H. Ramos, L. R. A. Ayala, D. F. T. Torres, and R. Gonzalez, "Method for Treatment and its Incidence in the Change of Social Rehabilitation Regime using Neutrosophic Compensatory Logic," *Neutrosophic Sets and Systems,* vol. 37, pp. 381-388, 2020.
[8] P. Y. Jadán-Solís, B. A. Auria-Burgos, M. L. Triana-Palma, C. Y. Mackencie-Álvarez, and F. D. R. Carriel-Paredes, "Compensatory fuzzy logic model for impact assessment when implementing ICT in pedagogical scenarios," *Neutrosophic Sets and Systems,,* vol. 26, pp. 41-48, 2019.
[9] R. A. Espín-Andrade, E. González-Caballero, W. Pedrycz, and E. Fernández, "An Interpretable Logical Theory: The case of Compensatory Fuzzy Logic," *International Journal of Computational Intelligence Systems,,* vol. 9, pp. 612–626, 2016.
[10] M. Abdel-Basset, M. Saleh, A. Gamal, and F. Smarandache, "An approach of TOPSIS technique for developing supplier selection with group decision making under type-2 neutrosophic number," *Applied Soft Computing,* vol. 77, pp. 438-452, 2019.
[11] R. M. Zulqarmer-Farooq, M. Saqlain, and Zaka-ur-Rehman, "The Selection of LASER as Surgical Instrument in Medical using Neutrosophic Soft Set with Generalized Fuzzy TOPSIS, WSM and WPM along with MATLAB Coding," Neutrosophic Sets and Systems,, vol. 40, pp. 29-44, 2021.
[13] M. Saqlain, M. N. Jafar, and M. Riaz, "A New Approach of Neutrosophic Soft Set with Generalized Fuzzy TOPSIS in Application of Smart Phone Selection," Neutrosophic Sets and Systems,, vol. 32, pp. 307-316, 2020.
[14] M. Riaz, K. Naeem, I. Zareef, and D. Afzal, "Neutrosophic N-Soft Sets with TOPSIS method for Multiple Attribute Decision Making," Neutrosophic Sets and Systems,, vol. 32, pp. 146-170, 2020.
[15] S. X. S. Muñoz anain, X. L. Xin, M. Saqlain, F. Smarandache, and M. I. Ahamad, "An integrated model of Neutrosophic TOPSIS with application in Multi-Criteria Decision-Making Problem," *Neutrosophic Sets and Systems,,* vol. 40, pp. 253-269, 2021.
[12] M. Und M. A. Q. Martinez, "A Framework for Selecting Machine Learning Models Using TOPSIS," in *Advances in* Artificial Intelligence, Software and Systems Engineering: Proceedings of the AHFE 2020 Virtual Conferences on Software and Systems Engineering, and Artificial Intelligence and Social Computing, July 16-20, 2020, USA, 2020, p. 119.
[16] M. Y. L. Vazquez, L. A. B. Peñafiel, S. X. S. Muñoz, and M. A. Q. Martinez, "A Framework for Selecting Machine Learning Models Using TOPSIS," in Advances in Intelligent Systems and Computing vol. 1213 AISC, ed, 2021, pp. 119-126.
[17] A R. Soria Acosta & Y. C. Hernández Zambrano. “Intervenciones de enfermería en la encefalopatía hipóxica isquémica aguda por asfixia neonatal”. Universidad y Sociedad, vol. 14 no. S2, pp 230-236, 2022.
[18] L. H. Carrión Hurtado, F. G. Naranjo Armijo & D. X. Lahuasi Palma. “Competitividad en colocación de microcréditos de cooperativas de ahorro y crédito en Santo Domingo”. Universidad y Sociedad, vol. 14 no. S2, pp 222-229, 2022.
[19] M. S. Cuarán Guerrero, B. G. Valle Fiallos & O. J. Torres Merlo. “Tendencias del emprendimiento joven: caso Emprende Joven Ecuador 2021”. Universidad y Sociedad, vol. 14 no. S2, pp 215-221, 2022.
[20] A R. León Yacelga & M. A. Checa Cabrera. “Uso de tableros Kanban como apoyo para el desarrollo de las metodologías ágiles”. Universidad y Sociedad, vol. 14 no. S2, pp 208-214, 2022.
[21] S. B. Gallegos Gallegos. “La imputación objetiva en el delito de tránsito”. Universidad y Sociedad, vol. 14 no. S2, pp 194-200, 2022.
[22] E. M. Arroyo Lalama & L. F. Pérez Solís. “Importancia de la magnificación en endodoncia”. Universidad y Sociedad, vol. 14 no. S2, pp 165-171, 2022.
[23] E. M. Arroyo Lalama. “Utilización del localizador Apical durante la terapia endodóntica por parte de los profesionales de la ciudad de Ambato”. Universidad y Sociedad, vol. 14 no. S2, pp 128-136, 2022
[24] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. “La investigación científica en la educación superior como contribución al modelo educativo”. Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.
[25] Ricardo, J. E. (2018). “Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador”. Infinite Study, 2018.
[26] von Feigenblatt, O. F., Pardo, P., & Cooper, M. “Sufficiency Economy Philosophy (SEP): Thailand's Emic Approach to Governance and Development as Evidence of an Asian-value Oriented Inclusive Leadership Management Philosophy”. Journal of Asia Pacific Studies, vol. 6. No. 2, pp 289-300, 2021.
[27] von Feigenblatt, O., Pardo, P., & Cooper, M. “The “Bad Students” Movement and Human Rights in Contemporary Thailand”. Ciencias Sociales y Económicas, vol. 5 no. 1, pp 156-176, 2021.

[28] von Feigenblatt, OF, Pardo, P. & Cooper, M. "Corporativismo y autoritarismo benévolo: antídotos viables contra el populismo". Revista de perspectivas alternativas en las ciencias sociales. Vol. 11 no. 1, pp 95-98, 2021.
[29] Von Feigenblatt, O. F. "Honor, Loyalty, and Merit: The Cultura Contemporary of the Spanish Nobility". Ediciones Octaedro, 2022.

Received: August 03, 2022. **Accepted:** October 04, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Criminal Protection of Copyright. Analysis from the Work and Professional Experience of its Actors

Rosa Evelyn Chuga Quemac[1], Luis Fernando Piñas Piñas[2], Cynthia Paulina Cisneros Zúñiga[3], and Edison Joselito Naranjo Luzuriaga[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.rosachuga@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.luispinias@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. E-mail: up.cynthiacisneros@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz. Ambato. Ecuador. E-mail: ua.edisonnaranjo@uniandes.edu.ec

Abstract. Attacks on copyright constitute an offense against the personality of the author, a violation of the spiritual heritage of society, or an injury to the decorum and dignity of a country. The issue addressed by this research is a reality that needs further analysis by all institutions involved in the administration of justice. The insufficiencies that exist in the legislation related to the criminal protection of Copyright and Intellectual Property, require a deep analysis of the subject. The objective would be to substantiate the need to have efficient criminal protection of these legal entities in Ecuador. For this, it is convenient to analyze the phenomenon from a practical point of view. In this way, determine their status before the legal spectrum and be able to turn their way of study. It would be a way to eradicate the legal loopholes regarding the subject of higher education. The Torgerson method will then be used through which the criteria of professionals who execute the Law in that sense will be contrasted.

Keywords: Copyright, Intellectual Property, Ecuador, Torgerson.

1 Introduction

In recent years, accelerated technological development has been taking place. This has influenced the emergence of new ways of using artistic works and others derived from the human intellect. Whenever these occur in the legal field, they will be more profitable for the author, the users, and, ultimately, the public. Thus, there would be greater and better access to culture and information.

However, sometimes, the technical and scientific development itself is used to violate the legitimate rights of authors and holders of intellectual rights. Faced with this situation, society must seek the appropriate mechanisms to avoid and repair the damage that the illicit use of works and artistic performances causes to their legitimate owners.

The functions of criminal law refer to the modes of influence of this with respect to social relations. This influence is carried out, mainly, in two ways. On the one hand, it confers particular protection on the system of social relations (protective function). On the other hand, it seeks to promote in all people the observance and development of behaviors adjusted, precisely, to the mentioned system of social relations (motivation function) [1].

Along with other legal systems, Criminal Law fulfills a restorative function of the balance of a social system. Likewise, it complies with the protection of legal assets which, due to their importance, Criminal Law is interested in protecting.

It is not possible to speak of Copyright without first referring to Intellectual Property. Intellectual Property refers to the creations of the mind: inventions, literary and artistic works, as well as symbols, names, and images used in commerce. Copyright is literary and artistic work (novels, poems, plays, movies, musical works, and artistic works such as drawings, paintings, photographs, sculptures, and architectural designs) [2].

Copyright is the branch of law in charge of regulating the subjective rights of the author in relation to his work. Only the form of expression of ideas is protected and not the ideas themselves. Creativity protected by copyright law is creativity in the selection and arrangement of words, musical notes, colors, and shapes. It consists of the set of faculties and rights that are recognized by the author concerning his works [3], [4].

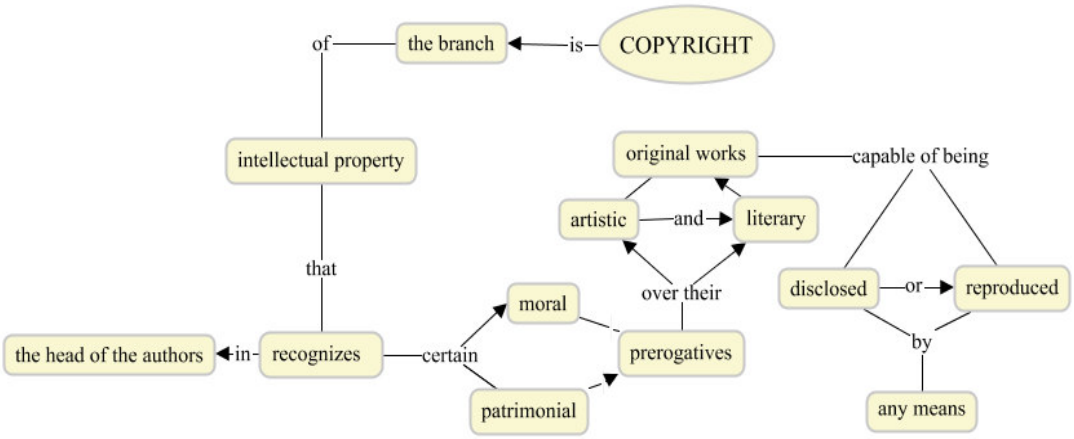


Figure 1: Concept map: Copyright. Note: Own elaboration

From the previous concept, two important concepts of copyright are detached, the subject and its object of protection. [4]–[6].

The author, subject to copyright protection, is the natural person with the intellectual capacity to create a work. He is the one who brings knowledge and characteristics of his personality. In pursuit of obtaining a work that can be perceived and appreciated by its recipients, by any means known or unknown.

The work, as a result of the human intellect, becomes the object of copyright protection, regardless of its literary or artistic value, provided that it meets the requirement of originality. The work must be able to distinguish itself from others that precede it and deal with the same theme. Hence, what is protected is the original form of expression of ideas and not ideas without any form of externalization. Consequently, all own, original creations, whatever their merit or destination, constitute protected works, and for this, the following protection criteria are taken into account [5], [6]:

- Originality: requires its own characteristics that allow it to be identified from other works, as it is the reflection of the imprint and talent of its creator.
- Independence: they are protected regardless of gender, merit or quality, purpose, and form of expression.
- Absence of requirements: it does not require an administrative act to be recognized as protected, but from the moment it is created and is formally expressed, it enjoys the protection granted by copyright.

The author has the right to authorize or prevent with his work:

- Reproduction (make copies)
- Public representation or interpretation
- Broadcasting or other communication to the public
- Translation and adaptation of the work

It is worth noting that the Intellectual Property Law was born to provide the State with adequate protection of intellectual rights and assume their defense, as an essential element for the technological and economic development of the country, based on the principles of universality and international harmonization.

The legal regime in Ecuador is determined, by the Intellectual Property Law in force, it was published in the Official Registry No. 320, on May 19, 1998, and its Regulations were published in the Official Registry No. 120 on February 1 of 1999, where it is established that [7], [8]:

- It is the function of the State to assume the defense of intellectual rights;
- That the protection of the intellectual property is vital for the technological and economic development of the Country, encourages investment in research and development, stimulates national technological production, and gives Ecuador a comparative advantage in the new world economic order;

- That the lack of adequate protection of intellectual property rights restricts free competition and hinders economic growth with respect to the widest range of goods and services that incorporate intangible assets

The Intellectual Property Law of Ecuador [7, 33, 34, 35], clearly specifies the infringement of intellectual property rights and the penalty that such conduct deserves. They are determined in chapter III referring to crimes and penalties, in articles 319, 320, 321, 322, 323, 324, 325, and 326, of that legal body. The objective of this research is to evaluate the effectiveness of the criminal protection provided by Ecuadorian legislation to copyright, analyzed from the point of view of legal professionals. This will serve as a starting point for future modifications of the current legislation, to offer better protection to the intellectual legal asset.

2 Methods

- Analytical-synthetic, and inductive-deductive. To establish the theoretical foundations of this research specifying concepts and theories generally accepted by the doctrine, identifying irregularities and trends on the subject under investigation.
- Exegetical-legal. To establish a characterization of the fundamental deficiencies of the norms that regulate the criminal protection of copyright

2.1 Instruments and techniques

A selection of legal professionals was chosen from professors, judges, and lawyers. For the calculation of the study sample, equation 1 was used. A sample of 111 people was chosen from a total population of 180 professionals, including professors from the same career, judges, and lawyers, as shown in Figure 1.

$$n = \frac{Z^2 pqN}{E^2(N-1) + Z^2 pq} \tag{1}$$

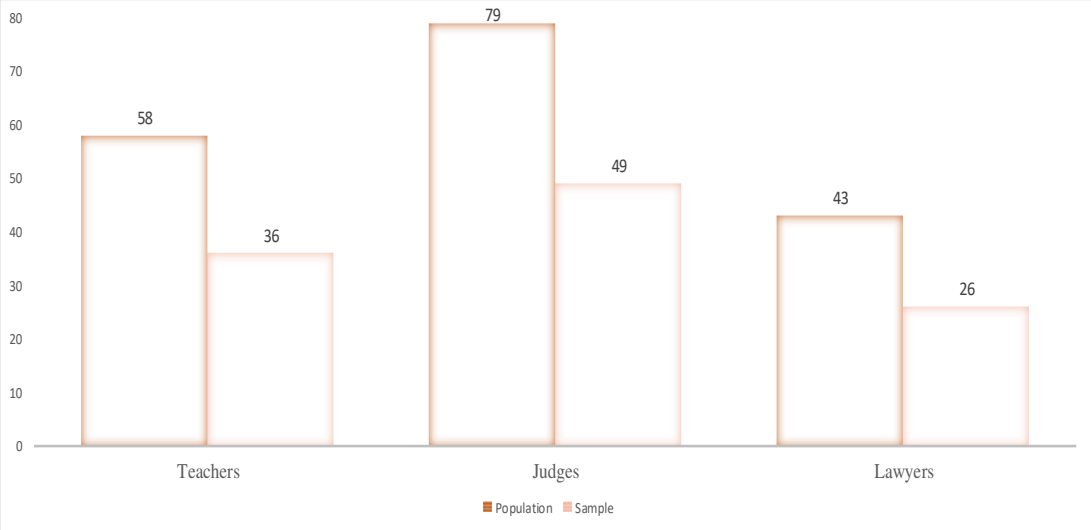


Figure 2: Description of the sample. Source: Own elaboration.

Torgerson's mathematical model [9]. Which objectivity is given to the criteria of the experts or other personnel surveyed, by converting the ordinal scale into an interval scale. This is given because the scales used for the judgments and criteria valued by the experts are ordinal, that is, they can be used to rank (eg, Indispensable, Very Useful, Useful, not useful, etc.) qualitative parameters [10]–[13]-[24]-[25]-[36]-[37]-[38]. The model is based on the following assumptions:

1. Each item corresponds to the subjective dimension of a normally distributed random variable, whose mean, m, is the scale value of that object. All variances are equal.

2. Each category limit corresponds to the subjective dimension of a normally distributed random variable, whose mean, t, is the scale value of that limit. All variables are the same.

3. The random variables that represent both the objects and the limits are independent. One variable cannot contain the values of another.

4. Decision rule: an object belongs to the kth category when its scale value x, is between the values of the order limits k-1 and k. This rule defines the border between each of the categories assumed for the indicators.

In this way, with the model, ordinal judgments, issued by experts, are converted into an instrument that expresses their relative position in a continuous range. [14]–[16]-[20]-[21]-[23]. In other words, it allows taking the ordinal scales to an interval scale (real numbers) and in this way knowing the limits, in real values, in which each evaluated category is found. The procedure to follow will be:

1. Frequency table: the indicators to be measured and the measurement scales established. The data is tabulated according to the frequency and its weighting.
2. Cumulative frequencies: each indicator's cumulative frequency is determined. That is the sum of the frequencies before it.

$$F_i = f_1 + f_2 + f_3 + \cdots + f_m \tag{2}$$

3. Cumulative relative frequency or cumulative probability: it is obtained by dividing the absolute frequency fi by the total data (M). That is, the cumulative probability matrix is determined with four decimal figures, which results from dividing each cumulative by the sample number.

$$F_i = \frac{f_1}{M} \tag{3}$$

4. Calculation of the cut-off points and scale of the indicators:
   a) Determine the inverse standard normal distribution values for each indicator and evaluation using the INV.NORM function in a Microsoft Excel sheet.
   b) For the cut-off points, the results of these previous values will be averaged for each one.
   c) For the scales, determine the limit value (N): average of the cut-off points, which is why some authors call it the average of the average. Calculate the average by indicators (rows).

To determine in which category each one of the indicators is found, the limit value N (average) is subtracted from the average of the evaluations obtained in each indicator, and in this way, its result can be compared with the cut-off points. In such a way that, if the calculated value is less than or equal to the cut-off point, then the analyzed indicator belongs to this interval. [17]–[19]-[26]-[27]-[28]-[29].

5. Determination of the level of consensus: the level of consensus (C) is determined by the expression:

$$C = \left[1 - \left(\frac{V_n}{V_t}\right)\right] * 100 \tag{4}$$

Where C: agreement coefficient, Vn: negative votes, and Vt: total votes

Decision rule: Yes C>75%, it is considered that there is consensus.

6. Conclusions: it is decided which indicator, variable, or measure is important, influential, or preferable for the study.

The indicators were established according to the criteria:

- Very Effective (VE)
- Effective (E)
- Indefinite (I)
- Low effective (LE)
- Ineffective (IN)

For the selection of the group of experts, a competency validation survey was applied where it is carried out through self-assessments, on an ascending scale from 1 to 10:

- Degree of knowledge that the potential expert possesses about the subject
- Degree of influence that each of the sources of argumentation

The processing of the form was based on the calculation of the rating factor of the experts through the following mathematical expression:

$$K = \frac{FA + GC}{2} = \frac{\left(\frac{SI + EP + IR + FB}{4} + GC\right)}{2} \quad (5)$$

Where:

Si= Intuition

PS= Practical experience

IR= Research conducted by you

FB= Consultation of bibliographic sources

CG: Degree of knowledge (1-10).

3 Results

To empirically evaluate the effectiveness criterion of the penalty for crimes against intellectual property, the Torgerson method was applied, with the classifications of Very Effective (VE), Effective (E), Indeterminate (I), Low Effective (LE), and, Ineffective (IN), obtaining the following results. They are shown below. [30], [31], [32]

The study and surveys were carried out based on the criteria of the importance that a future modification of the penalties for crimes committed against intellectual property rights may have. For this reason, the criterion of the three sample groups was studied. In this sense, professors, lawyers, and judges contributed their criteria regarding the effectiveness of each of the punitive actions endorsed in articles 319 to 326 of the Ecuadorian Intellectual Property Law. In short, if these legal pronouncements meet the punitive and social re-educational objective for which they were designed.

EIP Articles	VE	E	I	LE	IN	TOTAL
Article 319	5	9	6	12	4	36
Article 320	3	11	4	16	2	36
Article 321	9	9	8	4	6	36
Article 322	3	8	7	15	3	36
Article 323	6	10	9	11	0	36
Article 324	3	9	5	11	8	36
Article 325	2	13	7	14	0	36
Article 326	1	13	3	13	6	36

Table 1: Frequency established according to the criteria of teachers. Source: own elaboration

EIP Articles	5	4	3	2	1
Article 319	5	14	20	32	36
Article 320	3	14	18	3. 4	36
Article 321	9	18	26	30	36
Article 322	3	11	18	33	36
Article 323	6	16	25	36	36
Article 324	3	12	17	28	36
Article 325	2	15	22	36	36
Article 326	1	14	17	30	36

Table 2: Accumulated frequency. Source: own elaboration

EIP Articles	5	4	3	2	1
Article 319	0.1389	0.3889	0.5556	0.8889	1,0000
Article 320	0.0833	0.3889	0.5000	0.9444	1,0000
Article 321	0.2500	0.5000	0.7222	0.8333	1,0000
Article 322	0.0833	0.3056	0.5000	0.9167	1,0000
Article 323	0.1667	0.4444	0.6944	1,0000	1,0000
Article 324	0.0833	0.3333	0.4722	0.7778	1,0000
Article 325	0.0556	0.4167	0.6111	1,0000	1,0000
Article 326	0.0278	0.3889	0.4722	0.8333	1,0000

Table 3: Relative frequency, cumulative probability. Source: own elaboration

EIP Articles	5	4	3	2	1	Average	N- Avg.
Article 319	-1.09	-0.28	0.14	1.22	3.50	0.70	**0.07**
Article 320	-1.38	-0.28	0.00	1.59	3.50	0.69	**0.08**
Article 321	-0.67	0.00	0.59	0.97	3.50	0.88	**-0.11**
Article 322	-1.38	-0.51	0.00	1.38	3.50	0.60	**0.17**
Article 323	-0.97	-0.14	0.51	3.50	3.50	1.28	**-0.51**
Article 324	-1.38	-0.43	-0.07	0.76	3.50	0.48	**0.29**
Article 325	-1.59	-0.21	0.28	3.50	3.50	1.10	**-0.33**
Article 326	-1.91	-0.28	-0.07	0.97	3.50	0.44	**0.33**
Cut-off points	**-1.30**	**-0.27**	**0.17**	**1.74**	**3.50**	**N = 0.77**	

Table 4: Calculation of cut-off points and scale of the indicators. Source: own elaboration

EIP Articles	VE	E	I	LE	IN	Total
Article 319	3	4	15	23	4	49
Article 320	7	12	9	13	8	49
Article 321	7	21	4	11	6	49
Article 322	3	14	9	15	8	49
Article 323	8	23	3	14	1	49
Article 324	7	18	7	10	7	49
Article 325	11	13	9	9	7	49
Article 326	3	16	9	19	2	49

Table 5: Frequency established according to the criteria of the judges

EIP Articles	5	4	3	2	1	Mean	N- Avg.
Article 319	-1.54	-1.07	-0.13	1.39	3.50	0.43	0.31
Article 320	-1.07	-0.29	0.18	0.98	3.50	0.66	0.08
Article 321	-1.07	0.18	0.39	1.16	3.50	0.83	-0.09
Article 322	-1.54	-0.39	0.08	0.98	3.50	0.53	0.21
Article 323	-0.98	0.34	0.51	2.05	3.50	1.08	-0.34
Article 324	-1.07	0.03	0.39	1.07	3.50	0.78	-0.04
Article 325	-0.76	-0.03	0.45	1.07	3.50	0.85	-0.11
Article 326	-1.54	-0.29	0.18	1.74	3.50	0.72	0.02
Cut-off points	-1.20	-0.19	0.26	1.31	3.50	N=0.74	

Table 6: Calculation of cut-off points and scale of the indicators. Source: own elaboration

EIP Articles	VE	E	I	LE	IN	TOTAL
Article 319	2	3	7	8	6	26
Article 320	2	4	5	9	6	26
Article 321	1	9	8	7	1	26
Article 322	4	5	5	10	2	26
Article 323	1	7	2	12	4	26
Article 324	8	9	2	2	5	26
Article 325	6	6	6	7	1	26
Article 326	7	8	1	8	2	26

Table 7: Frequency established according to the criteria of lawyers. Source: own elaboration

EIP Articles	5	4	3	2	1	Average	N- Avg.
Article 319	-1.43	-0.87	-0.10	0.74	3.50	0.37	**0.32**
Article 320	-1.43	-0.74	-0.19	0.74	3.50	0.38	**0.31**
Article 321	-1.77	-0.29	0.50	1.77	3.50	0.74	**-0.05**
Article 322	-1.02	-0.40	0.10	1.43	3.50	0.72	**-0.03**
Article 323	-1.77	-0.50	-0.29	1.02	3.50	0.39	**0.30**
Article 324	-0.50	0.40	0.62	0.87	3.50	0.98	**-0.29**
Article 325	-0.74	-0.10	0.50	1.77	3.50	0.99	**-0.30**
Article 326	-0.62	0.19	0.29	1.43	3.50	0.96	**-0.27**
Cut-off points	**-1.16**	**-0.29**	**0.18**	**1.22**	**3.50**	**N = 0.69**	

Table 8: Calculation of cut-off points and scale of the indicators. Source: own elaboration

4 Discussion

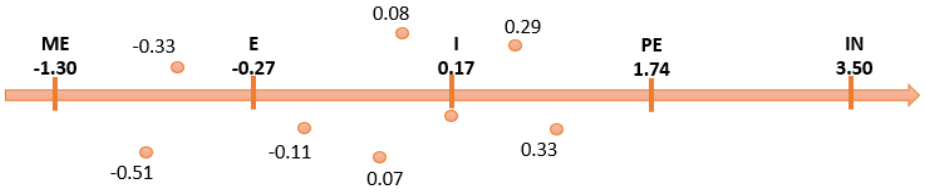


Figure 3: Graphic analysis of results with teachers, of the calculation of cut-off points. Source: Own elaboration

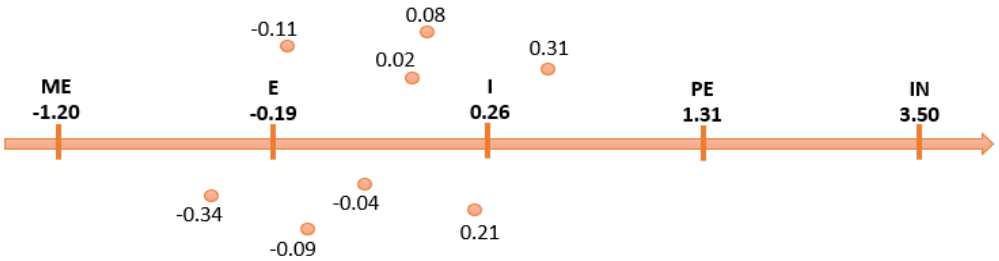


Figure 4: Graphic analysis of the result with judges, of the calculation of cut-off points. Source: Own elaboration

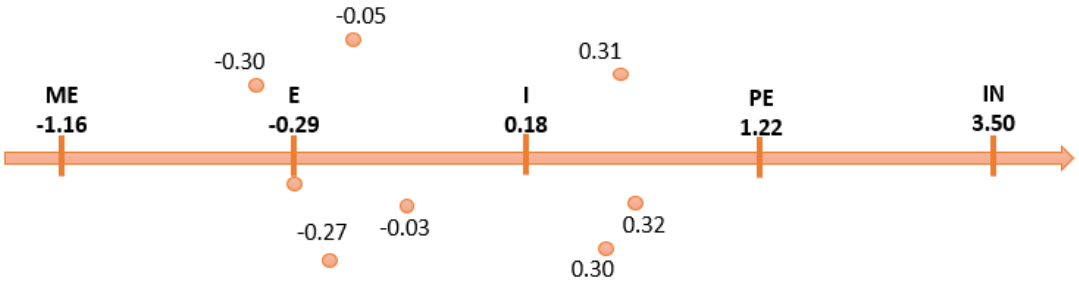


Figure 5: Graphic analysis of the result with lawyers, of the calculation of cut-off points. Source: own elaboration

As a result of the study carried out, it is evident that the participating professionals consider that the articles that regulate criminal offenses have certain effectiveness. However, a diversity of criteria tending to the need to provide better protection for copyright and intellectual property rights was evident. (Figures 3, 4, and 5).

Conclusion

Corresponding to the technological and scientific development of today's world, there is a need to provide efficient criminal protection for Intellectual Property and Copyright. The Ecuadorian State, in compliance with its constitutional principles, must offer the necessary legal tools for proper legal protection in this regard.

To preserve and increase the Ecuadorian cultural heritage, as well as to stimulate creators, society must be provided with efficient copyright protection. This must be tempered to the new technological conditions. Developed with national needs in mind. Likewise, provide protection not only for the creators of works but also for those who collaborate in the dissemination of the mentioned works (owners of related rights) concerning their rights.

Intellectual rights must be protected from a criminal perspective so that they have their true effects. For this, the legislator must be in technical conditions to be able to establish the criminal types that are harmful to a legal interest as precious as intellectual rights and artistic performances. In this way, the penalties that are imposed will fulfill a function that is not only repressive but at the same time dissuasive. In such a case, effective legal protection would be provided to the rights recognized to the authors and users of protected works, as well as to the owners of related rights.

References

[1] W. M. Landes and R. A. Posner, "An economic analysis of copyright law," J. Legal Stud., vol. 18, no. 2, pp. 325–363, 1989.
[2] W. F. Patry, Copyright law and practice. Bna Books, 1994.
[3] A. Latman, "Copyright Law," Ann. Surv. Am. L., p. 433, 1980.
[4] M. J. Meurer, "Copyright law and price discrimination," Cardozo L. Rev., vol. 23, p. 55, 2001.
[5] J. Litman, "Revising copyright law for the information age," Or. L. Rev., vol. 75, p. 19, 1996.
[6] J. C. Ginsburg and R. A. Gorman, Copyright law. Foundation Press, 2012.

[7] R. O. N. 320 Ley de Propiedad Intelectual, "Registro Oficial No 320 Ley de Propiedad Intelectual," Editor. Nac., no. 320, p. 92, 2015, [Online]. Available: https://www.correosdelecuador.gob.ec/wp-content/uploads/downloads/2015/05/LEY_DE_PROPIEDAD_INTELECTUAL.pdf
[8] L. A. Mayorga-Diaz and P. A. Quezada-Sarmiento, "Patent Laws in Ecuador: A Perspective for Invention and Creativity on Busines," in 2019 14th Iberian Conference on Information Systems and Technologies (CISTI), 2019, pp. 1–6.
[9] W. S. Torgerson, "Multidimensional scaling: I. Theory and method," Psychometrika, vol. 17, no. 4, pp. 401–419, 1952.
[10] A. Irimia, X. Lei, C. M. Torgerson, Z. J. Jacokes, S. Abe, and J. D. Van Horn, "Support vector machines, multidimensional scaling and magnetic resonance imaging reveal structural brain abnormalities associated with the interaction between autism spectrum disorder and sex," Front. Comput. Neurosci., vol. 12, p. 93, 2018.
[11] A. Mead, "Review of the development of multidimensional scaling methods," J. R. Stat. Soc. Ser. D (The Stat., vol. 41, no. 1, pp. 27–39, 1992.
[12] L. R. Tucker and S. Messick, "An individual differences model for multidimensional scaling," Psychometrika, vol. 28, no. 4, pp. 333–367, 1963.
[13] J. de Leeuw and W. Heiser, "13 theory of multidimensional scaling," Handb. Stat., vol. 2, pp. 285–316, 1982.
[14] S. J. Messick and R. P. Abelson, "The additive constant problem in multidimensional scaling," Psychometrika, vol. 21, no. 1, pp. 1–15, 1956.
[15] W. Backhaus, R. Menzel, and S. Kreißl, "Multidimensional scaling of color similarity in bees," Biol. Cybern., vol. 56, no. 5, pp. 293–304, 1987.
[16] C. B. Horan, "Multidimensional scaling: Combining observations when individuals have different perceptual structures," Psychometrika, vol. 34, no. 2, pp. 139–165, 1969.
[17] M. L. Davison, "Introduction to multidimensional scaling and its applications," Applied Psychological Measurement, vol. 7, no. 4. Sage Publications Sage CA: Thousand Oaks, CA, pp. 373–379, 1983.
[18] F. W. Young, Y. Takane, and R. Lewyckyj, "ALSCAL: A nonmetric multidimensional scaling program with several individual-differences options," Behav. Res. Methods Instrum., vol. 10, no. 3, pp. 451–453, 1978.
[19] W. Bilsky and M. Janik, "Investigating value structure: Using theory-based starting configurations in multidimensional scaling (Research note)," Rev. Psicol. Soc., vol. 25, no. 3, pp. 341–349, 2010
[20] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.
[21] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018
[22] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.
[23] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.
[24] González, I. A., Fernández, A. J. R., & Ricardo, J. E. "Violación del derecho a la salud: caso Albán Cornejo Vs Ecuador". Universidad Y Sociedad, vol. 13 no. S2, pp 60-65, 2021.
[25] Álvarez Gómez, S. D., Romero Fernández, A. J., Estupiñán Ricardo, J., & Ponce Ruiz, D. V. "Selección del docente tutor basado en la calidad de la docencia en metodología de la investigación". Conrado, vol. 17 no. 80, pp 88-94, 2021.
[26] de Mora-Litardo, K., & Estupiñan-Ricardo, J. "La influencia de la programación neurolingüística en estudiantes universitarios en la República de Ecuador". Luz, vol. 16 no. 1, pp 104-112, 2017.
[27] Ricardo, J. E., Vázquez, M. Y. L., Palacios, A. J. P., & Ojeda, Y. E. A. "Inteligencia artificial y propiedad intelectual". Universidad y Sociedad, vol. 13 no. S3, pp 362-368, 2021.
[28] Ricardo, J. E., Villalva, M. I. M., Padilla, Z. A. O., & Hurtado, L. A. C. "Filosofía de la comunicación, complemento necesario en el aprendizaje de las Ciencias Sociales". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 3 no. 2, pp 39-52, 2018.
[29] García, J. M. B., Ricardo, J. E., & Villalva, I. M. "Acciones didácticas para la autorrealización física integral de los estudiantes de carreras agropecuarias". Didasc@ lia: Didáctica y Educación, vol. 7 no. 2, pp 57-66, 2016.
[30] von Feigenblatt, O. F., & Linstroth, J. P. "Applied history and the teaching of leadership: a case for the use of historical case studies in leadership programs". Universidad y Sociedad, vol. 14 no. S3, pp 433-438, 2022.
[31] von Feigenblatt, O. F. "Education, culture, and underdevelopment: Haiti's tragic failure". Universidad y Sociedad, vol. 14 no. 3, pp 604-611, 2022.
[32] von Feigenblatt, O. F., Peña-Acuña, B., & Cardoso-Pulido, M. J. "Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones". Ediciones Octaedro, 2022.

[33] J. H. Almeida Blacio, C. W. Maldonado Gudiño, F. M. Pozo Hernández & O. R. Aldaz Bombón. "Incidencia económica de la carga impositiva del 2% sobre ingresos brutos en microempresas de Santo Domingo de los Tsáchilas". Universidad y Sociedad, vol. 14 no. S5, pp 16-24, 2022.
[34] V. Vega Falcón, M. Y. Leyva Vázquez & B. Sánchez Martínez. "Análisis FODA-PAJ: Una alternativa esencial para realizar el estudio de la empresa avícola Matanzas". Universidad y Sociedad, vol. 14 no. S5, pp 34-46, 2022.
[35] L. K. Baque Villanueva, A. M. Izquierdo Morán & D. A. Viteri Intriago. "Branding y el marketing estratégico, herramientas fundamentales para posicionar en el mercado una marca universitaria". Universidad y Sociedad, vol. 14 no. S5, pp 47-55, 2022.
[36] T. E. Criollo Yanzapanta, M. P. Mayorga Díaz & V. Vega Falcón. "Consecuencia económica del COVID-19 en la empresa "MAFESA SA" sede Ambato-Ecuador". Universidad y Sociedad, vol. 14 no. S5, pp 62-70, 2022.
[37] A. N. Súñiga Almache, R. M. Cando Almache, A. J. Peñafiel Palacios & E. S. Nivela Ortega. "Contaminación del agua en el Río Jujan Hídrica-Ecuador". Universidad y Sociedad, vol. 14 no. S5,
[38] J. A. Bravo Zapata, L. C. Sánchez Guilindro, E. A. Coello Bustamante & A. J. Peñafiel Palacios. "Contaminación del Medio Ambiente por parte del Ingenio Valdez". Universidad y Sociedad, vol. 14 no. S5, pp 79-86, 2022.

Received: August 03, 2022. **Accepted:** October 04, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the Violation of Rights of People Belonging to Priority Groups in Ecuador using Multicriteria Methods

Diego Fabricio Tixi Torres[1], Lilian Fabiola Haro Terán[2], Pablo Miguel Vaca Acosta[3], and Diego Fernando Coka Flores [4]

[1] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.diegotixi@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.lilianharo@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.pablovaca@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.diegocoka@uniandes.edu.ec

Abstract. The recognition of rights associated with members of society with special characteristics is a reality in the management of governments at a global level. Making these rights effective and respected is a permanent task for the states, among which is Ecuador. That is why the objective of this research is to identify the main factors that affect the violation of the rights of priority attention groups in Ecuador. To meet the proposed objective, methods such as PESTEL analysis, Pareto's technique, Promethee, and TOPSIS were used. As a result, the factors that favor the violation of rights in each area analyzed were identified. Once the most important ones were found, actions were proposed based on them, and the most appropriate actions to mitigate them were obtained.

Keywords: priority groups, violation of rights, PESTEL, neutrosophic TOPSIS, Promethee.

1 Introduction

The search for justice and the improvement of social operating mechanisms leads states to guarantee the protection of certain population groups because they are more prone to the violation of their rights. Priority attention groups are those individuals who are unable to join or rejoin society, regardless of their social, economic, political, and cultural status or condition, which makes it difficult or impossible for them to contribute to the development of society and prevents them from having a better life condition [1]. Priority attention groups are made up of a group of people regardless of their age, sex, or ethnic origin, united by a differentiating condition that may or may not include some of these factors. Within this group are people who are deprived of their liberty, children, adolescents, older adults, people with disabilities, pregnant women, and any other person who suffers from a catastrophic, terminal, or highly complex disease [2, 3].

In this regard, the Constitution of the Republic of Ecuador in its article 35 states that the priority care group comprises older adults, children and adolescents, pregnant women, people with disabilities, people deprived of liberty, and those suffering from catastrophic or highly complex illnesses, and assures that they will receive priority and specialized attention in the public and private spheres. The same priority attention will be given to people at risk, victims of domestic and sexual violence, child abuse, and natural or anthropogenic disasters. The State will provide special protection to people in a condition of double vulnerability [4].

It is understood as a violation of the rights that human beings have, this is due to the social and moral principles that society adopts during the trajectory of life. Another circumstance to overshadow the rights is the economic factor that may cause the fundamental rights to be violated. The analysis starts from the Constitution of the Republic of Ecuador that in its normative text establishes not only rights but also guarantees, which are mechanisms that ensure the effective protection of the rights contemplated in the same Magna Carta. Currently, there is great difficulty in finding a job in the labor market and this situation has a much greater impact on the most vulnerable groups who, due to their circumstances, have fewer resources: capacity, information, relationships, cultural barriers, etc., to access a job [5].

When addressing the issue of constitutionalized human and fundamental rights in the Ecuadorian regulatory framework, problems arise about the violation of the rights of priority attention groups in multiple circumstances. The case of pregnant women can be treated. Specifically, gynecological-obstetric violence is a violation of rights that infringes the physical and psychological integrity of pregnant women [6]. In the context of the improper and unequal treatment that, due to her state of pregnancy, she sometimes receives in some nursing homes. The unequal

labor treatment and sometimes non-compliance with what was agreed for women in this state. Permanence and inclusion in educational institutions, among others.

Due to their age and experience, older adults have a lot of rich knowledge to offer to society and to families who have the joy of having one of them in their homes, however, society does not see it this way, rather because of the fact of being an older adult is minimized by putting aside both in the social and family environment, for the same reason it is an echo of vulnerability because it has come to be idealized that they do not contribute to society with anything other than old age and fatigue [7]. The protection of the State and Society for the Elderly must be special. The constitution is clear and concise in detailing each of the rights, but it is specified that these rights should be reinforced since they are not sufficient to avoid a violation by an unconscious society, which allows the rights of the most vulnerable to be undervalued, making them feel useless before society [8].

The Fundamental Rights of the minor constitute a fundamental part of the legal system of the country, the rights of children are inalienable, and that is why they must be protected. In the same way, the State as a regulatory entity and guarantor of rights must ensure their correct application, a minor needs the love and care of his parents, that is to say, to have his right to a family and, from this first right, others are derived, it must be guaranteed by the State [9]. In relation to this group, there are vulnerabilities among children who are in the process of adoption or waiting for it so that they have a full life, framed in conditions that allow them to develop fully, that is, materially and emotionally. The protection of minors in relation to the workplace, as well as that associated with alimony [10].

Education serves to potentiate in this sense, it is a necessary condition for the development of personal skills, as well as tools to obtain other types of social goods, and this is related to personal satisfaction and citizen participation. The right to education is to access the different levels of education, therefore, various factors are required that are part of the learning process where it begins from the heart of the home in the teaching of values and is formed in school life, it is essential that when mentioning education it is universal in nature where everyone without any distinction can enter a training center such as schools, colleges, and universities for free [11].

In the supreme norm, the right to education is violated, due to non-compliance with all accessibility parameters due to the inefficiency of the educational apparatus, given that they do not adequately apply national legislation and the Convention on Persons with Disabilities, therefore It is urgently required that the state improve the quality of education because it violates a universal right, being the same Magna Carta that discriminates when classifying education as special and not providing due treatment in terms of accessibility, failing to comply with the transversal axes of Convention [12].

What has been analyzed so far shows that the issue of the violation of the rights of priority groups can be approached from multiple points of view, since several conditions can lead to this situation. That is why the objective of the research is to identify the main factors that affect the violation of the rights of priority attention groups in Ecuador.

2 Materials and methods

2.1 PESTEL Analysis

It is a strategic analysis technique to determine the external environment that affects the following factors, namely political, economic, sociocultural, technological, ecological, and legal. It consists of determining the forces that affect the specific environment: sector, employment market, target groups, and competition, among others. It is a technique to analyze businesses that allows and determines the context in which it moves, in turn, allows the design of strategies to defend, take advantage of or adapt to anything that affects the sector. Despite being developed for the business sector, it is also applicable to the social sciences as it offers a more general view of the factors that can influence a given situation [13].

2.2 Pareto Chart

The Pareto diagram was presented in 1930 by Juran in his Quality Control Manual based on what was described in 1909 by Vilfredo Pareto under the principle of "the vital few the trivial many". This diagram is based on the problem analysis and is used to present data, drawing attention to the main causes of the problem in question. Its objective is to determine the 20% of the causes that cause 80% of the problems. Its main advantages are:

- ✓ It allows you to focus on the aspects whose improvement will have the most impact, thus optimizing your efforts.
- ✓ Provides a quick and easy view of the relative importance of issues.
- ✓ It helps prevent some causes from getting worse while trying to solve other less significant ones.

- ✓ His graphical view of the analysis is easy to understand and encourages the team to continue improving.

For its elaboration, it executes the following algorithm:

1. Collect the data and tabulate it.
2. Calculate absolute and cumulative frequency, unitary and cumulative relative frequency.

Graph by locating all the causes along the axis of the coordinates ordered from highest to lowest incidence and corresponding to their percentages along the axis of the ordinates. Finally, the cumulative polygonal line is built, and the causes that are up to 80% will be the ones with the highest incidence [14].

2.3 PROMETHEE method

The PROMETHEE method is a non-compensatory method that handles classification problems by evaluating a set of alternatives under multiple, often conflicting, criteria [15]. The PROMETHEE I (partial classification) and PROMETHEE II (full classification) methods were developed and published by JP Brans in 1982 [16]. Its name refers to the acronym Preference Ranking Organization Method for Enrichment Evaluation, and it is included within the methods based on outranking relationships [17]. The modeling establishes a structural preference between the alternatives, considering a preference function, defined by the decision-maker for each criterion, where the global index allows partial and complete overcoming of the alternatives [18, 22, 23, 24].

A multicriteria problem responds to a structure of type $\max\{g_1(a), g_2(a) \dots g_j(a)/a \in A\}$ where A is a finite set of alternatives$\{a_1, a_2 \dots a_n\}$ and $\{g_1(.), g_2(.) \dots g_n(.)\}$ a set of evaluation criteria. In general, this problem will be poorly conditioned since no alternative will maximize all the criteria, so a compromise solution must be reached. The PROMETHEE method is based on pairwise comparisons, so the difference in value between two evaluations of two alternatives for a given criterion will be taken into account [16], [39], [40]. If this difference is small, a small preference or even indifference will be assigned if it is considered insignificant. The choice of a generalized criterion is reduced to the choice of the appropriate parameters, which can be considered a simple task [18]. In each problem, an alternative *a* is confronted with the (n-1) remaining alternatives that define A:

$$\phi^{+}(a) = \frac{1}{n-1}\sum_{x \in a} \pi(a, x) \tag{1}$$

$$\phi^{-}(a) = \frac{1}{n-1}\sum_{x \in a} \pi(a, x) \tag{2}$$

Positive Relevance Flow and Negative Relevance Flow. The first indicates as an alternative is relevant compared to the rest, it shows its dominating character. The higher, the better the alternative. The second shows its weakness, as it is dominated by the rest of the alternatives. The lower its value, the better the alternative [19].

- PROMETHEE I: The Partial Classification: In this method, the ranking is obtained using the positive and negative streams of relevance. It is important to realize that if we used both flows separately, the classifications would not be the same, therefore this method uses an intersection of both. The method is prudent and does not decide which alternative is better, leaving the final call to the decision-maker.
- PROMETHEE II: The complete classification: In this method, all the alternatives are comparable although, in turn, the information requires more study since when calculating the net flow as the subtraction of flows, a valuable amount of information is lost. In actual practice, both classifications should be used because although PROMETHEE II is easy to use, the incomparability analysis offered by PROMETHEE I can help make the appropriate decision.

Elaboration of the profiles of the alternatives: With the elaboration of the profiles of the alternatives, it is possible to appreciate the quality of an alternative according to the criteria and complete assessments, and to understand some of the results that can be obtained. Mathematically it is the cross-product of the vector of profiles of an alternative and the vector of weighted weights.

2.4 TOPSIS

The method provides a solution that is not only the closest to a hypothetically better solution but also the farthest from the hypothetically worse one [20]. The process is described below:

Determine the objective and identify the attributes to be evaluated.

Prepare a matrix based on the information available on the attributes. Each row corresponds to an alternative and each column to an attribute. The matrix element f_{ij} represents the non-normalized value of the j-th attribute for the i-th alternative [21, 25, 26].

The construction of the normalized matrix will be as follows:

$$r_{ij} = \frac{f_{ij}}{\sqrt{\sum_{j=1}^{n} f_{ij}^2}} \quad (3)$$

Where: r_{ij} is the normalized value for the rating of alternative i against criterion j and f_{ij} is the indicator of each alternative i against each indicator j.

The minimum distance to the positive ideal solution and maximum distance to the negative ideal solution, it is done according to the following equations.

$$A^+ = x_1^+, x_2^+, \dots x_{j+l}^+) \quad (4)$$

$$A^- = (x_1^-, x_2^-, \dots x_{j+l}^- \quad (5)$$

With the normalized values, we proceed to calculate the Euclidean distances of each of the alternatives to the positive ideal and negative ideal solutions, as stated in 6 and 7:

$$\rho(A^k, A^+) = \|w * (TA^k - TA^+)\| \quad (6)$$

$$\rho(A^k, A^-) = \|w * (TA^k - TA^-)\| \quad (7)$$

Finally, the Relative Proximity Index (Ri) is calculated as follows:

$$Ri(A^k, A^i) = \frac{\rho(A^k, A^+)}{\rho(A^k, A^+) + \rho(A^k, A^-)} \quad (8)$$

3 Results

From the study of the theoretical framework around the topic discussed, it is observed that multiple factors can influence the violation of rights, which is why a generalized analysis of this phenomenon is proposed to identify its main causes. It was carried out using the PESTEL analysis of causes as shown:

Dimension	Factor
Political	Compliance with what is stipulated in relation to the rights of people who belong to priority groups is not regularly controlled.
Economic	Prevalence of economic interests in decision-making regarding labor in relation to people belonging to priority groups.
	High budget is needed for subsidies.
	Difficulties in obtaining the necessary support for families that depend on people belonging to priority groups.
	Need for special resources to meet the specific needs of people belonging to priority groups.
Social	Damages associated with the social utility and lack of capacity of people who belong to priority groups.
	Discrimination against people who belong to priority groups.
	Visualization of people belonging to priority groups as a community independent of the social life of the nation.
	Absence of social programs aimed at identifying the needs and inclusion of people who belong to priority groups.

Technological	Improve the accessibility of the technological environment.
Ecological	Eliminate architectural barriers.
Legal	Implement a greater number of specific legal instruments for each situation, to comply with the provisions of the constitution on the protection of priority groups.

Table 1: Results using PESTEL. Source: own elaboration

The Application of the Pareto technique was carried out to determine the main causes, for which Judges of the Family Judicial Unit, of the Pastaza Canton, were consulted: 38 experts (jurists in professional practice and other experts in the subject).

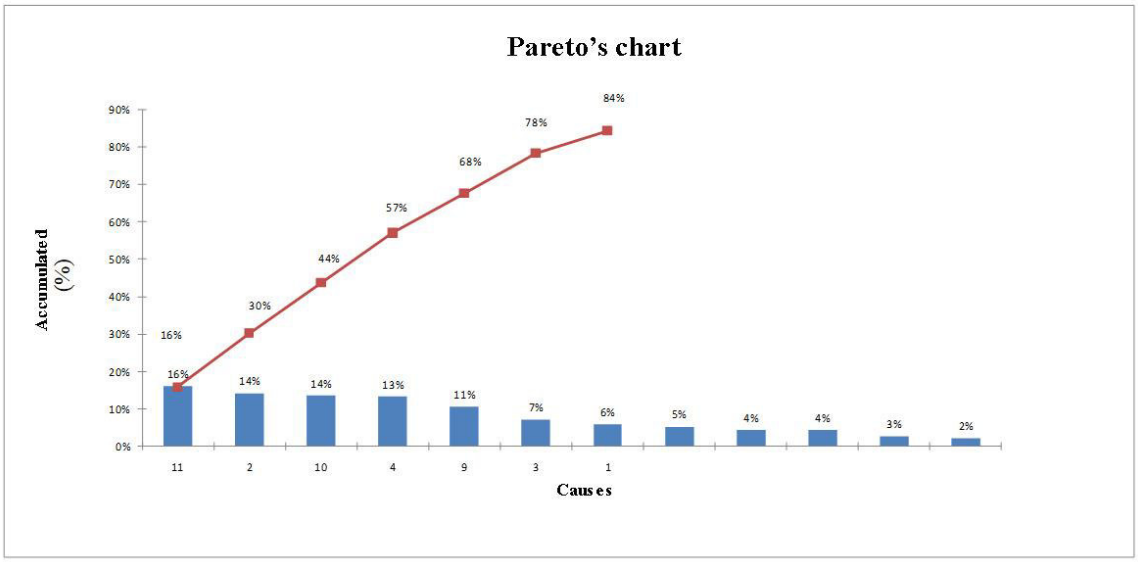


Figure 1: Pareto's chart. Source: own elaboration.

The actions associated with mitigating the most relevant causes, according to the experts consulted, applying Pareto's technique are:

1. Eliminate harm associated with social utility, lack of capacity, and discrimination against people who belong to priority groups.
2. Manage special resources to meet the specific needs of people who belong to priority groups and eliminate architectural barriers.
3. Implement a greater number of specific legal instruments for each situation, to comply with the provisions of the constitution on the protection of priority groups.
4. Avoid visualizing people who belong to priority groups as a community independent of the social life of the nation.

Reduce the prevalence of economic interests in decision-making regarding labor in relation to people belonging to priority groups.

3.1 Application of the Promethee method

For the application of the method, the Promethee software is used, and the data is entered as shown in (Figure 2). Five criteria were defined:

1. The political environment.
2. The economic environment.
3. The social environment.
4. The ecological environment.
5. The legal environment.

From the analysis carried out in the software, the following results can be seen:

Figure 3 shows the introduction of the data in the software, in this case, the weight of each criterion is found if it is a criterion to minimize or maximize, the preference functions, and the evaluation for each of the 5 alternatives presented, which are the proposed actions once the Pareto technique has been applied. [27, 28, 29, 30]

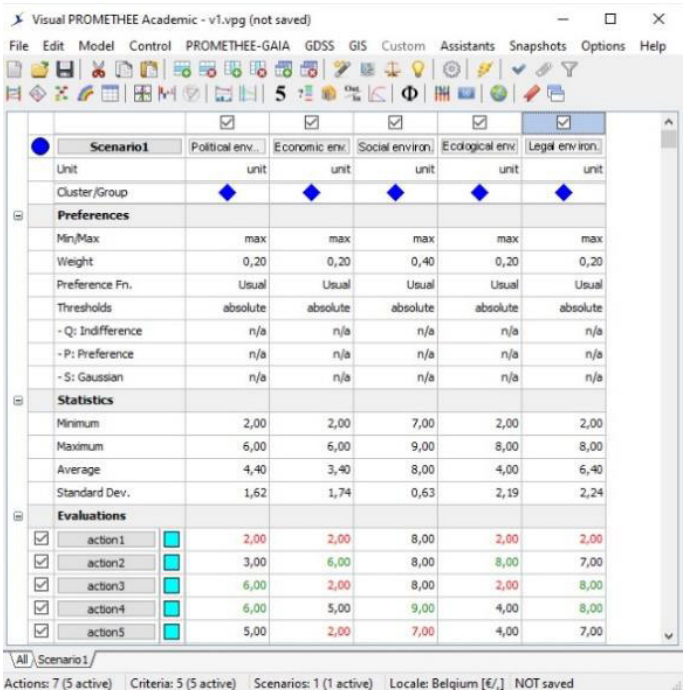


Figure 2: Entering the data in the software. Source: own elaboration

The Promethee I method, although it does not come to propose a decision, (Figure 3) shows that the most convenient actions are 4, 3, and 2, which adequately respond to a greater number of criteria, although in the case of alternative 3 it leaves a little of the acceptable range in one of the criteria. [35], [36], [37], [38]

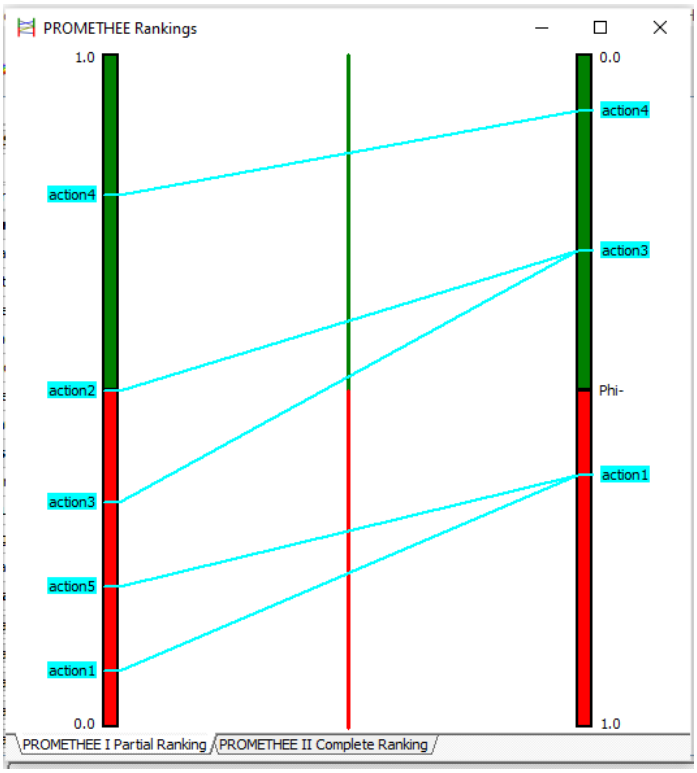


Figure 3: Results of the Promethee I method. Source: Own elaboration using the Promethee software.

For its part, the Promethee II method confirms that the best alternatives are 4, 2, and 3 in that classification order, and the least desirable is action 1. As can be seen in Figure 4. From the rainbow analysis (Figure 5), which is a mixture of the profiles of the alternatives, since it shows the impact of each of them on the 5 chosen criteria, it can be seen that the optimal result is achieved with action 4, in which In the case of action 2, it has a greater representation in the economic, ecological and social environment, but to a lesser extent in the legal and political area. In relation to action 3, it has a small impact on the political, legal, and social fields and to a lesser extent on the economic and ecological order. [31, 32, 33, 34]

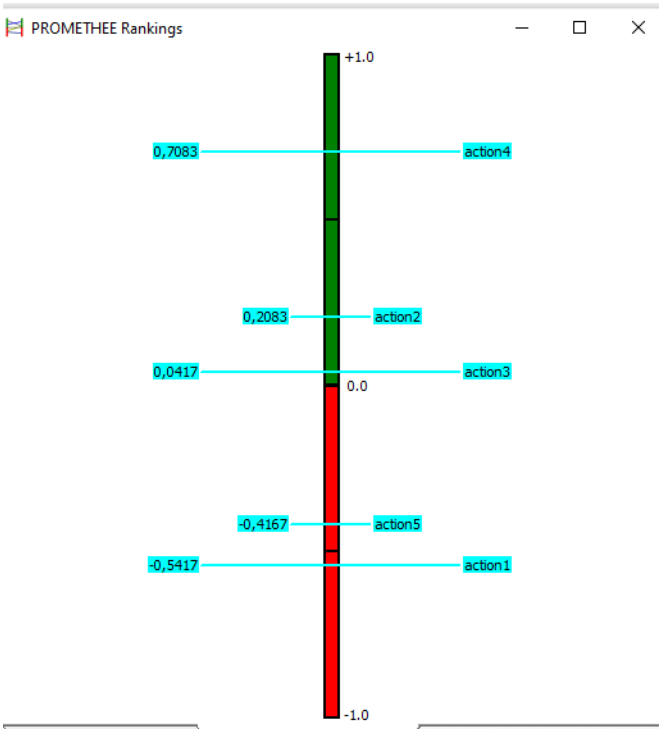


Figure 4: Results of the Promethee II method. Source: Own elaboration using Promethee software.

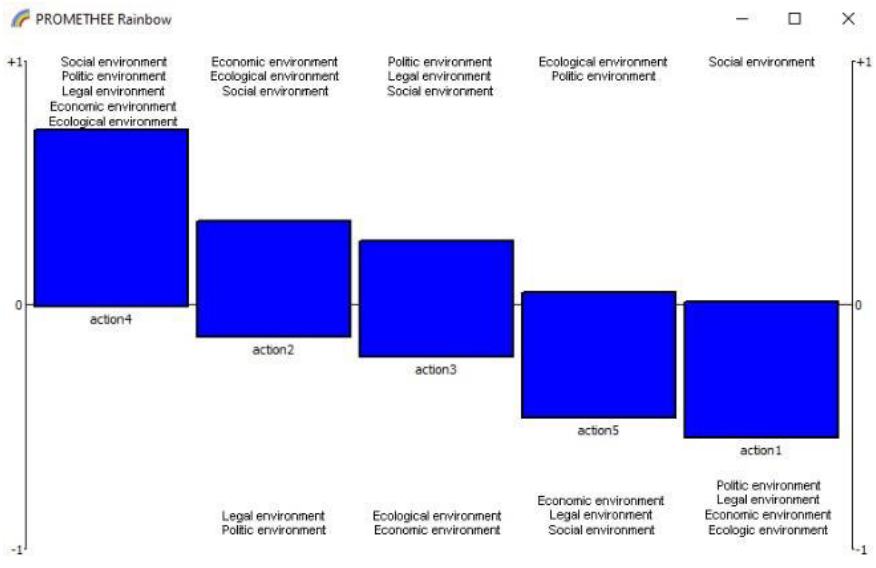


Figure 5: Rainbow analysis for each alternative. Source: Own elaboration using Promethee software.

3.2 Application of the TOPSIS method

Step 1*:* Create a decision matrix

In this study, 5 criteria and 5 alternatives are classified according to the Fuzzy TOPSIS method. The following table shows the type of criteria and the weight assigned to each criterion.

	Name	Type	Weight
1	Economic environment	+	(0.250,0.250,0.250)
2	Social environment	+	(0.250,0.250,0.250)
3	Ecological environment	+	(0.250,0.250,0.250)
4	Legal environment	+	(0.250,0.250,0.250)
5	Political environment	+	(0.250,0.250,0.250)

Table 2: Characteristics of the criteria. Source: own elaboration using online output software

The alternatives are evaluated in terms of various criteria and the results of the decision matrix are shown below. The following matrix represents the arithmetic mean of all the experts.

	Economic environment	Social environment	Ecological environment	Legal environment	Political environment
Alternative1	(1,000,2,333,4,333)	(4,333,6,333,8,333)	(1,000,2,333,4,333)	(3,000,5,000,7,000)	(1,000,1,000,3,000)
Alternative2	(1,000,3,000,5,000)	(3,667,5,667,7,667)	(4,333,6,333,8,333)	(3,000,5,000,7,000)	(3,000,5,000,7,000)
Alternative3	(5,000,7,000,9,000)	(3,667,5,667,7,667)	(1,000,3,000,5,000)	(1,000,3,000,5,000)	(5,000,7,000,9,000)
Alternative4	(2,333,4,333,6,333)	(5,667,7,667,9,000)	(2,333,4,333,6,333)	(4,333,6,333,8,333)	(2,333,4,333,6,333)
Alternative5	(1,000,3,000,5,000)	(3,667,5,667,7,667)	(3,000,5,000,7,000)	(5,000,7,000,9,000)	(4,333,6,333,8,333)

Table 3: Decision matrix. Source: own elaboration using online output software

2: Create the normalized decision matrix, based on the positive and negative ideal solutions.

	Economic environment	Social environment	Ecological environment	Legal environment	Political environment
Alternative1	(0.111,0.259,0.481)	(0.481,0.704,0.926)	(0.120,0.280,0.520)	(0.333,0.556,0.778)	(0.111,0.111,0.333)
Alternative2	(0.111,0.333,0.556)	(0.407,0.630,0.852)	(0.520,0.760,1.000)	(0.333,0.556,0.778)	(0.333,0.556,0.778)
Alternative3	(0.556,0.778,1.000)	(0.407,0.630,0.852)	(0.120,0.360,0.600)	(0.111,0.333,0.556)	(0.556,0.778,1.000)
Alternative4	(0.259,0.481,0.704)	(0.630,0.852,1.000)	(0.280,0.520,0.760)	(0.481,0.704,0.926)	(0.259,0.481,0.704)
Alternative5	(0.111,0.333,0.556)	(0.407,0.630,0.852)	(0.360,0.600,0.840)	(0.556,0.778,1.000)	(0.481,0.704,0.926)

Table 4. Normalized decision matrix. Source: Own elaboration using online output software.

Step 3: Create the weighted normalized decision matrix.

Considering the different weights of each criterion, the weighted normalized decision matrix can be calculated by multiplying the weight of each criterion in the normalized fuzzy decision matrix.

	Economic environment	Social environment	Ecological environment	Legal environment	Political environment
alternative1	(0.028,0.065,0.120)	(0.120,0.176,0.231)	(0.030,0.070,0.130)	(0.083,0.139,0.194)	(0.028,0.028,0.083)
alternative2	(0.028,0.083,0.139)	(0.102,0.157,0.213)	(0.130,0.190,0.250)	(0.083,0.139,0.194)	(0.083,0.139,0.194)
alternative3	(0.139,0.194,0.250)	(0.102,0.157,0.213)	(0.030,0.090,0.150)	(0.028,0.083,0.139)	(0.139,0.194,0.250)
alternative4	(0.065,0.120,0.176)	(0.157,0.213,0.250)	(0.070,0.130,0.190)	(0.120,0.176,0.231)	(0.065,0.120,0.176)
alternative5	(0.028,0.083,0.139)	(0.102,0.157,0.213)	(0.090,0.150,0.210)	(0.139,0.194,0.250)	(0.120,0.176,0.231)

Table 5. Weighted normalized decision matrix. Source: Own elaboration using online output software.

Step 4*:* Determine the fuzzy positive ideal solution (FPIS, A*), and the fuzzy negative ideal solution.

	Positive ideal	Negative ideal
Economic environment	(0.139,0.194,0.250)	(0.028,0.065,0.120)
Social environment	(0.157,0.213,0.250)	(0.102,0.157,0.213)
Ecological environment	(0.130,0.190,0.250)	(0.030,0.070,0.130)
Legal environment	(0.139,0.194,0.250)	(0.028,0.083,0.139)
Political environment	(0.139,0.194,0.250)	(0.028,0.028,0.083)

Table 6: Fuzzy positive ideal solution (FPIS, A*) and fuzzy negative ideal solution (FNIS, A-). Source: Own elaboration using online output software

Step 5: Calculate the distance between each alternative and the fuzzy positive ideal solution ^*and the distance between each alternative and the fuzzy negative ideal solution A^-

	Distance from the positive ideal	Distance from the negative ideal
Alternative1	0.476	0.074
Alternative2	0.272	0.281
Alternative3	0.261	0.291
Alternative4	0.227	0.326
Alternative5	0.22	0.332

Table 7: Distance from the positive and negative ideal alternatives. Source: Own elaboration using online output software.

Step 6: Compute the closeness coefficient and rank the alternatives.

The best alternative is the closest to the FPIS and the furthest from the FNIS. The closeness coefficient of each alternative and its ranking order is shown in the following table.

	Ci	Rank
Alternative1	0.135	5
Alternative2	0.507	4
Alternative3	0.527	3
Alternative4	0.59	2
Alternative5	0.602	1

Table 8: Closeness coefficient. Source: Own elaboration using online output software.

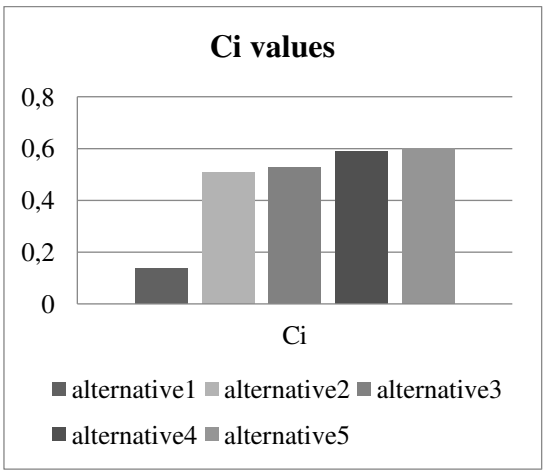


Figure 6. Representation of the proximity coefficients of the alternatives. Source: Own elaboration using online-output software.

Comparison of the results obtained between both methods:

In the case of the Promethee method, the eligible alternatives respond to orders 4, 2, 3, 5, and 1, with action 4 being the ideal. When applying the TOPSIS method, it is appreciated that the alternatives closest to the ideal solution respond to orders 5, 4, 3, 2, and 1. Therefore, certain similarities and some differences can be observed in relation to the order of the alternatives. However, considering the union of both methods, it could be said that the main actions to mitigate the violations of the rights of people who belong to priority groups should be:

- ✓ Avoid visualizing people who belong to priority groups as a community independent of the social life of the nation.
- ✓ Reduce the prevalence of economic interests in decision-making regarding labor in relation to people belonging to priority groups.
- ✓ Implement a greater number of specific legal instruments for each situation, to comply with the provisions of the constitution on the protection of priority groups.

Manage special resources to meet the specific needs of people who belong to priority groups and eliminate architectural barriers.

Conclusion

The recognition of rights associated with members of society with special characteristics is a reality in the management of governments at a global level. Making these rights effective and respected is a permanent task for the states, among which is Ecuador. In Ecuadorian legislation, groups of priority attention are recognized as the group of people who are united by a differentiating condition that makes special attention necessary. Within this group, there are people deprived of their liberty, children, adolescents, the elderly, people with disabilities, pregnant women, and any other person who suffers from a catastrophic, terminal, or highly complex disease.

There are factors associated with different areas of the political, economic, social, ecological, and legal order that favor the violation of the rights of people belonging to vulnerable groups, for their identification the PESTEL analysis was used, yielding a total of 12 factors. With the application of the Pareto technique, the main causes were identified and based on solving them, 5 actions were proposed aimed at mitigating the factors found. With the application of the Promethee and TOPSIS method, the most appropriate actions in relation to the priority groups are proposed: to avoid the visualization of the people who belong to these groups as an independent community in the social life of the nation, to reduce the prevalence of interests in decision-making regarding labor, implement a greater number of specific legal instruments for each situation, to comply with the provisions of the constitution on the protection of priority groups and manage resources to meet the specific needs of the people belonging to priority groups and remove architectural barriers.

References

[1] J. A. A. Vélez, "On the rights of the elderly in Ecuador: from constitutional dogmatic to local reality," *Universidad y Sociedad,* vol. 13, pp. 21-28, 2021.

[2] E. L. H. Ramos, L. R. A. Ayala, D. F. T. Torres, and R. Gonzalez, "Method for Treatment and its Incidence in the Change of Social Rehabilitation Regime using Neutrosophic Compensatory Logic," *Neutrosophic Sets and Systems,* vol. 37, pp. 381-388, 2020.

[3] R. L. Maldonado Manzano, J. J. Cellán Palacios, and F. M. Estrella Gómez, "Evaluation of the Effectiveness in the National Social Rehabilitation System using Neutrosophy and Compensatory Operators.," *Neutrosophic Sets & Systems,* vol. 44, pp. 299-307, 2021.

[4] M. Navarro Cejas, M. Cejas, L. Fernando, P. Piñas, and I. Quintana, "Neutrosofic Iadov for the analysis of satisfaction on the regularities in the international legal field concerning the human rights of migrant workers in Ecuador," *Neutrosophic Sets & Systems,* vol. 26, pp. 132-137, 01/01 2019.

[5] J. M. Macías Bermúdez, G. K. Arreaga Farias, and L. Torres Torres, "Profiles of Human Trafficking Violence in Regions of Ecuador," *Neutrosophic Sets and Systems,* vol. 37, pp. 200-207, 2020.

[6] J. Guzmán, "Decolonizing Law and expanding human rights: Indigenous conceptions and the rights of nature in Ecuador.," *Deusto Journal of Human Rights,* pp. 59-86, 2019.

[7] D. Banerjee, K. Rabheru, C. A. de Mendonca Lima, and G. Ivbijaro, "Role of dignity in mental healthcare: impact on ageism and human rights of older persons," *The American Journal of Geriatric Psychiatry,* vol. 29, pp. 1000-1008, 2021.

[8] B. Lewis, K. Purser, and K. Mackie. (2020) The Human Rights of Older Persons. *A Human Rights-Base Approach to Elder Law. Springer*.

[9] J. C. D. J. Arrias Añez, A. R. Pupo Kairuz, and R. E. Atencio González, "Critical analysis on the anti-drug legal system against drug trafficking comparing the Ecuadorian and Venezuelan legislation," *Dilemas contemporáneos: educación, política y valores,* vol. 8, pp. 1-14, 2021.

[10] F. Lopez Boo, M. Dormal, and A. Weber, "Validity of four measures of child care quality in a national sample of centers in Ecuador," *PloS one,* vol. 14, p. e0209987, 2019.

[11] S. Yepez, B. S. P. Guerra, and D. H. Mantilla, "Evaluación Inclusiva e Intercultural: Una mirada a la educación en el pueblo Waorani," *INNOVA Research Journal,* vol. 3, pp. 22-33, 2018.

[12] P. J. Stein and M. A. Stein, "Climate change and the right to health of people with disabilities," *The Lancet Global Health,* vol. 10, pp. e24-e25, 2022.
[13] R. González-Ortega, M. D. Oviedo-Rodríguez, M. Leyva-Vázquez, J. Estupiñán-Ricardo, J. A. Sganderla-Figueiredo, and F. Smarandache, "Pestel analysis based on neutrosophic cognitive maps and neutrosophic numbers for the sinos river basin management," *Neutrosophic Sets and Systems,,* vol. 26, pp. 105-113, 2019.
[14] B. Cuong, "Pareto Solution in Neutrosophic Set Setting for Multiple Criteria Decision Making Problems," in *Fuzzy Multi-criteria Decision-Making Using Neutrosophic Sets*, ed: Studies in Fuzziness and Soft Computing., 2019, pp. 371-415.
[15] P. Ziemba, "NEAT F-PROMETHEE–A new fuzzy multiple criteria decision making method based on the adjustment of mapping trapezoidal fuzzy numbers," *Expert Systems with Applications,* vol. 110, pp. 363-380, 2018.
[16] M. Edmerdash and E. Rushdy, "An Efficient Framework for Drug Product Selection–DPS according to Neutrosophic BWM, MABAC and PROMETHEE II Methods," *Neutrosophic Sets and Systems,* vol. 45, pp. 286-305, 2021.
[17] N. A. Nabeeh, A. Abdel-Monem, and A. Abdelmouty, "A Novel Methodology for Assessment of Hospital Service according to BWM, MABAC, PROMETHEE II," *Neutrosophic Sets and Systems,,* vol. 31, pp. 63-79, 2020.
[18] T.-Y. Chen, "A novel PROMETHEE-based outranking approach for multiple criteria decision analysis with Pythagorean fuzzy information," *Ieee Access,* vol. 6, pp. 54495-54506, 2018.
[19] J. Witkowski, J. Marcinkowski, and M. Kiba-Janiak, "A comparative analysis of electronic freight exchanges in the United States and Europe with the use of the multiple criteria decision-making method "Promethee"." *European Research Studies Journal,* vol. 23, pp. 1-13, 2020.
[20] R. Zulqarnain, X. Xin, M. Saqlain, F. Smarandache, and M. Ahamad, "An integrated model of neutrosophic TOPSIS with application in multi-criteria decision-making problem," *Neutrosophic Sets and Systems,* vol. 40, pp. 253-269, 2021.
[21] J. Briones Macias, M. Leyva Vazquez, and J. R. Hechavarría Hernández, "Study of Informal Human Settlements in Picoazá Parish, Portoviejo Canton: Towards a Bioclimatic Housing Approach," in *Advances in Intelligent Systems and Computing* vol. 1214 AISC, ed, 2020, pp. 122-128.
[22] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.
[23] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.
[24] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.
[25] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.
[26] Ricardo, J. E., & Vázquez, I. R. S. "La educación sexual para padres de niños con retraso mental, una vía para su consolidación". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 4 no. 3, pp 137-144, 2019.
[27] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.
[28] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018
[29] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.
[30] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.
[31] von Feigenblatt, O. F., Pardo, P., & Cooper, M. "Sufficiency Economy Philosophy (SEP): Thailand's Emic Approach to Governance and Development as Evidence of an Asian-value Oriented Inclusive Leadership Management Philosophy". Journal of Asia Pacific Studies, vol. 6. No. 2, pp 289-300, 2021.
[32] von Feigenblatt, O., Pardo, P., & Cooper, M. "The "Bad Students" Movement and Human Rights in Contemporary Thailand". Ciencias Sociales y Económicas, vol. 5 no. 1, pp 156-176, 2021.
[33] von Feigenblatt, OF, Pardo, P. & Cooper, M. "Corporativismo y autoritarismo benévolo: antídotos viables contra el populismo". Revista de perspectivas alternativas en las ciencias sociales. Vol. 11 no. 1, pp 95-98, 2021.
[34] Von Feigenblatt, O. F. "Honor, Loyalty, and Merit: The Cultura Contemporary of the Spanish Nobility". Ediciones Octaedro, 2022.
[35] J. D. Bósquez Remache, L. C. Campaña Muñoz & L. N. Chica López. "Terminación del contrato en servidores Públicos del Ecuador". Universidad y Sociedad, vol. 14 no. S5, pp 248-260, 2022.
[36] B. D. Narváez Montenegro, V. F. Flores Hernández, F. J. Caicedo Banderas & A. F. Solano Moreno. "Trastornos afectivos a causa de un divorcio unilateral, un estudio en la provincia de Tungurahua, Ecuador". Universidad y Sociedad, vol. 14 no. S5, pp 276-282, 2022.
[37] J. A. Urrutia Guevara, D. P. Gordillo Cevallos, M. M. Yancha Villacis & F. J. Caicedo Banderas. "Estrategias Jurídicas que aportan a los derechos del contribuyente". Universidad y Sociedad, vol. 14 no. S5, pp 314-321, 2022.

[38] R. Meléndez Carballido, H. Paronyan & K. E. Carrión León. "Estudio doctrinal y legal en el contexto del pluralismo Jurídico de Pueblos y Nacionalidades indígenas en el Ecuador". Universidad y Sociedad, vol. 14 no. S5, pp 322-331, 2022.

[39] C. J. Lizcano Chapeta, G. F. Vinueza Arroyo, L. A. Crespo Berti & D. X. Chamorro Valencia. "Estudio jurídico dogmático de protección integral de niños, niñas: papel protagónico del cambio social". Universidad y Sociedad, vol. 14 no. S5, pp 362-373, 2022.

[40] N. D. Silva Álvarez, L. A. Casco Robles, L. S. Racines Silva & G. R. Navas Espín. "Evaluación de los métodos de monitoreo aplicados por las cooperativas de ahorro y crédito de Pastaza". Universidad y Sociedad, vol. 14 no. S5, pp 417-426, 2022.

Received: August 04, 2022. **Accepted:** October 04, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the Right to Housing

Jairo Mauricio Puetate Paucar[1], Miguel Angel Guambo Llerena[2], Génesis Karolina Robles Zambrano [3], and Laura Marlene Ochoa Escobar[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.jairopuetate@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.miguelguambo@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador. E-mail: uq.genesisrobles@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.lauraochoa@uniandes.edu.ec

Abstract. The right to housing leads to the integration of the human being into the family and sets the basis for integrating economic, social, and cultural participation. It is established and recognized in national and international regulations and public policies on the protection of Human Rights and the right to an adequate and dignified standard of living. The violation of the right to housing puts at risk the right of the human being to make a family, to health, to physical and mental integrity. Housing is essential for survival and the achievement of a life with security and comfort. From the current state, it is necessary and opportune to evaluate the legal system to determine the factors that cause deficiencies in the legal system and visualize the State's solutions to decent housing through public policies. For this, the modeling of Saaty's AHP and Neutrosophic TOPSIS methods were used. As a result, it is proposed to develop a necessary public policy and support low-income families to achieve a decent home.

Keywords: housing, AHP, TOPSIS, Neutrosophy.

1 Introduction

The Ecuadorian State has spoken in Human Rights conventions, which establish the obligations of the State, in favor of improving the living conditions of people, thus guaranteeing the right to adequate housing. It is noteworthy that every person has the right to an adequate standard of living that assures him and his family, among other aspects, decent housing. An adequate standard of living then implies the possibility of having a home and this factor is as important as having health, food, welfare, social services, and insurance [1].

In Ecuador, different transformations have been carried out in the model for the provision of welfare services. In the specific field of social interest housing policies, the changes operated in terms of the implementation of schemes that combine subsidies focused on the demand with the incorporation of private sector providers [2]. However, one of the biggest problems is related to its market structure. The limited participation and consolidation of the financing offer from the private sector are generated not only by the lack of motivation in terms of the profitability of the sector. Although there are structural restrictions on access to credit for the majority of society [3].

In 2017, the government of Ecuador promoted a sector formulation, with a human rights approach at the national level. The country's public policy was the center of world attention thanks to the National Secretariat for Planning and Development (SENPLADES in Spanish), with the support of the Office of the United Nations High Commissioner for Human Rights. The 2030 agenda, which defines the Sustainable Development Goals (SDGs) with their respective goals, was adopted by the United Nations General Assembly in September 2015, Sustainable Development Goal number 11 recognizes the relevance of cities when considering achieving that cities and human settlements are inclusive, safe, resilient, and sustainable.

SENPLADES seeks to promote technical and orderly planning. The optimization of resources [4] and efforts made by the State to obtain a more equitable society. Therefore, the objectives of the State in terms of housing consist of:

- Increase the number of families with decent housing of their own that were in a situation of extreme poverty until the year 2021.
- Guarantee access to adequate and decent housing, with cultural relevance and a safe environment, which includes the provision and quality of public goods and services linked to the habitat.

The housing situation in Ecuador constitutes a structural phenomenon located in the:

- Accelerated urbanization experienced since the second half of the 20th century;
- A social structure characterized by marked socioeconomic inequalities
- Low social investment resulting from accumulated budget deficits;
- A scarcity of land, since it is a scarce and non-reproducible good that derives in an urban dynamic of a speculative nature.

Public policies are general guidelines promoted by a government to respect, protect and fulfill the rights of people, individually and collectively. Within the framework of the new constitutional state of rights and justice, public policies seek to guarantee the rights and good living of all Ecuadorians. Among the governing bodies in charge of fulfilling and guaranteeing the human right to decent housing is the Ministry of Urban Development and Housing (MIDUVI in Spanish). This State entity exercises stewardship and implementation of the public policy of cities and guarantees citizens access to safe and healthy housing habitats [5]. Among its main guidelines it focuses on:

- Public investments in the housing sector towards the lower-income social sectors,
- Promote the active participation of the private sector in the construction and financing of affordable housing,
- Promote the use of alternative technologies in housing construction and promote the offer of mortgage credit for low-income families.

The evaluation of the situation in Ecuador shows little participation of the private sector in financing housing construction. The social housing market is not very profitable, with a limited number of providers in terms of the number of bidders and the quality of the service[6]. As a result of several studies, they show that, in the income structure, most families would not be able to finance their housing without the support of the State subsidy.

For the legal treatment of the right to housing, this study defines the problem situation: deficiencies of the legal system in the right to housing. The main objective is to determine the factors that cause deficiency of the legal system and to visualize the solutions of the State to decent housing through public policies. For its resolution, the following specific objectives are proposed:

- Determine the factors that affect the analyzed variable.
- Carry out the measurement and neutrosophic modeling of the variable using AHP Saaty and TOPSIS methods.
- Project potential alternatives based on reducing the impact of factors on the right to housing

2 Neutrosophic Methods

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

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 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, $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy, and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, \text{ otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \dfrac{\left(a_2 - x + \beta_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}\,, & a_2 \le x \le a_3 \\ \dfrac{\left(x - a_2 + \beta_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \tag{2}$$

$$F_{\tilde{a}}(x) = \begin{cases} \dfrac{\left(a_2 - x + \gamma_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}\,, & a_2 \le x \le a_3 \\ \dfrac{\left(x - a_2 + \gamma_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \tag{3}$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \le a_2 \le a_3 \le a_4$

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

Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (4)

Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (5)

Inversión: $\tilde{a}^{-1} = \langle ({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3, a_4 \neq 0$. (6)

Multiplication by a scalar number:

$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases} \tag{7}$$

Definitions 3 and 4 refer to a single-valued triangular neutrosophic number when the condition *a2 = a3*. For simplicity, the linguistic scale of triangular neutrosophic numbers is used, see Table 1 and also compare with the scale defined.

The analytic hierarchy process models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme [8]. The levels of importance or weighting of the criteria are estimated using pair-wise comparisons between them. It can be found in [9] the theory of the AHP technique in a neutrosophic framework. Thus, the indeterminacy of decision-making can be modeled by applying neutrosophic AHP or NAHP for short. Equation 8 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\widetilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \tag{8}$$

Matrix $\widetilde{A}$ must satisfy condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in, they are the so-called score and accuracy indexes, respectively, see Equations 9 and 10:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \tag{9}$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (10)$$

Saaty's 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	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale. Source: [9]

- Step 1. Select a group of experts.
- Step 2. Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.
- The neutrosophic scale is attained according to expert opinions. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 6.
- Step 3. Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, ie, $a_{ik} = a_{ij}a_{jk}$ for all i,j, and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

- Step 4. Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it into a deterministic matrix using Equations 11 and 12. To get the score and the accuracy degree of $\tilde{a}_{ji}$, the following equations are used:

$$S(\tilde{a}_{ji}) = {}^{1}\!/_{S(\tilde{a}_{ij})} \quad (11)$$

$$A(\tilde{a}_{ji}) = {}^{1}\!/_{A(\tilde{a}_{ij})} \quad (12)$$

With compensation for the accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, the following deterministic matrix is derived:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (13)$$

- Step 5: Determine the ranking of priorities, namely the Eigen Vector X, from the previous 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 calculus of the Consistency Index (CI) when applying this technique, which is a function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that the consistency of the evaluations can be determined by the equation:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (14)$$

Where n is the order of the matrix. In addition, the Consistency Ratio (CR) is defined by the equation:

$$CR = \frac{CI}{RI} \quad 15$$

RI is given in Table 2.

Order(n)	1	2	3	4	5	6	7	8	9	10
IR	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

Table 2: RI associated with every order. Source: [9]

If CR≤0.1 experts' evaluation is sufficiently consistent and hence proceed to use NAHP. This procedure is applied to matrix "A" in Equation 13.

In the case of TOPSIS, the selection is based on finding the alternative that is closest to the ideal solution and, in turn, is further away from the worst solution. For the methodology, this method had its evolution towards Neutrosophic, therefore, in this paper, linguistic terms will be associated with Single Value Neutrosophic Numbers (SVNN). In such a way the experts can carry out their evaluations in linguistic terms, which is more natural [10, 11, 12, 13, 14, 20]. Therefore, the scales shown in Table 3 will be considered.

Linguistic term	**SVNN**
Equally influential	⟨(1,1,1);0.50,0.50,0.50⟩
Slightly influential	⟨(2,3,4);0.30,0.75,0.70⟩
Strongly influential	⟨(4,5,6);0.80,0.15,0.20⟩
Very strongly influential	⟨(6,7,8);0.90,0.10,0.10⟩
Absolutely influential	⟨(9,9,9);1.00,1.00,1.00⟩
Sporadic values between 2 scales	⟨(1,2,3);0.40,0.65,0.60⟩
Sporadic values between 2 scales	⟨(3,4,5);0.60,0.35,0.40⟩
Sporadic values between 2 scales	⟨(5,6,7);0.70,0.25,0.30⟩
Sporadic values between 2 scales	⟨(7,8,9);0.85,0.10,0.15⟩

Table 3: Linguistic terms that represent the evaluation of the criteria in the alternatives. Source: own elaboration.

The TOPSIS method for SVNN consists of the following: assuming that $A = \{\rho_1, \rho_2, \dots, \rho_m\}$ is a set of alternatives and $G = \{\beta_1, \beta_2, \dots, \beta_n\}$ is a set of criteria, where the following steps will be carried out:

Definition 1. Let X be a universe of discourse. A Neutrosophic Set (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x): X \to {}^{-}0,1^{+}[$, which satisfies the condition $-0 \leq inf u_A(x) + inf r_A(x) + inf v_A(x)\ sup\ u_A(x) + sup\ r_A(x) + \sup v_A(x) \leq 3^{+}$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively, and their images are standard or nonstandard subsets of $]-0,1+[$.

Definition 2. Let X be a universe of discourse. A Single Value Neutrosophic Set (SVNS) A over X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \tag{16}$$

where $u_A, r_A, v_A: X \to [0,1]$, satisfy the condition $0 \leq u_A(x), r_A(x), v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)\ and\ v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively. For convenience, a Single Value Neutrosophic Number (SVNN) will be expressed as A = (a, b, c), where a, b, c [0,1] and satisfies $0 \leq a + b + c \leq 3$. SVNSs arose with the idea of applying neutrosophic sets for practical purposes. Some operations between SVNN are expressed below [15, 16, 17, 18, 19]:

1. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2) two SNVN, the addition between A1 and A2 is defined as:

$$A_1\ A_2 = (a_1 + a_2 - a_2, b_1 b_2, c_1 c_2) \tag{17}$$

2. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2) two SVNN, the multiplication between A1 and A2 is defined as:

$$A_1\ A_2 = (a_1 a_2, b_1 + b_2 - b_1 b_2, c_1 + c_2 c_1 c_2) \tag{18}$$

3. The product by a positive scalar with a SVNN, A = (a, b, c) is defined by:

$$A = (1 - (1 - a), b, c) \tag{19}$$

4. Let $\{A_1, A_2, \dots, A_n\}$ be a set of n SVNNs, where Aj = (aj, bj, cj) (j = 1, 2, …, n), then the *Single Value Neutrosophic Weighted Mean Operator* (SVNWMO) over the set is calculated by the following Equation:

$$\sum_{j=1}^{n} \lambda_j A_j = \left(1 - \prod_{j=1}^{n} (1 - a_j)^{\lambda_j}, \prod_{j=1}^{n} b_j^{\lambda_j}, \prod_{j=1}^{n} c_j^{\lambda_j},\right) \tag{20}$$

Where λ_j is the weight of Aj, [0, 1] $\lambda_j \in [0, 1]$ and $\sum_{j=1}^{n} = 1$

Definition 3. Let $A^* = (A_1^*, A_2^*, \dots, A_n^*)$ be a vector of n SVNN such that $A_j^* = \left(a_1^*, b_2^*, c_j^*\right)(j = 1,2, \dots, n)$ and $B_i = (B_{i1}, B_{i2}, \dots, B_{im})(i = 1,2, \dots, m)$ are m vectors of n SVNNs such that (i = 1, 2, …,m)(j = 1, 2, …, n). Then the Separation Measurement between Bi and A* is calculated by the following Equation:

$$s_i = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^*\right)^2 + \left(b_{ij} - b_j^*\right)^2 + \left(c_{ij} - c_j^*\right)^2\right\}\right)^{\frac{1}{2}} \tag{21}$$

Where i= (1,2,...,m)

Definition 4. Let A = (a, b, c) a SVNN, the score function S of a SVNN, based on true membership degree, undetermined membership degree, and false membership degree is defined by the following Equation:

$$S(A) = \frac{1 + a - 2b - c}{2} \tag{22}$$

Where S(A) ∈ [-1, 1]

In this paper, linguistic terms will be associated with SVNN, so that experts can carry out their evaluations in linguistic terms, which is more natural. Therefore, the scales shown in Tables 4 and 5 will be considered.

Linguistic term	SVNN
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)
Fairly good (FG)	(0.60,0.35,0.40)
Medium (M)	(0.50,0.50,0.50)
Fairly Bad (FB)	(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 4: Linguistic terms used. Source: own elaboration.

Linguistic term	SVNN
Very Important (VI)	(0.9, 0.1, 0.1)
Important (I)	(0.77,0.30,0.35)
Medium (M)	(0.52,0.40,0.50)
Not Important (NI)	(0.33,0.70,0.70)
Very Not Important (VNI)	(0.15,0.75,0.95)

Table 5: Linguistic terms that represent the weight of the importance of the alternatives. Source: own elaboration.

The TOPSIS method for SVNN consists of the following, assuming that $A = \{\rho_1, \rho_2, \dots, \rho_m\}$ is a set of alternatives and $G = \{\beta_1, \beta_2, \dots, \beta_m\}$ is a set of criteria, the following steps will be carried out:

Step 1: Determine the weight of the experts. For this, the specialists evaluate according to the linguistic scale that appears in Table 1, and the calculations are made with their associated SVNN, call At = (at, bt, ct) the SVNN corresponding to the t-th decision-maker (t = 1, 2,…, k). The weight is calculated by the following formula:

$$\lambda_t = \frac{a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)}{\sum_{t=1}^{k} a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)} \tag{23}$$

$$\lambda_t \geq 0 \mathrm{Y} \sum_{t=1}^{k} \lambda_t$$

Step 2: Construction of the aggregate single value neutrosophic decision matrix. This matrix is defined by $D = \sum_{t=1}^{k} \lambda_t D^t$, where $d_{ij} = (u_{ij}, r_{ij}, v_{ij})$ and is used to aggregate all the individual evaluations. dij is calculated as the aggregation of the evaluations given by each expert $(u_{ij}^t, r_{ij}^t, v_{ij}^t)$, using the weights λ_t of each one with the help of Equation 5. In this way, a matrix $D = (d_{ij})_{ij}$ is obtained, where each dij is a SVNN (i = 1,2,..., m; j = 1,2,..., n).

Step 3: Determination of the Weight of the Criteria. Suppose that the weight of each criterion is given by W = (w1, w2,…, wn), where wj denotes the relative importance of the criterion $\lambda_t w_j^t = (a_j^t, b_j^t, c_j^t)$. *Si* is the evaluation of the criterion λ_t by the t-th expert. Equation 5 is then used to aggregate the w_j^t with the weights λ_t.

Step 4: Construction of the single-valued neutrosophic decision matrix $D^* = D * W$ of weighted operator with respect to the criteria, where $d_{ij} = (a_{ij}, b_{ij}, c_{ij})$

Step 5: Calculation of the positive and negative SVNN ideal solutions. The criteria can be classified as cost-type or benefit-type. Let G1 be the set of benefit-type criteria and G2 be the cost-type criteria. The ideal alternatives will be defined as follows:

$$\rho^+ = a_{\rho+w}(\beta_j), b_{\rho+w}(\beta_j), ac_{\rho+w}(\beta_j) \tag{24}$$

Denotes the positive ideal solution, corresponding to G1.

$$\rho^- = (a_{\rho-w}(\beta_j), b_{\rho-w}(\beta_j), ac_{\rho-w}(\beta_j)) \tag{25}$$

Denotes the negative ideal solution, corresponding to G2. Where:

$$a_{\rho+w}(\beta_j) = \begin{cases} max_i a_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ min_i a_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases} \qquad a_{\rho-w}(\beta_j) = \begin{cases} min_i a_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ max_i a_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases}$$

$$b_{\rho+w}(\beta_j) = \begin{cases} max_i b_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ min_i b_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases} \qquad b_{\rho-w}(\beta_j) = \begin{cases} min_i b_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ max_i b_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases}$$

$$c_{\rho+w}(\beta_j) = \begin{cases} max_i c_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ min_i c_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases} \qquad c_{\rho-w}(\beta_j) = \begin{cases} min_i c_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ max_i c_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases}$$

Step 6: Calculation of the distances to the positive and negative SVNN ideal solutions. With the help of Equation 6, the following Equations are calculated:

$$s_i^+ = \left(\frac{1}{3} \sum_{j=1}^{n} \left\{ \left(a_{ij} - a_j^+\right)^2 + \left(b_{ij} - b_j^+\right)^2 + \left(c_{ij} - c_j^+\right)^2 \right\} \right)^{\frac{1}{2}} \tag{26}$$

$$s_i^- = \left(\frac{1}{3} \sum_{j=1}^{n} \left\{ \left(a_{ij} - a_j^-\right)^2 + \left(b_{ij} - b_j^-\right)^2 + \left(c_{ij} - c_j^-\right)^2 \right\} \right)^{\frac{1}{2}} \tag{27}$$

Step 7: Calculation of the Coefficient of Proximity (CP). The CP of each alternative is calculated with respect to the positive and negative ideal solutions.

$$\widetilde{\rho_j} = \frac{s^-}{s^+ + s^-} \tag{28}$$

Where $0 \leq . \widetilde{\rho_j} \leq 1$

Step 8: Determination of the order of the alternatives.

They are ordered according to what was achieved by $\widetilde{\rho_j}$. The alternatives are ordered from highest to lowest, under the condition that $\widetilde{\rho_j} \rightarrow 1$ is the optimal solution.

Additionally, for statistical processing, the following formula was used to calculate the sample size.

$$n = \frac{ZNpq}{E^2(N-1) + Z^2pq} \tag{29}$$

Where: n: Sample size, Z: Is the value of the normal distribution with the assigned confidence level, E: Desired sampling error, N: Population size

3 Results

Once the different approaches in the introduction of the document have been analyzed, the aforementioned techniques are applied. For the data in the modeling, surveys were applied to the experts to determine the criteria to be evaluated and the state obligations regarding the right to housing. For them, the resulting table is presented

with the weights after having made the binary comparison matrix of the AHP Saaty (see Tables 6 to 9).

Code	Factors that cause a deficiency in the legal system
F1	No commitment to support lower-income families
F2	An incentive system is not strengthened
F3	Correct regulation of social rights is not applied
F4	The necessary public policies are not developed
F5	Guarantees of the right to housing are not promoted
F6	A government projection focused on housing is not defined

Table 6: Factors that cause a deficiency in the legal system. Source: own elaboration

Once the different previous approaches have been analyzed, the aforementioned techniques will be applied, as follows:
With the AHP Neutrosophic method, the weights of the factors or causes present in the licensing process are determined.

Factors	F1	F2	F3	F4	F5	F6
F1	0.9375	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
F2	⟨(1,1,1); 0.50,0.50,0.50⟩	0.9375	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩
F3	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	0.9375	⟨(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⟩
F4	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(6,7,8); 0.90,0.10,0.10⟩	0.9375	⟨(6,7,8); 0.90,0.10,0.10⟩	⟨(7,8,9); 0.85,0.10,0.15⟩
F5	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	⟨(2,3,4); 0.30,0.75,0.70⟩	⟨(6,7,8); 0.90,0.10,0.10⟩	0.9375	⟨(1,1,1); 0.50,0.50,0.50⟩
F6	⟨(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⟩	⟨(7,8,9); 0.85,0.10,0.15⟩	⟨(1,1,1); 0.50,0.50,0.50⟩	0.9375
Total	1.00	1.00	1.00	1.00	1.00	1.00

Table 7: Neutrosophic AHP paired matrix. Source: own elaboration

Factors	F1	F2	F3	F4	F5	F6	WEIGHT
F1	0.0938	0.0882	0.2368	0.0842	0.0714	0.1579	0.1221
F2	0.0938	0.0882	0.0789	0.0842	0.0714	0.1579	0.0957
F3	0.0313	0.0882	0.0789	0.0842	0.2143	0.1579	0.1091
F4	0.6563	0.6176	0.5526	0.5895	0.5000	0.4211	0.5562
F5	0.0938	0.0882	0.0263	0.0842	0.0714	0.0526	0.0694
F6	0.0313	0.0294	0.0263	0.0737	0.0714	0.0526	0.0475

Table 8: Determination of weights of the criteria applying the AHP Neutrosophic method. Source: own elaboration.

Factors	Approximate eigenvalues
F1	6.852845372
F2	6.456618500
F3	6.191000848
F4	6.671269279
F5	6.488961440
F6	6.224702916

Table 9: Analysis of the consistency of the paired matrix. Source: own elaboration.

The consistency analysis of the method revealed that its eigenvalue is 6.4809, IC= 0.10, and RC= 0.08, so the modeling meets the parameters. Of the causes analyzed, it was determined that solutions should be proposed to develop the necessary public policy and support lower-income families as the first action.

3.1 TOPSIS

Based on the above, it is decided to carry out a diagnosis to determine the possible solutions based on defending and achieving an accessible process that complies with the right to housing. For them, TOPSIS neutrosophic modeling was applied to evaluate possible solutions. For the study, the sample size of respondents is decided using equation 14, which is taken as 50% or 0.05 probabilities, with the results being as follows:

- Maximum margin of admitted error = 10.0%
- Population size=160
- Size for a confidence level of 95%: 60

It is decided to work with 95% confidence, so surveys will be applied to determine and promote the best alternative to apply (Table 10). Through the modeling of measurement criteria and their vector of weights to then apply the TOPSIS technique in its neutrosophic version. A sample of 60 respondents divided into five groups of 12 is used. The results were as follows:

From the detected factors obtained from the Neutrosophic AHP method to determine which solution should be enhanced. The experts proposed possible solutions with respect to developing the necessary public policy and supporting lower-income families, for which the following criteria were classified:

Alternatives	Solution to apply
A1	Support lower-income families
A2	Develop the necessary public policies
A3	Correct regulation of social rights
A4	Strengthen the incentive system
A5	Submit a law draft in favor of the right to housing

Table 10: Alternatives to apply. Source: own elaboration.

Strategic success evaluation criteria: 3

1. Job instability;
2. Lack of guarantees by the state.
3. Difficult access to credit and little participation from the private sector

Expert groups: 5 groups of 12 (total 60)

1. Group of experts in the provision of legal services
2. Private University Scheduling, Planning, and Performance Expert Group
3. Group of public university law experts

4. Group of experts in university assessment and assessment

Determine the weight:

Groups	Group 1	Group 2	Group 3	Group 4	Group 5
Importance vector	(0.15,0.75, 0.95)	(0.33, 0.7, 0.7)	(0.77, 0.3, 0.35)	(0.90, 0.1, 0.1)	(0.9,0.1,0.1)
λ_t	0.122452325	0.172132294	0.234504237	0.235455572	0.235455572

Table 11: Calculation of the importance vector (λ_t). Source: own elaboration.

			Criterion 1: Job instability		
Alternatives	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Team 5**
A1	(0.9;0.1;0.1)	(0.15;0.75;0.95)	(0.52;0.4;0.5)	(0.52;0.4;0.5)	(0.33;0.7;0.7)
A2	(0.77;0.3;0.35)	(0.77;0.3;0.35)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.77;0.3;0.35)
A3	(0.33;0.7;0.7)	(0.15;0.75;0.95)	(0.15;0.75;0.95)	(0.33;0.7;0.7)	(0.15;0.75;0.95)
A4	(0.15;0.75;0.95)	(0.52;0.4;0.5)	(0.9;0.1;0.1)	(0.15;0.75;0.95)	(0.52;0.4;0.5)
A5	(0.77;0.3;0.35)	(0.77;0.3;0.35)	(0.9;0.1;0.1)	(0.77;0.3;0.35)	(0.9;0.1;0.1)
			Criterion 2: Lack of guarantees by the state.		
A1	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.77;0.3;0.35)	(0.9;0.1;0.1)
A2	(0.52;0.4;0.5)	(0.77;0.3;0.35)	(0.52;0.4;0.5)	(0.52;0.4;0.5)	(0.77;0.3;0.35)
A3	(0.15;0.75;0.95)	(0.33;0.7;0.7)	(0.15;0.75;0.95)	(0.33;0.7;0.7)	(0.15;0.75;0.95)
A4	(0.33;0.7;0.7)	(0.52;0.4;0.5)	(0.15;0.75;0.95)	(0.15;0.75;0.95)	(0.52;0.4;0.5)
A5	(0.9;0.1;0.1)	(0.77;0.3;0.35)	(0.77;0.3;0.35)	(0.77;0.3;0.35)	(0.9;0.1;0.1)
			Criterion 3: Difficult access to credit and little participation of the private sector		
A1	(0.33;0.7;0.7)	(0.9;0.1;0.1)	(0.33;0.7;0.7)	(0.15;0.75;0.95)	(0.77;0.3;0.35)
A2	(0.9;0.1;0.1)	(0.77;0.3;0.35)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)
A3	(0.15;0.75;0.95)	(0.15;0.75;0.95)	(0.15;0.75;0.95)	(0.33;0.7;0.7)	(0.15;0.75;0.95)
A4	(0.33;0.7;0.7)	(0.33;0.7;0.7)	(0.33;0.7;0.7)	(0.15;0.75;0.95)	(0.33;0.7;0.7)
A5	(0.33;0.7;0.7)	(0.33;0.7;0.7)	(0.77;0.3;0.35)	(0.77;0.3;0.35)	(0.77;0.3;0.35)

Table 12: Single Values Criteria Matrix. Source: own elaboration.

Alterna-tives	**Criterion 1**	**Criterion 2**	**Criterion 3**
A1	(0.52724;0.42909;0.49633)	(0.87833;0.12952;0.13431)	(0.60292;0.41691;0.45706)
A2	(0.8445;0.17902;0.19426)	(0.64436;0.35574;0.43235)	(0.88458;0.12082;0.12407)
A3	(0.2194;0.73171;0.85164)	(0.22857;0.7292;0.83882)	(0.19631;0.73791;0.88409)
A4	(0.59233;0.3619;0.43135)	(0.34595;0.5756;0.70448)	(0.29139;0.71146;0.75219)
A5	(0.8445;0.17902;0.19426)	(0.82929;0.20247;0.22353)	(0.68485;0.38505;0.42929)

Table 13: Decision table aggregated by the experts. Source: own elaboration.

Criteria	**Weights**
Criterion 1	(0.82929;0.20247;0.22353)
Criterion 2	(0.82915;0.20268;0.2238)
Criterion 3	(0.67842;0.30719;0.34773)

Table 14: Weights assigned by the experts to each criterion. Source: own elaboration.

Alternatives	**Criterion 1**	**Criterion 2**	**Criterion 3**
A1	(0.43723;0.54468;0.60892)	(0.72827;0.30595;0.32805)	(0.40903;0.59603;0.64586)
A2	(0.70034;0.34524;0.37437)	(0.53427;0.48632;0.55939)	(0.60012;0.3909;0.42866)
A3	(0.18195;0.78603;0.8848)	(0.18952;0.78409;0.87489)	(0.13318;0.81842;0.9244)

A4	(0.49121;0.4911;0.55846)	(0.28684;0.66162;0.77062)	(0.19768;0.8001;0.83836)
A5	(0.70034;0.34524;0.37437)	(0.68761;0.36411;0.3973)	(0.46462;0.57396;0.62774)

Table 15: Weighted decision matrix of the SVNN. Source: own elaboration.

Criteria	Ideal value +	Ideal value-
C1	(0.70034;0.34524;0.37437)	(0.18195;0.78603;0.8848)
C2	(0.72827;0.30595;0.32805)	(0.18952;0.78409;0.87489)
C3	(0.60012;0.3909;0.42866)	(0.13318;0.81842;0.9244)

Table 16. Positive and negative ideal values by criteria. Source: own elaboration.

Alternatives	s_i^+	s_i^-	$\widetilde{\rho}_J$
A1	0.31079813	0.6378521	0.672379
A2	0.203049692	0.7477047	0.786433
A3	0.854016134	0	0
A4	0.609203334	0.3348454	0.354691
A5	0.18378923	0.7379594	0.80061

Table 17. Distances between the negative and positive solutions. Source: own elaboration.

Alternatives	Order
A1	3
A2	2
A3	5
A4	4
A5	1

Table 18. Hierarchy of the success factors analyzed. Source: own elaboration

The result of the modeling of the neutrosophic TOPSIS determined as the main alternative the presentation of a law draft in favor of the right to housing. Moments must be established for the correct application of the different policies regarding housing improvement. Due to this, the experts offer special interest in the need to have guarantees from the state and thus reduce job instability. For them, it is necessary to develop the required public policy and support lower-income families. With this, it would lay the foundations for success even when it depends on other factors such as difficult access to credit and little participation from the private sector.

Conclusion

In Ecuador, the fundamental rights to a safe habitat, and adequate and decent housing are constitutionally recognized. These are universally protected, and special emphasis is placed on policies and plans of social interest that protect people who are in extreme poverty. Thus, the national government, in compliance with the constitutional mandate, has declared as a priority to guarantee that all Ecuadorians can enjoy adequate and decent housing, even so, the housing problem has not yet been resolved. Far from solving it, there are fundamental factors to which the state must pay special attention.

The modeling of the AHP Saaty and TOPSIS neutrosophic methods visualize the factors that cause the deficiency of the legal system compliance with public policies to guarantee the enjoyment of adequate and decent housing. It was determined as a solution to propose a law draft in favor of the right to housing. So that a necessary public policy is developed that supports lower-income families.

For protecting the rights and needs of citizens to have decent housing. The necessary public policies that contribute to the goals outlined in the National Plan for Good Living for the period 2017-2021 must be ensured and strengthened. Therefore, the approval and implementation of a law draft in favor of the right to housing are defined as an alternative. For this, the evaluation process presents the transparency of the process outside of any previously qualified interference to exercise in decision-making.

The Ecuadorian Government must encourage and indicate to the governing bodies the legal and enforce compliance and respect for the regulations regarding the people's right to housing. It is vitally important that the state guarantees public policies for the right to housing, as well as job stability. Therefore, the State must provide job offers to families and strengthen the incentive system, to encourage credit to low-income families and thus improve housing space.

References

[1] I. Turok and A. Scheba. (2019) 'Right to the city' and the New Urban Agenda: learning from the right to housing. Territory, Politics, Governance. 494-510.

[2] R. Baušys, B. Juodagalvienė, R. Žiūrienė, I. Pankrašovaitė, J. Kamarauskas, A. Usovaitė, et al., "The residence plot selection model for family house in Vilnius by neutrosophic WASPAS method," International Journal of Strategic Property Management, vol. 24, pp. 182-196, 2020.

[3] R. Disney and G. Luo, "The Right to Buy public housing in Britain: A welfare analysis," Journal of Housing Economics, vol. 35, pp. 51-68, 2017/03/01/ 2017.

[4] E. K. Zavadskas, R. Bausys, B. Juodagalviene, and I. Garnyte-Sapranaviciene, "Model for residential house element and material selection by neutrosophic MULTIMOORA method," Engineering Applications of Artificial Intelligence, vol. 64, pp. 315-324, 2017.

[5] R. Baušys, B. Juodagalvienė, R. Žiūrienė, I. Pankrašovaitė, J. Kamarauskas, A. Usovaitė, et al., The residence plot selection model for family house in Vilnius by neutrosophic WASPAS method: Infinite Study, 2020.

[6] E. K. Zavadskas, R. Bausys, A. Kaklauskas, I. Ubarte, Kuzmin-, A. ske, &, et al., "Sustainable market valuation of buildings by the single-valued neutrosophic MAMVA method. ," Applied Soft Computing, vol. 57, pp. 74-87, 2017b.

[7] A. Karaşan, E. Bolturk, and C. Kahraman, "An integrated interval-valued neutrosophic AHP and TOPSIS methodology for sustainable cities' challenges," in International Conference on Intelligent and Fuzzy Systems, 2019, pp. 653-661.

[8] J. E. Ricardo, Z. M. M. Rosado, E. K. C. Pataron, and V. Y. V. Vargas. (2021) Measuring Legal and Socioeconomic Effect of the Declared Debtors Using The AHP Technique in a Neutrosophic Framework Neutrosophic Sets and Systems, . 357-366. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85116161925&partnerID=40&md5=948dae6f450340530ee8e2095525636b

[9] M. Abdel-Basset, M. Mohamed, and F. Smarandache, "An Extension of Neutrosophic AHP-SWOT Analysis for Strategic Planning and Decision-Making," Symmetry, vol. 10, p. 116, 2018.

[10] R. G. Ortega, M. L. Vázquez, J. A. S. Figueredo, &, and A. Guijarro-Rodriguez. (2018) Sinos river basin social-environmental prospective assessment of water quality management using fuzzy cognitive maps and neutrosophic AHP-TOPSIS. Neutrosophic Sets and Systems. 160–171. Available: http://fs.unm.edu/NSS2/index.php/111/article/view/408

[11] F. X. Poveda Paredes, K. J. Toctaquiza Cumbicos, & M. J. Goyes Baca. "Efectos adversos de la ivermectina en pacientes con Sars-Cov-2". Universidad y Sociedad, Vol. 14 Num. S2, pp- 479-487, 2022.

[12] S. A. Montecé Giler, & L. A. Montecé Giler. "Tipos de normas que regulan la sociedad". Universidad y Sociedad, Vol. 14 Num.S2, pp- 471-478, 2022.

[13] J. E. Jami Carrera, & A. A. Monsalve Guamán. "Efluvio telógeno como secuela de Covid-19". Universidad y Sociedad, Vol. 14 Num. S2, pp- 465-470, 2022.

[14] P. E. Salas Medina, & M. E. Orozco Manobanda. "Análisis de las dificultades en el proceso de implementación de protocolos de bioseguridad para reapertura de establecimientos turísticos en Tungurahua post Covid-19". Universidad y Sociedad, Vol. 14 Num.S2, pp- 456-464, 2022

[15] M. R. Aguilar Martínez, D. P. Gordillo Cevallos, J. A. Paredes López & G.P. León Burgos. "La aplicación de los principios procesales en la justicia electoral". Universidad y Sociedad, Vol. 14 Num. S2, pp- 450-455, 2022.

[16] A R. Soria Acosta, & Y. C. Hernández Zambrano. "Claves de emergencia obstétrica en la hemorragia post parto". Universidad y Sociedad, Vol. 14 Num. S2, pp- 445-449, 2022.

[17] M. M Vidal del Río, & A. A. Monsalve Guamán. "La equinococosis canina, una zoonosis de importancia". Universidad y Sociedad, Vol. 14 Num. S2, pp- 440-444, 2022.

[18] Álvarez Gómez, G. A., Viteri Moya, J. R., Viteri Intriago, D. A., & Estupiñán Ricardo, J. "Integración de los procesos sustantivos para la mejora de la calidad del aprendizaje". Conrado, vol. 17 no. 80, pp 21-27, 2021.

[19] Vega Falcón, V., Alarcón Quinapanta, M., Yancha Villacís, M., & Estupiñán Ricardo, J. Medición del capital intelectual: Caso hotelero. Dilemas Contemporáneos: Educación, Política y Valores, no. 96, pp 1-19, 2019.

[20] von Feigenblatt, O. F., & Linstroth, J. P. "Applied history and the teaching of leadership: a case for the use of historical case studies in leadership programs". Universidad y Sociedad, vol. 14 no. S3, pp 433-438, 2022

Received: August 05, 2022. **Accepted:** October 05, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Multicriteria Study of the Violation of the Principle of Innocence in Traffic Accidents

Eduardo Luciano Hernández Ramos[1], Carlos Gilberto Rosero Martinez[2], Janneth Ximena Iglesias Quintana[3], and Alex Javier Peñafiel Palacio[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.eduardohernandez@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.carlosrosero@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.jannetiglesias@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.alexpenafiel@uniandes.edu.ec

Abstract. In Ecuador, most traffic crimes are caused by drivers who do not have sufficient training on the rules that regulate transportation and road safety. Traffic crimes, also known as criminal offenses, are caused by actions of recklessness, incompetence, or non-compliance with legal norms. In traffic crimes, the principle of innocence is often violated due to the inadequate application of the constitutional principle of presumption of innocence. That is why the present work aims to determine the factors that violate the principle of innocence in traffic accidents and that violate the constitutional norm and propose potential strategies to mitigate its effect on society. For this, the AHPS and Vikor methods were used. It was obtained as a result that there is arbitrariness in jurisdictional actions and that constitutional precepts are violated, including the freedom of the individual. A reform project to the current regulations to change the misconception that justice operators have in constitutional law is proposed so that in this way they are not violated in judicial processes.

Keywords: traffic crimes, principle of innocence, freedom.

1 Introduction

In Ecuadorian society, most traffic crimes are caused by drivers who do not have sufficient training on the rules that regulate transportation and road safety. Drivers obtain driver's licenses without further requirements of experience and knowledge of basic driving rules. This happens not only in Ecuador. In many other countries, the failure rate of the driving test is very high, which leads to the occurrence of accidents on the road [1].

The nature of traffic crimes comes from guilt. They are caused by reckless, negligent, inexperienced actions, which cause unwanted damage, which is why the law punishes this type of action for not being careful when driving a vehicle [2]. The objective duty of care must be always maintained when driving a vehicle to avoid harming road users. Studies published by the WHO show that only 15% of countries have the full scope of legal regulations regarding speed limits, driving under the influence of alcohol, fastening of seat belts, the use of car seats child safety, and protective helmets [3].

Traffic crimes are caused by actions of recklessness or non-observance of legal norms, which leads to the violation of the objective duty of care. For some of these crimes when material damage has been caused to private property, only administrative sanctions are applicable, however, when damage to physical integrity and life is caused, they are sanctioned with imprisonment in addition to the administrative sanctions [4].

According to the Organic Integral Penal Code (COIP in Spanish), a crime is a criminal offense punishable by imprisonment for more than thirty days. On the other hand, Article 5, paragraph 4 guarantees that "every person maintains his legal status of innocence and must be treated as such until a sentence that determines the contrary is executed." Unfortunately, practice shows the opposite, since the defendant is treated as guilty from the very beginning of the process and the constitutional and regulatory principle of presumption of innocence is contravened [5].

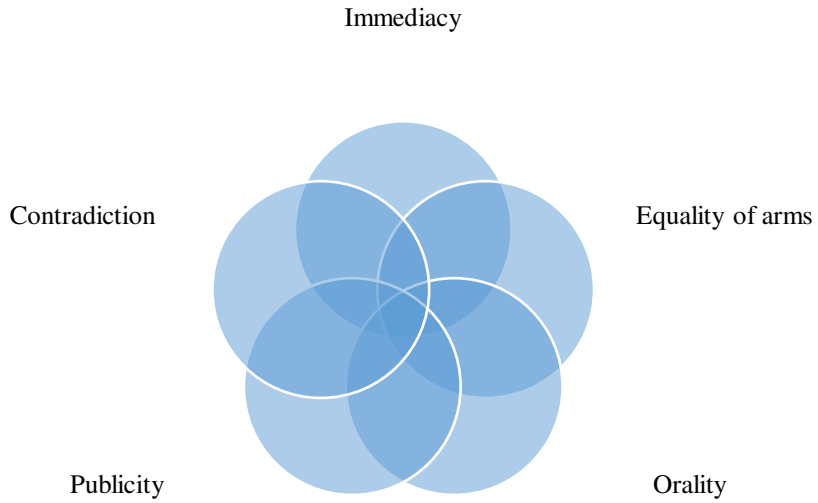


Figure 1: Procedural guarantees. Source: own elaboration.

In terms of Law, the *presumption of innocence* supposes that every person to whom an act is imputed in a criminal proceeding retains his quality of innocence until proven guilty, which must be in a trial with all the guarantees established by law (Figure 1). The right to the presumption of innocence also supposes that the accused does not have the burden of proving his innocence from her, but that it is the prosecution who has the burden of proving the guilt of the person against whom the procedure is directed [6].

The right to the presumption of innocence can only be undermined when the judgment of guilt is based on evidence legally practiced. The purpose of the presumption of innocence is to establish whether the person who is the passive subject of the state action is responsible or not for the imputed infraction. From what has been discussed so far, traffic crimes are increasingly recurrent on the roads of the Republic of Ecuador. Therefore, the preparation of lawyers is required from their formation. That is why in this article this last idea is deepened.

The presumption of innocence is the right that all people must be considered a priori and that they act according to a right reason, behaving according to the values, principles, and rules of the legal system. They have this guarantee until the competent judge does not acquire the conviction, through the legal means of proof of their participation in the act, through a final sentence. Likewise, every one of the rules of due process must be respected, all of which require applying the precautionary measures provided for in criminal proceedings without affecting fundamental rights [7].

Due process "has frequently been interpreted as a limit to laws and legal procedures so that judges, not legislators, must define and guarantee the fundamental principles of impartiality, justice, and freedom[8]. It is a legal principle by which the State must respect all the legal rights that a person has under the law."

The Constitution of the Republic recognizes and guarantees the principle of innocence in article 76.2: "The innocence of every person shall be presumed, and shall be treated as such, as long as their responsibility is not declared through a final resolution or judgment ".

Art. (…) Special cases of guilty traffic crimes. - Without prejudice to the penalty with which the infraction is sanctioned, the prosecutor may request preventive detention from the judge in flagrant traffic crimes only in the following cases:

1. To the driver who is under the influence of alcohol or narcotic or psychotropic substances, even in cases of material damage.
2. To the driver who does not have a driver's license, or it is canceled, suspended, or revoked, even in cases of material damage.
3. When only one vehicle participates in a traffic accident and results in the death or injury of one or more people or when the driver's responsibility is technically determined.

In all other cases, the prosecutor will ask the judge to order alternative measures such as the prohibition to leave the country, the obligation to appear periodically before the judge who knows the process or before the authority or institution that the judge designates, house arrest or use the electronic surveillance device.

The judge of criminal guarantees deems it necessary to guarantee the appearance of the defendant in the process

or to ensure compliance with the sentence, and may order preventive detention, provided that the following requirements are met:

1. Sufficient indications about the existence of a crime of public action;
2. Clear and precise indications that the accused is the author or accomplice of the crime;
3. That it is a crime punishable by imprisonment for more than one year;
4. Sufficient indications that it is necessary to deprive the defendant of his freedom to ensure his appearance at trial; and,
5. Sufficient indications that the non-custodial measures are insufficient to guarantee the presence of the defendant at the trial.

The presumption of innocence is an innate right of a person. The State recognizes this quality and that their condition of innocence can be distorted when there are mechanisms capable of establishing the responsibility and guilt of a citizen, to impose a sentence. However, the legal conception that preventive detention had in the previous criminal law has not changed at present, therefore, it has not evolved with the desired rigor over time. Thus, based on the analysis of the existing situation, this study intends to determine the factors that violate the principle of innocence in traffic accidents and that violate the constitutional norm to propose potential strategies to mitigate its effect on society.

- Risk factors that influence the presumption of innocence.
- Visualize the dimensions of violation in the right to freedom.
- Propose regulatory reforms of the laws that regulate this matter.

As illustrated in Figure 1, the processing of information will be as follows:

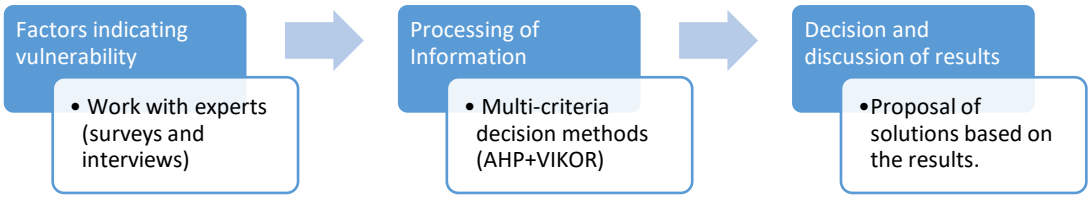


Figure 2: Diagram of the research processes. Source: own elaboration

2 Materials and methods

For the development of this research, empirical and theoretical methods will be used. the Analytic Hierarchy Process and VIKOR are used as empirical methods and methodologies are discussed later. Both methods are based on the criteria of experts exposed in the surveys and interviews to discern the factors of interest for the investigation. Which is based on the use of the following theoretical methods:

- Inductive: within the investigation, it is used above all to obtain particular conclusions regarding the investigation case.
- Deductive: based on scientific doctrine, it is used above all for the deduction and analysis of the situation from referential information. This together with the inductive allows generating the conclusions.
- Analytical-synthetic: it makes it possible to carry out a detailed analysis of the problem detected, especially the consequences that the violation of the principle of innocence entails.
- Descriptive: in the present investigation this method is used to describe the factors of interest for the investigation.
- Systemic: it serves to structure the analysis of the subject and the description of these aspects, through its decomposition into the elements that comprise it.

The Analytic Hierarchy Process (AHP Saaty) was proposed by Thomas Saaty in 1980 (see methodology in [9-11], which is summarized below:

1. Prioritization of the elements of the hierarchical model
2. Binary comparison of elements
3. Evaluation of elements by assigning weights
4. Ranking of the alternatives according to the given weights
5. Synthesis and sensitivity analysis

The VIKOR method was proposed by Serafin Opricovic in 1990 [12]. In this method, the obtained compromise

solution could be accepted by the decision-maker because it provides a maximum group utility (represented by the alternative with the min S) and a minimum individual regret (represented by the alternative with the min R). A summary of it is set out below [13,14, 15, 16, 17]:

1. Determine the weights of the criteria
2. Define the decision matrix
3. Obtain the compromise solution (or solutions) (calculation of f_i^*, f_i^-, for criteria and values S_j, R_j, and Q_j for each alternative)
4. Sort the alternatives. The alternatives are ordered, according to the values of S, R, and Q.
5. Determine as a compromise solution the alternative $A^{(1)}$ that is the best classified according to the value of Q, that is, with the minimum value of Q, if the following two conditions are satisfied:
   a. Condition 1: Acceptable Advantage
   $Q\left(A^{(2)}\right) - Q\left(A^{(1)}\right) \geq DQ$,
   Where $A^{(2)}$ is the second alternative according to the ranking of the values of Q, and $DQ = \frac{1}{N-1}$, with N as the number of alternatives.
   b. Condition 2: Acceptable stability in the decision process
   The alternative $A^{(1)}$ must be the best ranked according to the list of values of S and/or R.
   If one of the conditions is not satisfied, then a set of compromise solutions is proposed, which consists of:
      - Alternatives $A^{(1)}$ and $A^{(2)}$ if condition 2 is not satisfied.
      - Alternatives $A^{(1)}, A^{(2)}, \ldots, A^{(m)}$ and $A^{(m)}$ if condition 1 is not satisfied; is determined by considering the relationship $Q\left(A^{(2)}\right) - Q\left(A^{(1)}\right) \geq DQ$. These alternatives are within the vicinity of the ideal solution

3 Results

To determine the factor that has the greatest incidence in the violation of the right to freedom, the modeling of the AHP Saaty method is carried out. Surveys were designed for the experts to determine the criteria on which to evaluate the excess of the power of the administrators of justice (alternatives). Next, the resulting table is presented with the weights after having carried out the pairwise comparison matrix of the AHP Saaty.

Criteria	a	b	c	d
Establish mechanisms that guarantee responsibility (a)	1	0.2	3.0	3.0
Correctly apply the principle of innocence (b)	5	1	5	7
Promote a true criminal transit system (c)	0.3	0.2	1	1
Defenselessness of the parties (d)	0.3	0.15	1	1
Total	**6.60**	**1.55**	**10.00**	**12.00**

Table 1: Matrix A of pairwise comparison of the criteria. Source: own elaboration.

Criteria	a	b	c	d	Weight
a	0.15	0.13	0.30	0.25	0.20764
b	0.76	0.65	0.50	0.58	0.62152
c	0.05	0.13	0.10	0.08	0.08946
d	0.05	0.10	0.10	0.08	0.08139

Table 2: Normalized matrix. Source: own elaboration

Criteria	W x Weight	Approx. eigenvalues
a	0.844477	4.067086447
b	2.676711	4.30673351
c	0.357440	3.995751946
d	0.326364	4.009855877

Table 3: Exercise consistency analysis. Source: own elaboration

Consistency analysis: Eigenvalue=4.2091764; CI=0.03, CR=0.04<0.10= Consistent.

Consistent to determine the key alternatives to enhance solutions and eliminate existing system failures, the following hierarchy must be followed: [18, 19, 20, 21, 22, 23]

b>a> c>d>, according to Saaty's AHP modeling.

The AHP Saaty modeling defines as a factor with the highest hierarchical level:

- *Correctly apply the principle of innocence*

To enhance the predominant dimension, the strategies with the best results must be evaluated, therefore, the experts determine 6 criteria to be evaluated in this dimension and determine the resulting weight. It is decided to repeat the AHP Saaty method to the following criteria:

Criteria to evaluate

- Reduce the procedural burden (C1),
- Sense of proportionality (C2),
- Training (C3),
- Obtain the correct preliminary report (C4)
- Compliance with due process (C5),
- Knowledge of traffic laws (6)
- Preparation of lawyers (7)
- proportionality principle (8)

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	Weight
C1	0.07	0.18	0.15	0.04	0.06	0.14	0.12	0.13	0.11
C2	0.02	0.06	0.15	0.04	0.06	0.14	0.12	0.21	0.10
C3	0.02	0.02	0.05	0.04	0.06	0.14	0.12	0.04	0.06
C4	0.35	0.29	0.25	0.20	0.15	0.23	0.19	0.21	**0.24**
C5	0.49	0.41	0.36	0.60	0.44	0.23	0.27	0.29	**0.39**
C6	0.02	0.02	0.02	0.04	0.09	0.05	0.12	0.04	**0.05**
C7	0.02	0.02	0.02	0.04	0.06	0.02	0.04	0.02	**0.03**
C8	0.02	0.01	0.05	0.04	0.06	0.05	0.04	0.04	**0.04**

Table 4: Normalized matrix. Source: own elaboration

Criteria	Decision matrix by weights	Approximate eigenvalues
C1	1.05	9.532916435
C2	0.86	8.547793002

C3	0.51	8.221445498
C4	2.32	9.852565829
C5	3.73	9.628964804
C6	0.39	7.971787998
C7	0.28	9.549303069
C8	0.34	8.566059876

Table 5: Exercise consistency analysis. Source: own elaboration.

Consistency analysis: Eigenvalue= 8.98385; CI=0.14; CR=0.10=0.10. consistent

Consistent After obtaining the weight of each criterion, it is decided to evaluate the strategies with the best results against the violation of due process. For the modeling, it is decided to apply the VIKOR method to define the decision matrix and define the strategies with the greatest potential to ensure that the administration of justice makes an adequate application of the constitutional principles, in this case, the right to freedom. To process the information, a team (made up of an end user, an occasional user, and a technical advisor) analyzes the information obtained and models the method. [24, 25]

Code	Alternatives	Scope
A1	Research	• Achieve a trial with sufficient evidence that cannot be easily distorted. • Get to the truth of the facts, through technical elements that manage to establish whether the defendant is to blame or not.
A2	Reform regulations of the laws that define the presumption of innocence	• Protect the rights of freedom, • Determine the methodological procedure for the application of the constitutional principle of presumption of innocence • Shape an effective reform that provides an improvement in the administration of justice
A3	Transform objectivity on the part of the judges of the room	• Carry out the scale of crimes according to their seriousness, for the application of the exceptional nature of preventive detention
A4	Strengthen compliance with the legal norm	• Review the excess of the power of justice administrators when dictating preventive detention.
A5	Strengthen the legal system	• Discriminate application of legal precepts. • Theoretically based on the application of the principle of presumption of innocence • Educational seminars for justice operators and officials of the Judiciary Council

Code	Alternatives	Scope
A6	Reform the requirements for obtaining a driver's license	• Guide and train drivers on the rules that regulate transportation and road safety. • Deepen the performance of tests for drivers.

Table 6: Alternatives and scope. Source: own elaboration

Once the evaluation of each alternative for each criterion has been obtained (see Table 9) and the vector of weights of the AHP Saaty, the VIKOR method is applied to obtain the ranking of alternatives, and thus determine the compromise solution or solutions, which will be the most suitable alternatives.

For this, determine the f_i^*, and the worst f_i^-, values of the different alternatives for each criterion, so that through the VIKOR method it is established which solution is closest to the solution. In this sense, the values f_i^* and the worst f_i^-, are those values of each alternative that for each criterion would be closer and farther, respectively, from the ideal solution (Table 10). It includes the measures of utility S_j and regret R_j and the Index Q_j of each alternative (see Tables 11 and 12).

	C1	C2	C3	C4	C5	C6	C7	C8
Weight	**0.11**	**0.10**	**0.06**	**0.24**	**0.39**	**0.05**	**0.03**	**0.04**
fj	**Max**	**min**	**Max**	**Max**	**Max**	**Max**	**Max**	**Max**
A1	9	5	5	9	9	7	8	8
A2	9	1	7	9	9	3	9	9
A3	9	2	2	1	9	7	8	5
A4	9	2	7	2	9	7	8	8
A5	8	1	5	3	7	3	7	8
A6	8	8	7	3	7	3	8	9
Better f_i^*	**9**	**1**	**7**	**9**	**9**	**7**	**9**	**9**
Worse f_i^-	**8**	**8**	**2**	**1**	**7**	**3**	**7**	**5**

Table 7: Linear normalization of the decision matrix. Source: own elaboration

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8	S_j	R_j
A1	0.00	0.06	0.02	0.00	0.00	0.00	0.01	0.01	**0.10**	**0.06**
A2	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	**0.05**	**0.05**
A3	0.00	0.01	0.06	0.24	0.00	0.00	0.01	0.00	**0.32**	**0.24**
A4	0.00	0.01	0.00	0.21	0.00	0.00	0.01	0.00	**0.23**	**0.21**
A5	0.11	0.00	0.02	0.18	0.39	0.05	0.03	0.00	**0.78**	**0.39**
A6	0.11	0.10	0.00	0.18	0.39	0.05	0.01	0.00	**0.84**	**0.39**

Table 8: Measure of utility and regret of each alternative. Source: own elaboration

For the classification of the alternatives, it is evaluated for av ~ 0.5 (vote by consensus)

Alternatives	S_j	R_j	v	Q_j	Hierarchy
A1	0.10	0.06	0.5	0.05	2
A2	0.05	0.05		0.00	1
A3	0.32	0.24		0.45	4
A4	0.23	0.21		0.35	3

A5	0.78	0.39	0.96	5
A6	0.84	0.39	1.00	6

Table 9: Index of each alternative. Source: own elaboration

Alternatives	Q(a'')	Hierarchy	Q(a')	N	Q(a'') - Q(a')	DQ	Q(a'') - Q(a') ≥ DQ
A1	0.05	2	0.00	6	0.05	0.2	fails
A2	0.00	1			0.00		fails
A3	0.45	4			0.45		passes
A4	0.35	3			0.35		passes
A5	0.96	5			0.96		passes
A6	1.00	6			1.00		passes

Table 10: Acceptable lead condition. Source: own elaboration.

The condition of acceptable advantage in alternative A2 is met. It is decided to apply the condition of acceptable stability in the decision process (see Figure 3).

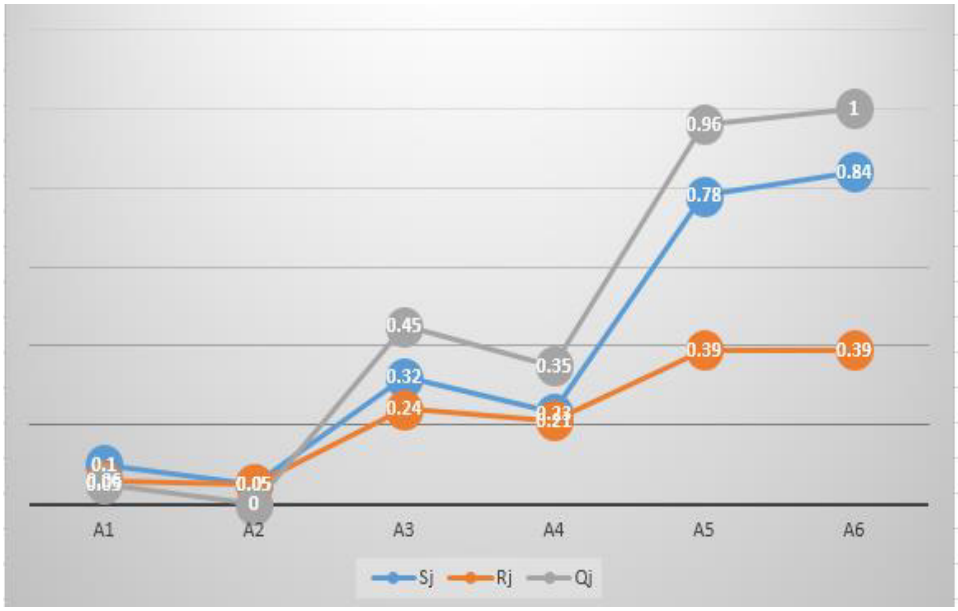


Figure 3: Graphic representation of the analysis of $S_j, R_j$and Q_j. Source: own elaboration

The graph shows a minimum of the values S_j, R_j and Q_j, in the case of alternative (A2) meets the condition of being best classified in Q_j and it is also best classified by R_j and S_j with a value of 0.05. It is defined as the best alternative to guarantee due process and to reform the regulations of laws that regulate the presumption of innocence. A2 meets the criteria:

- Institutionalize a true criminal traffic system,
- Train justice officials and administrators on traffic regulations,
- Theoretically based the application of the principle of presumption of innocence in traffic accident crimes.
- Propose a regulatory reform of this figure to adapt it to the constitutional postulates and avoid the violation of civil rights.

Conclusion

There is indeed a violation of the presumption of innocence and the right to freedom of those involved in traffic accidents. It has been shown that the administrators of justice do not make differences or distinctions in the norms for their application for this concept. In this sense, the administrators of justice in traffic matters, despite being guarantors of the rights of Ecuadorian citizens, indiscriminately apply the provisions of article 167 of the Code of

Criminal Procedure and the provisions of article 534 of the Organic Integral Penal Code.

Judges must define and guarantee the fundamental principles of impartiality, justice, and freedom since *due process* is a constitutional guarantee directly related to the country's peaceful coexistence and legal security. Guaranteeing a correct administration of justice, in addition to real validity and respect for human rights, is the mechanism for applying the principles and guarantees of constitutional, criminal, and procedural law.

Propose a reform project to the Organic Law of Land Transport, Traffic and Road Safety, and other regulations on the matter, which allow protecting the rights of freedom, the principle of proportionality, and the principle of legality. In addition to reviewing the regulations that apply in this class of hearings and correcting this and other shortcomings that are detected not to allow violations of rights granted by the supreme norm in force.

References

[1] Ingenie, "How to get over failing your driving test," ed: blog.ingenie, 2019.

[2] N. Hosseinichimeh, R. Williams, R. MacDonald, K. Li, and F. E. Vaca, "What determines the success of states in reducing alcohol related crash fatalities? A longitudinal analysis of alcohol related crashes in the U.S. from 1985 to 2019," Accident Analysis & Prevention, vol. 174, p. 106730, 2022/09/01/ 2022.

[3] N. Unidas, Glo*bal Plan for the Decade of Action for Road Safety 2021-2030*, 2021.

[4] A. Olowosegun, N. Babajide, A. Akintola, G. Fountas, and A. Fonzone, "Analysis of pedestrian accident injury-severities at road junctions and crossings using an advanced random parameter modelling framework: The case of Scotland," Accident Analysis & Prevention, vol. 169, p. 106610, 2022/05/01/ 2022.

[5] D. R. Willett and A. Gordon. (2022) The Collapse of Constitutional Remedies. The Yale Law Journal. 2020-2386. Available: https://www.yalelawjournal.org/review/rights-structure-and-remediation

[6] Steven A. Steinbach, Maeva Marcus, and R. Cohen, With Liberty and Justice for All?: Oxford University Press, 2022.

[7] A. Chilton and M. Versteeg, "IS A SCIENCE OF COMPARATIVE CONSTITUTIONALISM POSSIBLE?," HARVARD LAW REVIEW vol. 135, pp. 2110-2149, 2020.

[8] M. Antoniazzi, " Advisory Opinion OC-26/20, Denunciation of the American Convention on Human Rights and the Charter of the Organization of American States and the Consequences for State Human Rights Obligations. ," *American Journal of International Law,* vol. 116, pp. 409-416, 2022.

[9] J. E. Ricardo, Z. M. M. Rosado, E. K. C. Pataron, and V. Y. V. Vargas, "Measuring legal and socioeconomic effect of the declared debtors usign the ahp technique in a neutrosophic framework," Neutrosophic Sets and Systems, vol. 44, pp. 357-366, 2021.

[10] L. K. Baque-Villanueva, D. A. Viteri-Intriago, L. K. Álvarez-Gómez, and A. M. Izquierdo-Morán, "Business Plan for Entrepreneurs, Actors and Organizations of Social and Solidarity Economy based on Neutrosophic AHP-SWOT," Neutrosophic Sets and Systems,, vol. 37, pp. 224-234, 2020.

[11] R. G. Ortega, M. L. Vázquez, J. A. S. Figueiredo, and A. Guijarro-Rodriguez, "Sinos river basin social-environmental prospective assessment of water quality management using fuzzy cognitive maps and neutrosophic AHP-TOPSIS," Neutrosophic Sets and Systems,, vol. 23, pp. 160–171, 2018.

[12] S. Opricovic and G. H. Tzeng, "Extended VIKOR method in comparison with outranking methods. European Journal of Operational Research," vol. 178(2), pp. 514–529. , 2007.

[13] S. Opricovic, & Tzeng, G. H. , "Extended VIKOR method in comparison with outranking methods," *European Journal of Operational Research,* vol. 178, pp. 514-529, 2007.

[14] H. Paronyan, R. M. Carballido, and M. A. Matos, "Neutrosophic VIKOR for Proposal of Reform to Article 189 of the Integral Criminal Code in Ecuador," *Neutrosophic Sets and Systems,* vol. 37, pp. 287-294, 2020.

[15] C F. Benavides Salazar, J. C. Benavides Salazar, A. L. Santillán Molina, & S. J. Santillán Ojeda. "Efectividad del habeas corpus en defensa de los derechos a la libertad, a la vida e integridad física, en tiempos de pandemia". Universidad y Sociedad, Vol. 14 Num. S2, pp- 432-439, 2022.

[16] F P. Cañizares Galarza, N. V. Quevedo Arnaiz, & N. García Arias. "Aproximación a indicadores de calidad en un estudio sobre la revista Mikarimin". Universidad y Sociedad, Vol. 14 Num. S2, pp- 423-431, 2022.

[17] L. X. Cangas Oña, L. B. Salazar Andrade, E. L Hernández Ramos & J. X. Iglesias Quintana. "Vaguedad del ordenamiento jurídico ecuatoriano referente al uso progresivo de la fuerza". Universidad y Sociedad, Vol. 14 Num. S2, pp- 415-422, 2022.

[18] A Romero Fernández, I. Alonso González, L. F. Latorre Tapia, & G. A. Álvarez Gómez. "Procedimiento para el mejoramiento de la gestión de los servicios de alojamiento en hoteles de destinos de sol y playas. Revisión de literatura". Universidad y Sociedad, Vol. 14 Num. S2, pp- 406-414, 2022.

[19] P. A. Mena Silva, N. M Pérez Seminario & S. O Espinoza Guevara. "Comparación entre toxina botulínica tipo A y férulas oclusales para tratamiento de bruxistas". Revisión de literatura. Universidad y Sociedad, Vol. 14 Num. S2, pp- 398-405, 2022.

[20] P. Hayk, M. R. Meléndez Carballido, M. Alfaro Matos & K. E. Carrión León. "Genocidio cultural y la cuestión del Tibet". Universidad y Sociedad, Vol. 14 Num. S2, pp- 391-397, 2022.

[21] R. González Salas & I. Pimienta Concepción. "El enfoque "Una sola salud" y las zoonosis reemergentes". Revista Universidad y Sociedad, Vol. 14 Num. S2, pp- 385-390, 2022.

[22] Ricardo, J. E., & Vázquez, I. R. S. "La educación sexual para padres de niños con retraso mental, una vía para su consolidación". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 4 no. 3, pp 137-144, 2019.

[23] Leyva, M., Estupiñán, J., Coles, W., & Bajaña, L. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, pp 130-135, 2021.
[24] Acuña, B. P., & Von Feigenblatt, O. F. "La lengua y la literatura en el aula del futuro enmarcado en el aprendizaje personalizado. In Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones" (pp. 13-24). Ediciones Octaedro, 2022.
[25] von Feigenblatt, O. F., Calderon, R. D., & MacDonald, T. "The Case for an Eclectic and Flexible Leadership Research Agenda: Dealing with Social Justice and Diversity in the 21st Century Workplace". Centro Sur, vol. 6 no. 1, pp 130-142, 2022.

Received: August 06, 2022. **Accepted:** October 06, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic IADOV in the Analysis of Child Labor and its Causes

Raúl Fabricio Sánchez Santacruz[1], Mesías Elías Machado Maliza[2], Cristina Mercedes Rosero Morán[3], and Andrea Katherine Bucaram Caicedo[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.raulsanchez@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.mesiasmachado@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.cristinarm00@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.andreabucaram@uniandes.edu.ec

Abstract. In Ecuador, there is a systematic regulatory legal framework that contemplates child labor in correspondence with the provisions of international organizations, institutions, treaties, and conventions. A work that is prohibited if its nature or the conditions in which it is carried out, is likely to harm the physical and mental development, health, safety, and morality of minors. The objective of this work is to analyze child labor and its causes. This kind of work is exercised by girls, boys, and adolescents and it hinders, among other things, access to education for those minors. To investigate the causes that provoke it, it is decided to use the Iadov neutrosophic method, to analyze the consensus and acceptance of the experts. It is concluded that poverty is the main cause of child labor. So, the ability of the poorest families to protect their children should be supported.

Keywords: child labor, poverty, Iadov, Neutrosophy.

1 Introduction

The number of boys, girls, and adolescents who are dedicated to work and are exploited economically is significant. It is very common to see children who carry out the most varied tasks in public places, even in the surrounding area of government institutions, which reveals that in practice the provisions and regulations are systematically violated [1]. The International Labor Organization defines child labor as all work that deprives children of their childhood, their potential, and their dignity, and that is detrimental to their physical and psychological development.

This definition identifies as child labor any activity that deprives the boy or girl of the enjoyment of the rights of that age, such as education, health, and recreational activities that are so important for the psychosocial development of the individual and that damage their physical, mental and/or moral, well-being, as stipulated in article 48 of the Code for Children and Adolescents when expressing the obligation of the State to assume this care [1]. Child labor can be understood as all those activities that generate risk and systematic vulnerability of human rights and limit the comprehensive development of children and adolescents who are exploited. Although not all its forms are harmful to the lives of minors. If the work does not harm their health, or their physical and mental development, and does not interfere with their school activities, it is a positive activity that contributes to the comprehensive education of children and adolescents (Figure 1).

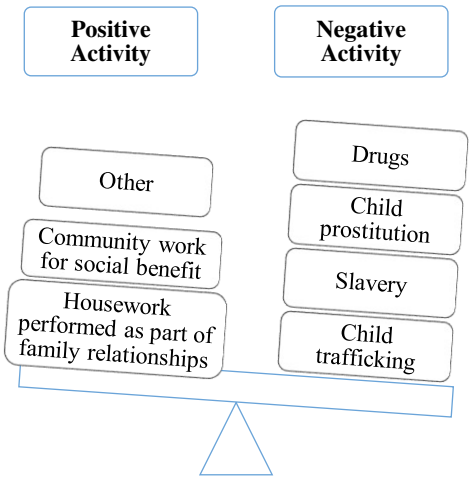


Figure 1: Child labor. Source: own elaboration

The legal and technical criterion is that child labor is that which is carried out by a minor under 18 years of age. It is aimed at obtaining economic returns, through the offer of a good or service, whether paid or not, performed temporarily or permanently, both in the family environment, as well as for third parties, with a contractual relationship or in a precarious manner and can be legal or illegal:

- Special protection against any type of labor or economic exploitation.
- The work of minors under the age of fifteen is prohibited, and
- Policies for the progressive eradication of child labor should be implemented.
- The work of adolescent girls and adolescents will be exceptional, and
- It may not violate the right to education or be performed in situations that are harmful or dangerous to health or personal development.

The concept of child labor differs from adolescent work. In this sense, the United Nations Children's Fund recognizes child labor as "all work activity, paid or not, carried out by boys and girls under 15 years of age that hinders their educational process or affects their health and integral development. Meanwhile, adolescent work is when this activity is carried out by people over 15 and under 18 years of age. In Ecuador, child labor is defined as "any paid or unpaid activity carried out by boys, girls and adolescents below the general minimum age for admission to employment in the production, marketing, processing, sale or distribution of goods or services; or that carried out by adolescents in conditions of violation of the norms that regulate the work of adolescents". For UNICEF, child labor refers to the population between 5 and 14 years old that is involved in work activities. More specifically, a boy or girl is considered to be in child labor under the following classification [2]:

1) boys and girls between 5 and 11 years old who worked at least one hour a week in some economic activity or at least 28 hours a week in domestic work; and
2) boys and girls between 12 and 14 years old who work at least 14 hours a week in paid activities, or at least 28 hours a week in domestic activities.

Although there is extensive literature on the consequences of child labor on immediate child well-being, there has not been enough debate, outside of academic circles, on the medium-term effects that child labor has on labor markets, poverty, well-being, and economic development, as well as in the future development of children and, therefore, in the intergenerational reproduction of poverty. The consequence of this is that the debate and the policies tend to focus on finding mechanisms for compliance with current regulations, which is related to locating the problem in the workplace and family. Child labor is located, from this point of view, in the field of capabilities. Work disables or limits, on the one hand, the achievement of freedoms that occur through learning and experiences.

The phenomenon of child labor has multiple causes, including social, cultural, economic, historical, and political factors. It argues that to achieve the eradication of this social problem, the Ecuadorian State and government must fight the scourge of poverty and guarantee parents a decent job that allows them to meet the needs of the home, with which they will not have to allow and in many cases demand economic cooperation from their offspring through work. Another cause of this problem is associated with social, cultural, and economic inequalities, which uniquely affect the civil rights of children and adolescents.

For reasons of gender, girls are marginalized both in their present and in their future. A girl marginalized from her origins and without education has a high probability of becoming the mother of a child forced by circumstances to work prematurely. This unfortunate probability transcends from generation to generation, hindering initiatives to eliminate child labor in its entirety [3]. The elimination of child labor must be a priority state policy, which must be institutionalized and integrated into all social agendas and national government programs [4]. To achieve a progressive elimination of child labor, international organizations, ministries, and commissions for the eradication of child labor in each country have agreed that it is necessary to adopt social, state, legislative, educational, cultural, and economic measures [5].

In the country, the minimum age to work legally is 15 years, as long as this does not affect the physical and psychological development and access to all rights of adolescents. To achieve a society of Good Living, it is necessary that children and adolescents stop working and recover their rights to study, play, receive medical attention and share with their families. In the diverse international and national regulations, as well as in the policy guidelines defined by the countries, there is no uniformity in determining the minimum age to socially, culturally, and legally accept child labor [1]. In this context, the United Nations system and the permanent secretariat of the International Labor Organization (ILO) define child workers as those who enter the labor market and perform excessive work at a very young age [6].

Work is the activity that dignifies us and allows us to lead a stable life, but when minors are immersed in it, it can be determined as a violation of human rights, since child labor harms the development of children, and adolescents and may affect their physical and moral integrity with damage that will probably last for a lifetime. Throughout history, it can be concluded that the origins of child labor date back to the 16th century when children

began to be integrated into mining operations since they had the perfect size to access spaces that an adult body could not reach. Then in the eighteenth century with the industrial revolution, it was considered that child labor was of vital contribution since minors have always helped their parents with household tasks. Therefore, at the time, it was not considered a problem since throughout history and in all kinds of cultures, for example in Latin America, children had always contributed to the home.

But some time later it did bring negative consequences since the heavy work left as a result that many children were disfigured or died when trying to perform certain dangerous jobs and that is where the slogan of child exploitation was born. And because of that in 1919, the ILO adopts a convention that prohibits the work of children under 14 years of age in the industrial sector. These activities must be carried out in appropriate conditions for their age, ability, physical condition, and intellectual development while respecting their moral and cultural values, and their rights to rest, recreation, and play.

Generally, child labor occurs in precarious conditions, children and adolescents are forced at an early age to carry out activities that place them in total vulnerability and risk their health and add the fact that their body is not fully developed and thus affecting their full growth and depriving them of growing in a healthy environment. All children and adolescents have the right to grow up in a healthy environment, that is, to live, study and play in healthy places. These factors are grouped into two large groups, the direct and indirect ones that bring together aspects of the family economy, socio-cultural aspects, and regional and national capacities to respond to this situation.

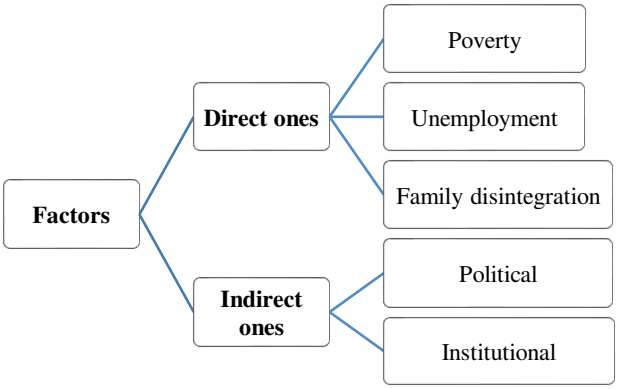


Figure 2: Most relevant factors. Source: own elaboration

Governments, parents, and citizens, in general, must become aware of the necessary elimination of the labor exploitation of children and adolescents due to the seriousness that it entails not only for the minor and his family but also for society. Among the consequences that derive from this phenomenon are the physical, psychological and social ones [7]. Until July 2011, Ecuador released 2,160 girls, boys, and adolescents from work in garbage dumps; being the first country in Latin America to eradicate child labor in these spaces. In 2012, 238 flower growers and 396 companies in the agriculture, livestock, hunting, and forestry branches were inspected and processes for the restitution of the rights of children and adolescents were managed. In addition, that same year it was possible to eradicate child labor in municipal slaughterhouses nationwide. [24, 25]

These achievements are constantly monitored by the Ministry of Labor Relations and since this year its work has been focused according to the danger and the highest incidence by branches of work in each province, to optimize the work of identifying and disassociating child labor according to the territorial problem. Additionally, the Child Labor Eradication Project implements the business network for a country free of child labor. It is a public-private alliance, framed in corporate social responsibility, which has the support of the United Nations Children's Fund (UNICEF). The Network seeks to develop strategies and exchange good practices for the eradication of child labor among the 15 member companies: National Telecommunications Corporation, OCP, El Comercio, Danec, Diners, Holcim, Petroamazonas, Telefónica-Movistar, Cementos La Farge, Poweron, ACE Seguros, Quito Electric Company, Pronaca, TANASA.

As an objective, it is proposed to investigate the causes of child labor. Therefore, it is necessary to raise awareness and sensitize an entire society so that together they can ensure the safety of children and adolescents who in the future can become great minds, humans who, with their contributions, help create a better world, a world where rights are not violated and where there is no doubt that dreams can come true.

2 Materials and methods

To apply the neutrosophic Iadov technique, the experts must base themselves on a linguistic evaluation system that shows their opinion [8] [9]. This system and its neutrosophic and numerical equivalents are shown in Table 3 [8] [10], [17], [18], [19].

Linguistic term	Single Value Neutrosophic Number	Scale
Clearly satisfied	(1; 0; 0)	3
More satisfied than dissatisfied	(1,0.35,0.35)	23
Indeterminate	I	1.5
More dissatisfied than satisfied	(0.35, 0.35, 1)	1
Clearly dissatisfied	(0;0;1)	0
Contradictory	(1;0;1)	2

Table 3: Evaluation system for experts. Linguistic terms are associated with their neutrosophic evaluation and score value. Source: [11]

The term I in neutrosophy is interpreted as a unit of indeterminacy. Another component of the method is the Iadov Logical Table, which assigns numerical values to three closed questions that are applied to the experts. If necessary, open questions can be applied to the surveys [12], [20], [21], [26], [27].

1st Question	Yes			I don't know			No		
2nd Question	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
				3rd Question					
It is a consolidated research process	1	2	6	2	2	6	6	6	6
It is a partially consolidated research process	2	3	3	2	3	3	6	3	6
It does not matter to me	3	3	3	3	3	3	3	3	3
It is a less consolidated research process than it claims to be	6	3	6	3	4	4	3	4	4
It is an unconsolidated research process	6	6	6	6	4	4	6	4	5
I don't know what to say	2	3	6	3	3	3	6	3	4

Table 4: Derivation of Iadov's Logic table. Source: [11]

To survey the level of satisfaction of the experts, the Iadov neutrosophic technique was used. This technique is based on the use of single-value neutrosophic sets (SVNS) associated with linguistic variables or their ability to increase interpretability in recommendation models and the use of indeterminacy [13] [14]. The definition of SVNS is the following:

Let X be a universe of discourse. An SVNS A over X is an object of the form.

$$A = \{[x, u_a(x), r_a(x), v_a(x)] : \in X\}\, dA\, \{[x, u_a(x), r_a(x), v_a(x)] : \in X\} d \quad (1)$$

Where:

$u_a(x): X \to [0,1], r_a(x): X \to [0,1]\ y\ v_a(x): X \to [0,1]$ with $0 \leq\ u_a(X), r_a(X), v_a(X)\ \leq 3, \forall x\ \in X$

For convenience, a SVNN will be expressed as $A = (a, b, c)$, where $a, b, c \in\ [0,1]$ and satisfies $0 \leq a + b + c\ \leq 3$. To find a SVNS set that describes multiple sets at once, aggregation operators are used. One of these operators is the neutrosophic weighted average (WA), which is defined as follows [12]. Let $\{A_1, A_2, \dots, A_n\} \in SVNS\ (x)$, where $A_j = (a_j, b_j, c_j)(j = 1, 2, \dots, n)$, the Neutrosophic Weighted Average Operator (WA) is calculated:

$$WA\ (A_1, A_2, \dots, A_n) = \sum_{i=1}^{n} [w_j\ , A_i] \quad (2)$$

Where:

$WA\ (w_1, w_2, \dots, w_n) = \sum_{i=1}^{n} [w_j\ , A_i]$ is the vector of $(j = 1,2, \dots, n)$ such that $w_n \in [0,1]\ y\ \sum w_j = 1$

To deneutrosophicate this set so that a single value is obtained, a scoring function is usually used [15]. Let A = (a, b, c), the score function S of an SVNS, based on the degree of indeterminate membership and the degree of false membership, is defined by the following equation:

$$S(A) = 2+abc \quad (3)$$

For the use of an SVNS to measure individual satisfaction, this value must be associated with a linguistic variable [8]. Therefore, the scales shown in Table 2 were specified and the corresponding score was calculated using (3). For cases in which the evaluation corresponds to indeterminacy (not defined) (I), a process was developed.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{4}$$

To calculate the Global Satisfaction Index of the respondents (GSI), the WA aggregation operator (2) was used, taking into consideration the score values and that all the respondents have the same weight, so $w_i = \frac{1}{n}$. The instrument designed for the application of the survey was a questionnaire of five questions, of which three are closed (1, 3, and 5) and two are open (2 and 4). The three closed questions were related through the "Iadov Logic Table", which is presented in Table 3 [13] [9]. The algorithm used for the application of the neutrosophic Iadov technique is then the following:

1. Once the questionnaire has been applied, the corresponding value (from 1 to 6) for the satisfaction rating of the surveyed experts is found in Iadov's logical table of three inputs [9], [22], [23].
2. The linguistic variable, the SVNS, and the score according to Table 2 are matched to this value.
3. The score value of each respondent is used to calculate the group satisfaction index (GSI) from the aggregation of all the scores using the WA (2) aggregation operator formula.
4. The GSI is interpreted from the location of the value in the graph in Figure 1.

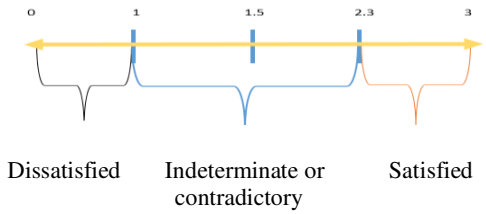


Figure 3: Scale for determining the level of satisfaction according to the scores used. Source: adapted from [16].

The two open questions allowed to complete the assessment of the level of satisfaction of the students with the applied methodology. These are the questions:

1. Do you consider that current regulations protect children and adolescents from child labor? (Question 1)
2. Do you consider that the scope should be developed and specify what elements should be present in the design of new policies? (Question 4)
3. What is your opinion about the economic policies developed by the state? (Question 5)
4. Do you think that campaigns could be developed to link infants to schools again? (Question 2)
5. What do you think about the special protection measures against any type of labor or economic exploitation? (Question 3).

3 Results

From the information obtained from the survey, it is possible to refer to the variables that must define the elements to be considered when evaluating the causes of child labor (see Figure 2) (see Table 5).

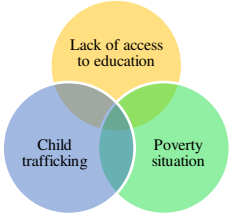


Figure 4: Sub-elements of the neutrosophic set of inequality. Source: own elaboration.

To mitigate the impact of child labor on children and adolescents, the evaluation of each element and sub-element must be analyzed to decide on a possible diagnosis within the neutrosophic set called selective capture (see Table 5).

Code	Items	Sub-elements
E1	Lack of access to education	A poorly functioning education system is related to the proportion of working children. Accessibility and availability of educational resources.
E2	Poverty situation	Low income in the family pushes children to work. Loss of jobs.
E3	Child trafficking	Includes servitude, Organ trafficking.

Table 5: Elements of the neutrosophic inequality set. Source: own elaboration.

From the application of the survey by the group of experts, the results were obtained regarding the individual satisfaction levels shown in Figure 3 and the information regarding the neutrosophic group studied.

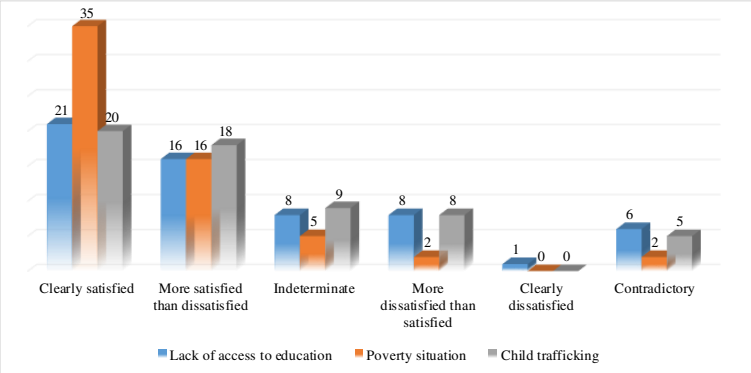


Figure 5: Levels of satisfaction of the group of experts for each element. Source: own elaboration.

Positive levels of satisfaction can be seen in the causes of child labor, with a predominance of the situation of poverty. However, experts are observed to be dissatisfied, especially with regard to child trafficking. Indeterminate and contradictory positions were also found, between the level of belonging of each element. Inequality increased both within and between countries, causing long-term impacts on access to opportunities and social mobility. The calculations of the GSI according to the frequency of observation and the individual satisfaction indices of the designed categories and their corresponding scores are shown in tables 6 to 8, for each group, respectively.

Linguistic term	SVNN	Scoring (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1; 0; 0)	3	18	54	0.90
More satisfied than dissatisfied	(1,0.35,0.35)	23	15	34.5	0.58
Indeterminate	I	1.5	10	15	0.25
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	8	8	0.13
Clearly dissatisfied	(0;0;1)	0	3	0	0.00
Contradictory	(1;0;1)	2	6	12	0.20
	Group Satisfaction Index				2.00

Table 6: Calculation of the Group Satisfaction Index (GSI) of the element Lack of access to education. Source: own elaboration.

Linguistic term	SVNN	Scoring (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1; 0; 0)	3	31	93	1.55
More satisfied than dissatisfied	(1,0.35,0.35)	2.5	14	35	0.58
Indeterminate	I	1.5	7	10.5	0.18
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	5	5	0.08
Clearly dissatisfied	(0;0;1)	0	0	0	0.00
Contradictory	(1;0;1)	2	3	6	0.10
	Group Satisfaction Index				2.58

Table 7: Calculation of the Group Satisfaction Index (GSI) of the Poverty Situation element. Source: own elaboration.

Linguistic term	SVNN	Scoring (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1; 0; 0)	3	23	69	1.15
More satisfied than dissatisfied	(1,0.35,0.35)	2.5	15	37.5	0.63
Indeterminate	I	1.5	10	15	0.25
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	7	7	0.12
Clearly dissatisfied	(0;0;1)	0	0	0	0.00
Contradictory	(1;0;1)	2	5	10	0.17
	Group Satisfaction Index				2.06

Table 8: Calculation of the Group Satisfaction Index (GSI) of the Child Trafficking element. Source: own elaboration.

Of the elements evaluated, only the *poverty situation* element is greater than 2.30, so it is established that the experts agree on integrating fighting economic inequality and low income as part of the process to eliminate child labor. As one of the primary requirements, it would imply drawing the attention of institutions and governments to the possible reductions in the world's absolute rate of poverty. For the elements: *lack of access to education* and *child trafficking;* there is a level of indeterminacy or contradiction between the sub-elements of each element of the neutrosophic set. Indeterminacy studies must be carried out for each sub-element and analyze the degree of belonging that affects the needs of children and adolescents.

These results obtained from the experts' satisfaction with the elements found in the collection set with the Iadov technique, were reaffirmed with the experts' answers to the open questions. Among the most frequent opinions, the lack of resources stands out as incidence variables. Among the contradictions, the experts refer that it is a consolidated process, although each sub-element must be defined and evaluated under conditions of subset and set in the inequality, but they can help to receive equal treatment regardless of social position or economic situation.

Conclusion

Currently, child labor is seen as a problem, but national and regional capacities have not been sufficient to confront it. Although there is evidence of progress in policies and plans to confront child labor, its high incidence in Ecuador and the region shows the need to redouble efforts for its elimination. Early school leaving and early entry into work can negatively influence young people's paths to work.

Support the ability of the poorest families to protect their children from child labor. Establish cash transfer plans, access to bank loans, and health and education insurance. It should receive special treatment in the criminal legal system. The eradication of child labor largely depends on the political will of the governments, which have the necessary resources and decisions to design and implement projects and strategies to fight this problem.

Governments, parents, and citizens, in general, must become aware of the necessary elimination of the labor exploitation of children and adolescents due to the seriousness that it entails not only for the minor and his family but also for society. Child labor hinders access to education for minors; many are illiterate, and others do not finish their basic studies due to the abandonment of the classrooms.

References

[1] J. D. Fluke, L. Tonmyr, J. Gray, L. Bettencourt Rodrigues, F. Bolter, S. Cash, et al., "Child maltreatment data: A summary of progress, prospects, and challenges," Child Abuse & Neglect, vol. 119, p. 104650, 2021/09/01/ 2021.

[2] D. S. Soneson E, Burn AM, et al. Child Maltreatment. 2022 Mar:10775595221079308. DOI: 10.1177/10775595221079308. PMID: 35240863., " Leveraging Administrative Data to Better Understand and Address Child Maltreatment: A Scoping Review of Data Linkage Studies. Child Maltreatment. 2022 Mar:10775595221079308. DOI: PMID: ," Europe PMC, 2022.

[3] E. Allen, "Norms and values: Faith-based advances in child protection," Child Abuse & Neglect, vol. 119, p. 104820, 2021/09/01/ 2021.

[4] L. Williams, V. Gama, R. Oliveira, and S. D'Affonseca, "SOME CHALLENGES IN CHILD ABUSE PREVENTION IN A MIDDLE INCOME COUNTRY: THE BRAZILIAN PERSPECTIVE," Child abuse & neglect, vol. 119, p. 104720, 09/19 2020.

[5] S. Raman, T. Muhammad, J. Goldhagen, R. Seth, A. Kadir, S. Bennett, et al., "Ending violence against children: What can global agencies do in partnership?," Child Abuse & Neglect, vol. 119, p. 104733, 2021/09/01/ 2021.

[6] F. Wulczyn, A. Parolini, and S. Huhr, "Human capital and child protection: A research framework in the CRC context," Child Abuse & Neglect, vol. 119, p. 104610, 2021/09/01/ 2021.

[7] V. Lidchi and A. Wiener, "How can services be improved to effectively address the mental health of vulnerable children and young people?," Child Abuse & Neglect, vol. 119, p. 104648, 2021/09/01/ 2021.

[8] M. Leyva Vázquez and F. Smarandache, Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre. Bruselas: Pons, 2018.

[9] N. Batista, N. Valcárcel, M. Leyva-Vázquez, and F. Smarandache. (2018) Validation of the pedagogical strategy for the

formation of the competence entrepreneurship in high education through the use of neutrosophic logic and IADOV technique. Vol. 22. Neutrosophic Sets and Systems.

[10] J. L. Salmeron and F. Smarandache, "Redesigning Decision Matrix Method with an indeterminacy-based inference process. Multispace and Multistructure. ," Neutrosophic Transdisciplinarity (100 Collected Papers of Sciences), vol. 4, p. 151, 2010.

[11] V. V. Falcón, J. L. T. Espinoza, A. R. L. Yacelga, and L. O. A. Zambrano, "Managing Contradictions in Software Engineering Investigations using the Neutrosophic IADOV Method," *Neutrosophic Sets and Systems,,* vol. 44, pp. 100–107, 2021.

[12] M. A. Andino-Herrera, Cuenca-Díaz, H. Paronyan, and V. Murillo. (2019) Use of the neutrosophic IADOV technique to diagnose the real state of citizen participation and social control, exercised by young people in Ecuador. Neutrosophic Sets and Systems, 26. 169-173.

[13] L. Guerrero Morales, R. W. Proenza Ventura, and A. H. González. (2019) Iadov Neutrosofico para medir la satisfacción de los docentes con la aplicación del Solver de Excel en la programación lineal. . Neutrosophic Computing and Machine Learning, Vol. 5. 14-25.

[14] M. G. M. E.-h. Abdel-Basset, A.; Smarandachec, F., A novel model for evaluation Hospital medical care systems based on plithogenic sets," vol. 100,: Artif Intell Med, 2019.

[15] A. S. W. Alfredo-Cacpata, Gil-Betancourt, N. J. Enríquez-Guanga, and K. T. Castillo-Núñez. (2019) Validation of the proof reversal on the inexistence of untimely dismissal by using neutrosophic IADOV technique. Neutrosophic Sets and Systems, 26(Special Issue: Social Neutrosophy in Latin America), 45-51.

[16] V. V. Falcón, J. L. T. Espinoza, A. R. L. Yacelga, and L. O. A. Zambrano. (2021) Managing Contradictions in Software Engineering Investigations using the Neutrosophic IADOV Method. *Neutrosophic Sets and Systems*. 100-107.

[17] B D. Narváez Montenegro, F.J Caicedo Banderas, E. J. Naranjo Luzuriaga & F. D. Guaigua Vizcaíno. "El goce de la licencia de maternidad en el Ecuador". Universidad y Sociedad, Vol. 14 Num. S2, pp- 379-384, 2022.

[18] W. A. Cacpata Calle, V. V. Ponce Meza, A. S. Gil Betancourt, & J. P. Pardo. "La conciliación como mecanismo de justicia restaurativa en el delito de robo: cantón Santo Domingo". Universidad y Sociedad, Vol. 14 Num. S2, pp- 373-378, 2022

[19] A L. Santillán Molina, N. V. Vinueza Ochoa & C. F Benavides Salazar. "La infracción al deber objetivo de cuidado en el proceso de Hardening". Universidad y Sociedad, Vol. 14 Num. S2, pp- 364-372, 2022.

[20] M. M Vidal del Río & A. A. Monsalve Guamán. "Babesiosis humana, una zoonosis emergente". Universidad y Sociedad, Vol. 14 Num. S2, pp- 358-363, 2022.

[21] I A. Cruz Piza, L. J. Bajaña Bustamante & M. O Morales Campoverde. "Derechos de la naturaleza en Ecuador". Universidad y Sociedad, Vol. 14 Num. S2, pp- 351-357, 2022.

[22] R. A. Diaz Vásquez & A. R. León Yacelga. "La gestión de producción del hato lechero de la finca "Playa Alta" del cantón Tulcán a través de una aplicación Web". Universidad y Sociedad, Vol. 14 Num. S2, pp- 344-250, 2022.

[23] R. A. Diaz Vásquez & A. R. León Yacelga. "Alternativa tecnológica de seguridad comunitaria en tiempos actuales". Universidad y Sociedad, Vol. 14 Num. S2, pp- 337-343, 2022.

[24] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[25] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.

[26] von Feigenblatt, O. F. "Education, culture, and underdevelopment: Haiti's tragic failure". Universidad y Sociedad, vol. 14 no. 3, pp 604-611, 2022.

[27] von Feigenblatt, O. F., Peña-Acuña, B., & Cardoso-Pulido, M. J. "Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones". Ediciones Octaedro, 2022.

Received: August 06, 2022. **Accepted:** October 07, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Violation of the Rights of Older Adults

Genaro Vinicio Jordan Naranjo [1], Nelly Valeria Vinueza Ochoa [2], Mónica Del Rocio Mosquera Endara [3], and Jessica Johanna Santander Moreno[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.genarojordan@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail ub.nellyvinueza@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.monicamosquera@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.jessicasm33@uniandes.edu.ec

Abstract. The present work aims to mitigate conflicts faced by older adults, due to the vulnerability to which they are subjected and the non-observance of their rights. From this, an analysis is made of the role of human rights and the constitutional rights of older adults. It is evident that to assess the living conditions of the elderly, some aspects such as culture, the social environment, food, and social security, which directly affect the reality of the elderly. To this extent, the objective of this research is to identify intervention strategies for the violation of the rights of the elderly. For the modeling of the study, the Delphi method was used to determine the factors that affect the violation of the rights of the elderly. It is concluded that the state bodies must carry out periodic assessments of plans, programs, and projects to benefit the care of the elderly and to improve, restructure or expand the coverage and quality of services for this group of people.

Keywords: violation of rights, older adult, Delphi method.

1 Introduction

The aging of the population currently experienced in Latin American countries has brought with it challenges for society and States. The elderly, due to their inactive status, their higher levels of dependence on others, and their growing frailty, are a vulnerable group that is numerically very significant. However, they are at a disadvantage when it comes to lobbying for increased rights. In addition to the prevention of the violation of the human rights and freedoms of the elderly and the elimination of all forms of abuse [1]. The Constitution of the Republic, articles 35 and 36, determines that the elderly must receive priority attention and specialized attention [2]. Just as article 37 provides that the State will guarantee older adults the following rights [3]:

a) free and specialized health care,
b) remunerated job,
c) universal retirement,
d) reduction in private transport services and shows,
e) exemptions in the tax regime,
f) exemption from payment of notarial and registry costs, and
g) access to housing that ensures a decent life.

The Inter-American Convention on the Protection of the Human Rights of Older Persons implies a substantive normative advance for the protection of the human rights of these persons. This instrument presents an opportunity not only to expand legal protection mechanisms but also to place older persons in a new category. By locating the elderly as an object and subject of human rights discourse, a new form of enunciation is inaugurated that has the power to produce understanding regarding old age. They enable new emancipatory practices with the power to reinterpret the role of older people in the social space [4].

Article 17 of the Additional Protocol to the American Convention on Human Rights in the area of Economic, Social, and Cultural Rights establishes the right to special protection during old age. Provide adequate facilities, as well as food and specialized medical attention to elderly people who lack it and are unable to provide it for themselves. Execute specific work programs aimed at granting them the possibility of carrying out a productive activity appropriate to their abilities, which respects their vocation or wishes. Stimulate the formation of social organizations aimed at improving their quality of life [5].

All older adults have the right to a dignified old age, with quality and human warmth. They can live fully and without discrimination, and have access to education and culture [6]. Actively participate in society and contribute experiences and skills; as well as organize freely. Receive support and care from family; to access social, health,

and legal services. The State is responsible for adopting public policies for the protection, care, recreation, rest, and social occupation of older adults, under their capacities and possibilities. Prohibits and sanctions all forms of abuse, abandonment, violence, and discrimination against older adults [7].

There is an epidemiologically proven relationship between disease and aging. This does not mean that all diseases increase with age. Some diseases are related to age, which are more frequently associated with a specific age, and diseases that depend on age, for example, Alzheimer's disease, which increases its incidence exponentially as age increases. Privatization and decentralization of health services tend to focus on public health priorities based on the cost-effectiveness of their actions and not necessarily on the fair distribution of health resources [1, 3, 8].
Social vulnerability in old age has been addressed, above all, by identifying high-risk groups, such as poor, dependent, and isolated older adults. This approach has contributed to maintaining the stereotypes of the group rather than favoring strategies for their reduction. Vulnerability is the product of social processes that generate unequal exposure to risks and situations of crisis and stress, where certain individuals and groups, such as the elderly, are more prone [9].

The greatest vulnerability of older adults is to health problems. This means that differentiated and appropriate human, technological and material resources are required for health care, at a stage of life in which diseases tend to be chronic and not acute. The distribution of health resources and the barriers to accessing them vary enormously. The decision on the allocation of public health resources for the prevention of dysfunction and disability is an important issue of distributive justice related to public health and aging.
The human rights law provides for people over 60 years of age to:

- Live with integrity, dignity, and preference.
- Receive dignified and appropriate treatment by the authorities in any jurisdictional process.
- Receive medical services and training and guidance regarding their health, nutrition, hygiene, and all those aspects that favor their personal care.
- Education,
- Work and social assistance.
- They may have a say in decisions that directly affect their well-being.
- They have the right to report any transgression of government organizations and el Access to public services.

In society, the elderly must not be socially marginalized or discriminated against in any public or private space that violates human dignity and has the purpose of annulling or undermining their rights or freedoms. Any person 60 years of age or older who considers their rights violated, can go to the National Human Rights Commission, to hear complaints related to alleged violations thereof. Go to systems for the Integral Development of the Family. In case of crimes against the elderly, you can go directly to the Attorney General's Office or the Attorney General's Office of the federal entities.

In recent years there have been advances in the incorporation of standards and care programs for the elderly. In the direct experience of care in public services, mistreatment in the quality of care and the provision of information is common. Situations of undertreatment have been detected in health care, in which complete treatment is not granted or the total population that presents a diagnosis is not treated, due to lack of visibility, prejudice, and naturalization of the disease in old people. Thus, situations of discrimination based on age or ageism are observed, which produce a violation of the right to health protection. The elderly population shows a diversity of social realities, education, family roles, technical or cultural belonging,

Research indicates that among the factors that determine the social vulnerability of heterogeneous populations aged 60 and over, age, sex, and educational level stand out. However, the social vulnerability of older adults is not only determined by their demographic characteristics. But it is also the product of the combination of characteristics and interactions between social risks, threats and exposures, assets, and coping capacities in specific environmental contexts. One of the reasons that originate the mistreatment of older adults is given by the deterioration of family relationships. Likewise, the stress of the caregiver that can lead to abuse is highlighted, especially when it comes to caring for a sick and dependent person who constitutes a burden for the person and mainly when support is scarce, non-existent, or difficult to access for economic reasons by the community.

Family abuse is a reality, from cases of neglect and abandonment. Retirement implies a loss of the status of an active and useful person to society and can become a path to social isolation. The older adult in a situation of poverty can also experience various situations that reduce their quality of life, such as poor nutrition, difficulty in accessing some goods and services, and inadequate housing conditions. Social isolation and lack of support networks affect the mental health of older people and even more so in dependent adults. Loneliness, and lack of help to carry out their basic daily activities, can plunge them into severe depressive states.

Special attention has been paid to the increase in social vulnerability with retirement. This implies a significant reduction in income and a significant threat of falling into poverty and deteriorating quality of life, linked to factors such as isolation, exclusion, and rejection. This circumstance is aggravated in the most vulnerable individuals without a pension or with an insufficient pension, generally related to informal employment and a low level of

education, while it may be accompanied by a chronic illness and the lack of informal and welfare assistance.

Researchers show that those households, whose main provider of help and economic support is the elderly, are more exposed to threats associated with their loss, such as neglect of the care of grandchildren and dependent elderly people, and the dispersion of members of the home. Sometimes, it is often overlooked that changes in the family environment exposed to threats, such as the unemployment of the head of the household and the illness of the caregiver, can generate abandonment, mistreatment, and neglect of the elderly. Likewise, new situations in the family unit linked to separation, divorce, and the death of one of the spouses, increase the difficulties, especially for economically dependent widowed women, to face household expenses and enable family and social relationships.

In developing countries, such as Mexico, where there are high rates of the population aged 60 and over without medical coverage and with very limited coverage, older adults are more exposed to problems of access to health services. The direct consequence is the delay in treatment and the worsening of the health of the elderly, as well as the loss of income that aggravates situations of vulnerability in the face of new risks. Chronic diseases generate economic costs that cannot be borne by millions of older adults or their families, even in the poorest households.

There are some deficiencies in physical and human capital, problems of accessibility to basic services and equipment, in which older adults present a high risk of disability and dependency, and a moderate risk of social exclusion; and urban areas of low vulnerability, located in central and peripheral areas with high accessibility to high-quality equipment and services and a predominance of nuclear and single-person families, where older adults register a low risk of social exclusion and a high risk of disability and dependency.

The coronavirus (COVID-19) pandemic has exacerbated discrimination and gender inequalities, while at the same time bringing to the forefront the enjoyment of all human rights by older persons [10]. Mortality rates for those over 80 years of age are five times the world average. Less visible, but no less worrying are the broader effects:

a) medical care denied for conditions unrelated to COVID-19;
b) neglect and abuse in institutions and care facilities;
c) an increase in poverty and unemployment;
d) the dramatic impact on well-being and mental health; and
e) the trauma of stigma and discrimination.

All of which caused untold fear and suffering among older people around the world. So efforts to protect older people should not overlook the many variations within this category, their incredible resilience, and positivity, and the multiple roles they play in society, including as caregivers, volunteers, and community leaders. In addition to that, every citizen must intensify their efforts to support the elderly. Every effort must be made to preserve your rights and dignity at all times.

Enjoying personal integrity is a fundamental right of immediate application that guarantees all people are protected against unfair acts that harm or deteriorate their physical or mental health. Every person has the right not to be the victim of behaviors that cause detriment or impairment to their psychophysical integrity. The authorities and officials of the health system are obliged both to refrain from incurring in conduct that undermines the integrity of patients and to act in order to adopt the necessary precautions to prevent such undermining.

Aging is a natural process and longevity is a natural and desirable goal in any society. Aging is also a risk factor for decreased health and functionality. The accumulation of the normal characteristics of aging defines a threshold, which, once crossed, tends to increase the propensity for loss of functional capacities due to age. However, not all people age the same way. It is well documented that quality of life and functionality in old age is related to personal characteristics and lifestyle, societal resources, and the environment to which one is exposed. Despite the current and future importance of the population aged 60 and over in the countries of the region, the current services do not have a reorientation policy for the promotion, prevention, and health care of the elderly. Therefore, the present work has a general objective to identify intervention strategies for the violation of the rights of the elderly.

2 Delphi Method

The Delphi technique was developed in 1950 by the RAND Corporation of Santa Monica, California. The application of the scientific method aims to resolve a specific problem through a process of representing reality through a reliable, consistent, and non-arbitrary model, as a way of obtaining the highest consensus possible in the opinion of a group of experts. through a series of questionnaires on the scientific bases, as an element of work in the inexact sciences, to become a structured and effective method in the collection of information from a group, before the resolution of a specific problem [11].

Among the qualitative methods used in the scientific method, the Delphi method stands out as one of the most used in scientific research in problematic situations that include the identification of topics to the elaboration of analysis and information collection instruments, highlighting its usefulness in the field of social sciences in general.

Its use is documented throughout the scientific literature [12], as a predictive tool and even as a validation system for information collection tools.

The Delphi method is a prospective expert-based method that is defined as a "systematic and iterative process aimed at obtaining the opinions and, if possible, the consensus, of a group of experts" [13] when considering these as people who "have a close relationship on the issue, sector, technology or object of the investigation". Its methodology is appropriate for obtaining information from experts based on the knowledge of the sector and the capacity and ability to analyze the items consulted, which are especially appropriate in the "complex, dynamic, ambiguous and lacking areas of knowledge". of information" due to its low cost in obtaining it [11]. In addition, its use has been recommended in those studies that show a low rate of information on previous empirical evidence [14].

There are several forms of application of the Delphi method, generally present in empirical studies, in which the most common is established from an initial round structured and organized by the study's monitoring panel, through one or two interactions depending on the degree of agreement among the panelists until the group judgments were refined "through a mathematical procedure of aggregation of individual judgments". In its development, after the different rounds applied in a Delphi method, the responses of the panelists are analyzed qualitatively and quantitatively, usually statistically through the treatment of medians and the consequent confidence intervals. Since the goal of the Delphi method is to achieve the greatest possible consensus among the panelists involved, empirically, it will be considered that it has been reached, determining it through the measurement of the variance in the answers of the panelists through the different rounds.

The phases typically identified in the application of a Delphi method [11, 16, 17, 18] range from the definition of the problem by the Coordinating Group, identification of the objective and determination of the consensus criteria, to the evaluation of the results and conclusions, which go through the formation of the Panel of Experts using the established selection criteria, design of the questionnaire for the first and successive rounds of questions, evaluation of the Questionnaire by the group of experts, analysis of the answers and iterations until reaching the necessary degree of agreement and application of the improvements accepted by the Coordinating Group.

For the individual selection of the experts, the Expert Biogram was used in which, as a report, information was collected on their professional experience, scientific production, fields of study, and work involvement. For the definitive selection of the experts from those obtained in the Extended Tentative Panel by the Coordination Group, the Expert Competence Coefficient (K) was used, calculated from: "the opinion expressed by the expert himself on his level of knowledge about the analyzed problem, as well as the sources that allow arguing its answer" and it depends on two coefficients: the Knowledge Coefficient (K_C) and the Argumentation Coefficient (Ka).

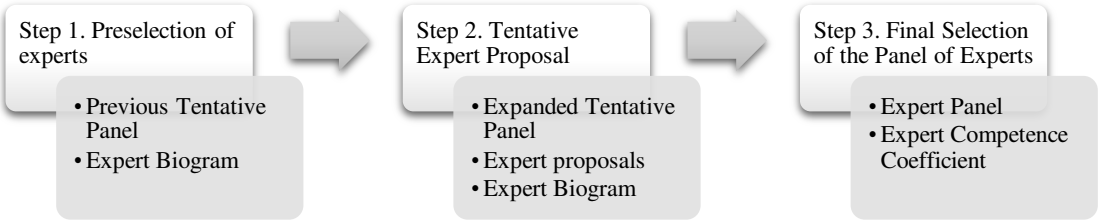


Figure 1. Steps for the configuration of the panel of experts. Source: own elaboration

$$K = \frac{1}{2}(K_a + K_c) \quad (1)$$

The so-called Knowledge Coefficient Kc, was shown to be determined by the information that the expert himself presents about the object of study, determined through a self-assessment process on a graphic closure scale multiplied by a factor of 0.1; the value of 10 would imply full knowledge of the problem under study and the value 0 the null knowledge about the topic. (see Table 1).

Knowledge level	Scale
Full knowledge of the subject of study (FK)	1.0
Very very good in the subject of study (VVGK)	0.9
Very good in the subject of study (VGK)	0.8
Good at study subject (GK)	0.7
Fairly good in the subject of study (MGK)	0.6
Know the subject of study (K)	0.5
Moderately poorly knows the subject of study (MBK)	0.4

Knowledge level	Scale
Poorly knows the subject of study (BK)	0.3
Very poorly knows the subject of study (VBK)	0.2
Very very poorly knows the subject of study (VVBK)	0.1
Null knowledge of the subject of study (NK)	0.0

Table 1: Terms used to determine K_C. Source: own elaboration

The Argumentation coefficient Ka evaluates the criteria for substantiating the expert's opinion based on the weighted sum of values obtained in a series of Influence Factors determined by the Coordinating Group: experience obtained through its activity and practice, knowledge of the state of the issue at the national and international level, intuition about the topic addressed and knowledge about technology and study of works and publications on the subject obtained the results shown in Table 2.

Finished	Scale	Points to analyze:
High	0.5	1. Experience gained through your activity and practice
	0.4	2. Knowledge about the state of the issue at the national
Medium	0.3	and international level
	0.2	3. Intuition about the topic addressed and knowledge
Low	0.1	about technology
		4. Study of works and publications on the subject

Table 2: Terms used to determine Ka. Source: own elaboration

The evaluation of the responses of all the experts established as an objective criterion the screening of those who in the Coefficient of Expert Competence did not reach the required critical level established by the Coordinating Group in value of 0.8, as indicated. For the evaluation and validation of questionnaires through the Delphi method, the scale of the Torgerson model was used, to achieve greater objectivity in the treatment of information that allows the evaluation of the criteria exposed by the judges of the Panel of Experts of each one of the items individually. [19, 20, 21]

2.1 Interpretation of Responses and Evaluation of Actions

One of the main difficulties in the evaluation and validation of questionnaires using the Delphi method comes from the subjectivity of the criteria put forward by the judges of the Panel of Experts and, consequently, their difficulty in adapting a mathematical model for the corresponding analysis. In the development of the evaluation questionnaire sent to the experts, nominal scale values were used (Not at all adequate, Little adequate, Adequate, Quite adequate, and Very adequate) automatically associated with ordinal indicators (0.1, 2, 3, and 4 respectively) for its simple tabulation, assumes the relationships between categories and their limits as defined without considering the true real limits or values corresponding to interval scales, which may imply an error in the precision of the determination of those values. In this way, by assigning the values directly, a staggered distribution is established in integers with a fixed value that does not correspond to a valuation in a continuum and that, therefore, it does not have a distribution on a real line bounded by interval valuations (see Table 3).

Nominal value	Ordinal Assignment
Very Adequate (VA)	4
Fairly Adequate (FA)	3
Adequate (A)	2
Poorly Adequate (PA)	1
Not Adequate (NA)	0

Table 3: Assessment criteria. Source: own elaboration

To verify the correctness of this assumption of equivalence between scales, the model of [15, 24, 25] through a rescaling so that greater objectivity is achieved in the treatment of information by converting the original ordinal scale (qualitative) into an interval scale (quantitative) that allows the assessment of each item individually. In this way, Torgerson's model is based on the following assumptions:

- Each object (indicator) corresponds to the subjective dimension of a normally distributed random variable, whose mean, m, is the scale value of that object. It is also assumed that all variances are equal.
- Each category limit corresponds to the subjective dimension of a normally distributed random variable, whose mean, t, is the scale value of that limit. It is also assumed that all variables are equal.
- The random variables that represent both the objects and the limits are independent. One variable cannot contain the values of another variable.
- An object belongs to the Kth category with its scale value x, it is between the values of the order limits k-1 and k, so that the limits between the categories assumed for the indicators are clearly defined.

In our case, with the double objective of evaluating the convenience of directly assigning values to the responses of the ordinal scale in the assessment of the questionnaire items by the judges participating in the Panel of Experts for their quantification, and to analyze the adequacy of the items raised through the following steps:

1. A summary table of the different weightings provided by the expert judges was established, assigning a score to the answers according to the criteria.
2. From the evaluations, the absolute response frequencies and the accumulated frequencies were calculated, as well as the relative accumulated frequency, obtained from the quotient between the accumulated frequency in the responses and the number of existing responses or the number of experts, expressing the latter with two decimal places. It is interesting to observe how the relative accumulated frequency saturates its maximum value before the first accumulated category and its maximum probability in all the criteria so that the minimum indicator present will be "not very adequate". [22, 23]
3. Using the accumulated relative frequencies, the cut-off points and their respective indicator scales were calculated using the inverse standard normal values of the accumulated probabilities of each indicator in each question. For this, the approximation to the closest value of the Standard Normal curve of the accumulated probability was used. It is necessary to indicate that, for cumulative probability values equal to 1, the corresponding inverse standard value is 3.5 as a practical reduction since it is asymptotic from the value of 3.49. Similarly, for cumulative probability values equal to 0, the inverse standard value will be assumed to be equal to -3.5. Once this consideration is taken into account,
4. To the calculated values, the “Average” column was added, obtained from the calculation of the average of the values found per row. Similarly, the Cut-off Points were estimated, and calculated as the average of the values of the inverse standard function for each of the scale values (columns). The value of Limit N was also determined, through the average of the Cut-off Points (whose result will be the same as the average of the averages of each category) and which will delimit the true interval ranges to which each category belongs.

To determine the consensus among the participants of the Panel of Experts, the Agreement Coefficient was used, determined through the expression:

$$Cc = \left(1 - \frac{V_n}{V_t}\right) 100 \tag{2}$$

where:

Vn the number of negative votes contributed by the judges.
Vt is the number of total votes cast by the judges.

A level of consensus must be reached with the Concordance Coefficient Cc to obtain a value greater than 75%, thus producing the conclusion of the process. However, if the Concordance Coefficient does not reach a value greater than 75%, a new evaluation round must be established to consider the appropriate assessments provided by the Panel of Experts.

In this work, the application of the method was established in four fundamental stages:

1. Design by the Coordinating Group based on the variables identified in the dimensions determined in the qualitative analysis.
2. Selection of the Panel of Experts.
3. Obtaining responses and evaluating actions.

4. Interpretation of responses and results.

3 Results and Discussion

3.1 Stage 1. Design

The review of the literature and the identification of the main aspects in the environment of the rights of the elderly violated and their effects were obtained from initial interviews, where the Coordinating Group established a series of main objectives in obtaining the necessary basic information which was distributed among the experts. The objective of collecting information was to obtain the greatest amount of interpretable information in these aspects and to submit it to the panel of experts through the validation of the Delphi method.

3.2 Stage 2. Selection of the Panel of Experts.

The present study in a group of experts made up of the participation of individuals from heterogeneous fields grouped into four groups:

- academic field,
- legal field,
- professional field of health and
- methodological field in social security.

Validation Objectives	Analyze and determine the factors that affect the violation of the rights of the elderly and contradict the constitutional norm regarding priority and specialized care in public and private areas that people have.
Experts	Master, Academics, Health officer, lawyer, and doctor of sciences with more than 5 years of experience.
Validation Mode	Delphi method of multiple rounds, individual and without contact between the experts consulted.

Table 4: Summary of the objectives and validation method by experts. Source: own elaboration

Due to the difficulty of the object of investigation, an assessment of competence as an expert was assigned"High" and "Very High" their coefficient was established above a required assessment (see table 5).

Expert	Profile	C1	C2	C3	C4	k c	Ka	K	Assessment
E1	Academic	1.0	1.0	0.8	0.4	0.4	0.80	0.600	Medium
E2	Academic	1.0	0.4	0.8	0.2	0.3	0.75	0.525	Medium
E3	Doctor	0.2	0.4	0.4	0.2	0.2	0.60	0.400	Low
E4	Academic	0.2	0.2	0.8	0.8	0.5	0.80	0.650	Medium
E5	Academic	0.8	0.8	0.6	0.6	0.6	0.55	0.575	Medium
E6	Attorney	0.6	1.0	0.6	1.0	0.7	0.65	0.675	Medium
E7	Attorney	0.6	0.6	1.0	0.8	0.7	0.65	0.675	Medium
E8	Academic	0.4	1.0	0.4	0.2	0.3	0.60	0.450	Low
E9	Academic	0.8	0.6	0.6	0.8	0.0	0.55	0.275	Low
E10	Health-officer	0.4	0.2	0.8	0.8	0.8	0.55	0.675	Medium
E11	Academic	0.2	0.4	0.4	0.2	0.2	0.60	0.400	Low
E12	Health-officer	0.8	1.0	0.4	0.2	0.8	0.60	0.700	Medium
E13	Master	0.2	0.4	0.4	0.2	0.2	0.60	0.400	Low
E14	Academic	0.2	0.6	1.0	0.6	0.9	0.65	0.775	High
E15	Academic	0.6	0.6	0.4	0.2	0.3	0.45	0.375	Low
E16	Academic	0.2	0.6	1.0	0.2	0.2	0.45	0.325	Low
E17	Academic	0.2	0.8	1.0	0.2	0.5	0.45	0.475	Low

E18	Doctor	0.6	0.8	1.0	0.8	1.0	0.45	0.725	Medium
E19	Master	0.6	0.2	0.6	0.2	0.9	0.65	0.775	High
E20	Academic	0.6	0.6	0.4	0.2	0.4	0.70	0.550	Medium
E21	Master	0.2	0.4	0.4	0.2	0.2	0.60	0.400	Low
E22	Master	0.2	0.4	0.4	0.2	0.2	0.60	0.400	Low
E23	Health-officer	1.0	1.0	0.2	0.6	0.8	0.55	0.675	Medium
E24	Master	0.2	0.2	0.4	0.2	0.4	0.55	0.475	Low
E25	Attorney	0.4	0.6	1.0	1.0	0.7	0.60	0.650	Medium
E26	Doctor	0.4	0.8	0.6	0.2	1.0	0.55	0.775	High
E27	Health-officer	0.4	0.2	0.4	0.2	0.8	0.45	0.625	Medium
E28	Attorney	0.2	0.8	1.0	0.6	0.7	0.55	0.625	Medium
E29	Master	0.4	0.8	0.2	0.4	0.9	0.55	0.725	Medium
E30	Attorney	0.4	0.6	0.6	1.0	0.7	0.70	0.700	Medium
E31	Academic	0.2	1.0	0.4	0.6	0.4	0.45	0.425	Low
E32	Academic	0.8	0.2	0.8	0.4	0.2	0.75	0.475	Low
E33	Academic	1.0	0.4	1.0	0.2	0.2	0.80	0.500	Medium
E34	Academic	0.2	0.4	0.8	0.2	0.6	0.55	0.575	Medium
E35	Academic	0.8	1.0	0.4	0.6	0.3	0.50	0.400	Low
E36	Academic	1.0	0.6	0.4	0.2	0.4	0.95	0.675	Medium
E37	Academic	0.4	0.6	0.8	0.4	0.6	0.80	0.700	Medium
E38	Academic	0.2	0.6	1.0	0.2	0.4	0.70	0.550	Medium
E39	Academic	1.0	0.8	0.4	0.4	0.2	0.55	0.375	Low
E40	Academic	0.6	0.6	0.8	0.4	0.4	0.75	0.575	Medium
E41	Academic	0.4	1.0	0.6	0.2	0.1	0.55	0.325	Low
E42	Master	0.8	1.0	0.8	0.8	0.9	0.70	0.800	High
E43	Academic	0.2	0.2	0.4	0.2	0.4	0.55	0.475	Low
E44	Academic	1.0	0.8	0.8	0.8	0.5	0.45	0.475	Low
E45	Academic	1.0	1.0	0.2	1.0	0.1	0.45	0.275	Low
E46	Health-officer	0.2	0.2	0.6	0.4	1.0	0.80	0.900	Very high
E47	Academic	1.0	0.4	0.4	1.0	0.6	0.75	0.675	Medium
E48	Master	0.8	0.8	0.2	1.0	0.9	0.70	0.800	High
E49	Academic	1.0	1.0	0.8	1.0	0.4	0.55	0.475	Low
E50	Doctor	0.4	1.0	0.4	0.4	1.0	0.30	0.650	Medium
E51	Doctor	0.6	0.2	0.6	0.8	1.0	0.80	0.900	Very high
E52	Academic	0.8	0.2	0.6	0.8	0.3	0.70	0.500	Medium
E53	Academic	0.2	0.2	1.0	0.6	0.3	0.45	0.375	Low
E54	Academic	1.0	0.8	0.4	0.2	0.2	0.55	0.375	Low
E55	Academic	0.8	0.2	1.0	0.6	0.6	0.80	0.700	Medium
E56	Academic	0.2	0.8	0.4	0.2	0.4	0.50	0.450	Low

E57	Academic	0.8	0.2	0.8	0.6	0.3	0.55	0.425	Low
E58	Doctor	1.0	0.4	0.4	0.6	1.0	0.85	0.925	Very high
E59	Attorney	1.0	1.0	0.6	0.8	0.7	0.80	0.750	Medium
E60	Master	0.6	0.8	0.6	0.2	0.9	0.55	0.725	Medium
E61	Attorney	0.6	0.8	0.4	0.8	0.7	0.65	0.675	Medium
E62	Doctor	0.2	0.8	0.8	0.4	1.0	0.50	0.750	Medium
E63	Academic	0.6	1.0	0.8	0.4	0.4	0.55	0.475	Low
E64	Academic	0.2	0.4	0.8	0.2	0.0	0.55	0.275	Low
E65	Master	0.2	0.2	0.4	0.2	0.4	0.55	0.475	Low
E66	Academic	0.6	0.6	1.0	0.4	0.5	0.65	0.575	Medium
E67	Academic	1.0	0.8	1.0	0.8	0.3	0.50	0.400	Low
E68	Academic	0.4	0.4	0.8	0.2	0.5	0.90	0.700	Medium
E69	Academic	0.2	1.0	0.8	0.4	0.2	0.45	0.325	Low
E70	Academic	0.8	0.8	0.6	0.2	0.3	0.55	0.425	Low
E71	Academic	0.2	0.6	0.4	0.8	0.3	0.75	0.525	Medium
E72	Health-officer	0.2	0.4	0.4	0.2	0.2	0.60	0.400	Low
E73	Academic	0.2	0.2	0.2	0.4	0.5	0.50	0.500	Medium
E74	Academic	0.6	0.4	0.2	0.2	0.6	0.75	0.675	Medium
E75	Academic	1.0	0.6	0.6	0.4	0.0	0.70	0.350	Low
E76	Academic	1.0	0.4	0.8	0.8	0.3	0.80	0.550	Medium
E77	Health-officer	1.0	0.4	0.2	0.8	0.8	0.55	0.675	Medium
E78	Academic	0.8	0.2	1.0	0.4	0.0	0.80	0.400	Low
E79	Doctor	0.2	0.4	0.4	0.2	0.2	0.60	0.400	Low
E80	Academic	1.0	1.0	0.4	0.4	0.3	0.75	0.525	Medium

Table 5: Determination of the coefficient of expert competence. Source: own elaboration

The Panel of Experts is made up of 1 academic, 1 health official, 3 masters, and 3 doctors for a total of 8 experts needed in Delphi modeling (see Table 6).

Profile	Very high	High	Medium	Low	Very low	Total
Academic	0	1	21	26	0	48
Attorney	0	0	7	0	0	7
Health-officer	1	0	5	1	0	7
Master	0	3	2	5	0	10
Doctor	2	1	3	2	0	8
Total	3	5	38	3. 4	0	80

Table 6. Panel of definitive experts. Source: own elaboration

3.3 Obtaining Responses and Evaluating Actions

FIRST ROUND

Depending on the analyzed documentation. Each expert is sent the following question: summarize what are the factors or criteria that affect the violation of the right of the elderly.

Entrance to the Coordinator Group

The answers sent by the experts are consolidated and evaluated by the Coordinator Group, each criterion is considered a key factor in the processing and development of the method (see Table 7). From the processed results, the key indicators for the focus of the study are obtained.

Code	Criteria or indicators
I1 (1)	Protection against violence.
I2 (2)	Insufficient medical assistance
I3 (3)	Social Security Limitation
I4 (4)	Equality rights are not fulfilled as determined for some people
I5 (5)	Loss or lack of conditions to strengthen autonomy
I6 (6)	Inaccessibility to counseling services.
I7 (7)	Lack of financial resources
I8 (8)	Not having alimony or retirement

Table 7: Factors or criteria that affect the violation of the right of the elderly. Source: own elaboration

SECOND ROUND

Experts are sent the following question: Determine the level of importance of each criterion. It must take into account those with the highest incidence of the violation of the right of the elderly.

Entrance to the Coordinating Group

For the Coordinating Group, the use of Delphi modeling allows obtaining criteria, such as the level of incidence and determination between the factors.

Each expert was asked to establish in which categories the eight proposed indicators were considered to have a relationship with the violation of the rights of the elderly. They evaluated the factors according to the Torgerson scale, respectively, to determine the cut-off points and scale of the indicators. (see tables 8 to 11).

Profile	VA	FA	A	PA	NA	Total
C1	1	3	3	0	2	9
C2	4	3	0	1	1	9
C3	0	0	2	4	3	9
C4	0	4	3	1	1	9
C5	2	3	2	0	2	9
C6	2	2	3	0	2	9
C7	4	1	0	3	1	9
C8	1	1	3	3	1	9

Table 8: Criteria validation level. Source: own elaboration

Indicators	VA	FA	A	PA	NA
I1 (1)	1	4	7	7	9
I2 (2)	4	7	7	8	9
I3 (3)	0	0	2	6	9
I4 (4)	0	4	7	8	9
I5 (5)	2	5	7	7	9
I6 (6)	2	4	7	7	9

Indicators	VA	FA	A	PA	NA
I7 (7)	4	5	5	8	9
I8 (8)	1	2	5	8	9

Table 9: Cumulative frequency. Source: own elaboration

Indicators	VA	FA	A	PA	NA
I1 (1)	0.1111	0.4444	0.7778	0.7778	1,0000
I2 (2)	0.4444	0.7778	0.7778	0.8889	1,0000
I3 (3)	0.0000	0.0000	0.2222	0.6667	1,0000
I4 (4)	0.0000	0.4444	0.7778	0.8889	1,0000
I5 (5)	0.2222	0.5556	0.7778	0.7778	1,0000
I6 (6)	0.2222	0.4444	0.7778	0.7778	1,0000
I7 (7)	0.4444	0.5556	0.5556	0.8889	1,0000
I8 (8)	0.1111	0.2222	0.5556	0.8889	1,0000

Table 10: Relative frequency and cumulative probability. Source: own elaboration

Indicators	VA	FA	A	PA	NA	Average	N-Avg.	Order
I1 (1)	-1.22	-0.14	0.76	0.76	3.50	0.73	-0.13	5
I2 (2)	-0.14	0.76	0.76	1.22	3.50	1.22	-0.62	1
I3 (3)	-3.50	-3.50	-0.76	0.43	3.50	-0.77	1.37	
I4 (4)	-3.50	-0.14	0.76	1.22	3.50	0.37	0.23	
I5 (5)	-0.76	0.14	0.76	0.76	3.50	0.88	-0.28	3
I6 (6)	-0.76	-0.14	0.76	0.76	3.50	0.82	-0.22	4
I7 (7)	-0.14	0.14	0.14	1.22	3.50	0.97	-0.37	2
I8 (8)	-1.22	-0.76	0.14	1.22	3.50	0.58	0.02	
Cut-off points	-1.41	-0.46	0.42	0.95	3.50	N=0.60		

Table 11: Calculation of cut-off points and scale of the indicators. Source: own elaboration

4 Discussion

4.1 Stage 4. Interpretation of Responses and Results

From the modeling, it is highlighted that the factors indicated to determine the violation of the right of the elderly corresponds to:

- Criteria C2, C7, C5, C6, and C1; and between the given evaluation, with greater incidence in factor C2
- The determinations of the degree of relevance of each dimension by the experts indicate that criteria C3, C4, and C8 should not be included in the study as significant factors in the fight against the violation of the right of the elderly.
- Insufficient medical assistance is considered the main factor that directly affects them.

To determine the consensus among the participants of the Panel of Experts, the Coordinating Group considered that this level of consensus had been reached with the Concordance Coefficient Cc obtaining a value greater than 75%, thus producing the conclusion of the process (see Table 12).

Expert	C1	C2	C3	C4	C5	C6	C7	C8
E1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
E2	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
E3	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
E4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
E5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
E6	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
E7	No	Yes	No	Yes	Yes	Yes	Yes	Yes
E8	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
E9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yes	7	9	7	8	9	9	9	7
No	2	0	2	1	0	0	0	2
Coefficient	77.78	100	77.78	88.89	100	100	100	77.78

Table 12: Final evaluations of the criteria. Source: own elaboration

The analysis of the Delphi method determines that the following criteria are considered fundamental among experts, so it is required that measures be taken to mitigate its impact on the violation of the right of the elderly.

1. Insufficient medical assistance
2. Lack of financial resources
3. Loss or lack of conditions to strengthen autonomy.
4. Inaccessibility to counseling services.
5. Protection against violence.

For this, the following solutions are proposed:

- For the benefit of the elderly, free and specialized health care must be guaranteed, as well as free access to medicines.
- Priority and specialized attention in the public and private spheres, especially in the fields of social and economic inclusion, and protection against violence.
- Guarantee care units in alternative spaces with home care, in such a way as to optimize the use of existing resources for the service and care of a larger population of older adults, in their most diverse needs.

Improve the quality of life through the rights of older adults, through comprehensive care, which implements actions aimed at strengthening the enjoyment of their physical, social, and mental well-being.

Conclusion

The aging of the population, health, and poverty has implications for development and can become an obstacle if the appropriate measures are not taken on time. Therefore, the development of a fair and sustainable infrastructure for the aging population should be part of the international development agenda. The notion of older adults as subjects of rights involves placing these people as rights holders with the capacity to demand that the state fulfill its obligations. They are part of a vulnerable group of priority care and require that the care provided be of a reinforced nature. The level of access that the elderly have to appropriate care to health services must be evaluated and public health policy implemented to address the needs of the elderly with respect to the coverage and accessibility of appropriate health services.

The special and reinforced protection determined by the Constitution and international instruments must be specified and thus respond to the real expectations of older adults in the workplace. From the family, the contribution of older adults within the life and economy of the home must be revalued, and generate mechanisms so that older adults feel useful and with the possibility of giving their opinion and deciding on family agreements. It should contribute to improving the image of older adults by banishing negative myths and stereotypes that generally surround their figure. From the national, departmental, and municipal governments, their integration must be promoted and integrative and intergenerational spaces generated in the community, to promote greater participation of this population so that they can contribute with alternative solutions to this problem and continue contributing to the country's development.

The population of older adults living in poverty will continue to grow. As the number of older adults increases,

the costs to protect them also increase. Unless society organizes itself and develops policies aimed at the elderly, the combination of aging with the increase in poverty could become a serious problem that affects individuals as well as society.

References

[1] J. A. lvarado Vélez, "On the rights of the elderly in Ecuador: from constitutional dogmatic to local reality.," *Universidad y Sociedad,* vol. 13, pp. 21-28, 2021.

[2] G. D. J. Bastida Tello, R. Comas Rodríguez, and J. L. García Delgado, "Selection of Non-Pharmacological Treatments for mild Cognitive Impairmentin older Adults with Neutrosophic-AHP," *Neutrosophic Sets and Systems,* vol. 37, pp. 132-140, 2020.

[3] P. Sloane and S. Zimmerman, *Long-Term Care Options for Retired Americans in Cuenca, Ecuador and San Miguel de Allende, Mexico*: Retirement Migration from the U.S. to Latin American Colonial Cities, 2020.

[4] Benjamin Mason Meier, Hannah Rice, and S. Bandara, "Monitoring Attacks on Health Care as a Basis to Facilitate Accountability for Human Rights Violations," *Health and Human Rights Journal,* vol. 23, no.1, pp. 55-70, 2021.

[5] D. S. Palloni A, "Aging and Latin America and the Caribbean," *Madison: Center for Demography and Ecology. University of Wisconsin, CDE Working Paper* vol. 99-02, 1989.

[6] XinQi Dong, Ruijia Chen, Terry Fulmer, and M. A. Simon, "Prevalence and Correlates of Elder Mistreatment in a Community-Dwelling Population of U.S. Chinese Older Adults " *Journal of Aging and Health,* vol. Volume: 26, pp. 1209-1224, 2014.

[7] O. R.-C. Liliana Giraldo-Rodríguez, "Development and psychometric properties of the Geriatric Mistreatment ScaleLiliana Giraldo-Rodríguez, Oscar Rosas-Carrasco," *Geriatr Gerontol,* vol. 13, pp. 466-474, 2012.

[8] I. Sisa and R. Vega, "Knowledge Gaps in Health Care Research in Older Adults in Ecuador: Policy Challenges and Opportunities," *Ageing International,* vol. 47, pp. 1-11, 06/01 2022.

[9] M. S. Lachs and K. A. Pillemer, "Elder Abuse," *New England Journal of Medicine,* vol. 373(20=, pp. 1947-1956, 2015.

[10] *Secretary-General's Policy Brief: The Impact of COVID-19 on older persons. 2020.* , 2020.

[11] F. ORTEGA. (2008) "El método Delphi, prospectiva en ciencias sociales". *Revista EAN*. 31-54.

[12] T. S. BAINES and V. G. Shi. (2015). *"A Delphi study to explore the adoption of servitization in UK companies". Production Planning & Control, (August), 1–17.* . Available: https://doi.org/10.1080/09537287.2015.1033490

[13] J. LANDETA. (2005) "Current validity of the Delphi method in social sciences". . *Technological Forecasting & Social Change*. 467-482.

[14] M. E. ASSELIN and M. HARPER, ""Revisiting the Delphi technique: Implications for Nursing professional development". ," *Nurses in Professional Development,* vol. 30 (1), pp. 11-15, 2014.

[15] W. S. TORGERSON. (1958) Theory and Methods of Scaling. New York, New York, USA: Wiley. *Psychometrika,* . 401-419. Available: https://doi.org/10.1007/BF02288916

[16] E. B. Prado Calderón, W. A. Cacpata Calle & A. S. Gil Betancourt. "Sistemas de votación, su impacto sobre el comportamiento de los votantes y los resultados electorales". Universidad y Sociedad, Vol. 14 Num. S2, pp- 330-336, 2022.

[17] D. A. Freire Muñoz & D. S. Diaz López. "Método de fermentación y secado para el beneficio de la obtención del chocolate blanco a partir del cacao criollo (Theobroma cacao L.), ecuatoriano". Universidad y Sociedad, Vol. 14 Num. S2, pp- 323-329, 2022.

[18] P. E. Salas Medina & R. Acosta Lizano. "Análisis del uso del marketing digital ante la emergencia sanitaria Covid-19 en la industria turística de Ambato, provincia de Tungurahua". Universidad y Sociedad, Vol. 14 Num. S2, pp- 315-322, 2022.

[19] R. F. Sánchez Santacruz, L. I. Barahona Tapia, & R. L. Maldonado Manzano. "Causas fundamentales de la migración hacia y desde el Ecuador". Universidad y Sociedad, Vol. 14 Num. S2, pp- 308-314, 2022.

[20] R. F. Sánchez Santacruz, R. L Maldonado Manzano & L. I. Barahona Tapia. "La rehabilitación social en el Estado Constitucional del Ecuador". Universidad y Sociedad, Vol. 14 Num. S2, pp- 300-307, 2022.

[21] M. J. Cabezas Arellano, F. M. Pozo Hernández & O. R. Aldaz Bombón. "Competitividad de empresas envasadoras de agua en Santo Domingo". Universidad y Sociedad, Vol. 14 Num. S2, pp- 290-299, 2022.

[22] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.

[23] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.

[24] von Feigenblatt, O. "Mediation for management: Dealing with Conflict in the Workplace". Innovaciones de Negocios, vol. 18 no. 35, pp 113-119, 2021. 4 OK

[25] von Feigenblatt, O. F. "Un estudio de caso sobre la competencia diplomática entre la República Popular China y la República de China (Taiwán): La experiencia de la República de Costa Rica de 1995 a 2010". Dilemas contemporáneos: Educación, Política y Valores. Vol. 9no. (Edición especial), pp 1-19, 2021. 4 OK

Received: August 07, 2022. **Accepted:** October 08, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Limitations for the Application of Indigenous Justice in Ecuador

Raúl Clemente Ilaquiche Licta[1], Luis Andrés Crespo Berti[2], Marco Rodrigo Mena Peralta [3], and Paul Orlando Piray Rodríguez[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.raulilaquiche@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.luiscrespo@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. E-mail: up.marcomena@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.paulpr13@uniandes.edu.ec

Abstract. The application of indigenous justice in Ecuador is a topic of interest given its implications for the social life of the nation. The problem focuses on the fact that this constitutes a part of the country's cultural heritage, but in turn, sometimes contradicts the so-called ordinary justice. Due to the, it is proposed as the objective of the investigation to propose the most appropriate actions to mitigate the limitations of the application of indigenous justice in Ecuador. Empirical methods such as the interview, the cause-effect diagram, and multi-criteria decision methods such as Promethee and Vikor were used for this. It was obtained as a result that the main actions must strengthen the communication system through dialogues and conferences of judicial institutions, with the objective of Indigenous Justice, to increase the knowledge on that topic among the members of the society, and encourage the protection of the ethnical minorities and, in turn, set the necessary limits in each territory, to prevent the violation of rights and impunity, and to achieve that the indigenous communities comply with all the stipulated on the Constitution, the international treaties that Ecuador has signed, considering the indigenous justice as an immediate source of right.

Keywords: indigenous justice, Promethee, Vikor, cause-effect diagram.

1 Introduction

For a long time, indigenous peoples and their rights have not been a concern for international law, a situation that has changed over the years, which is why it is increasingly common to find research on the matter [1]. The first organization to pay attention to what was then called indigenous populations was the International Labor Organization (ILO), which incorporated into its work the reality of indigenous workers, especially those who lived in colonial territories that were and continue to be the object of discrimination and exploitation [2].

The recognition of indigenous justice in Ecuador, like other Latin American countries that have the character of being ethnically and culturally diverse, has included Indigenous Justice in their constitutional regulations [3]. In the 2008 Constitution, Chapter Four Judicial Function and Indigenous Justice is implemented, in article 171, which specifies that "the authorities of the indigenous communities, peoples, and nationalities will exercise jurisdictional functions, based on their ancestral traditions and their law, within its territorial scope, with the guarantee of participation and decision of women. The authorities will apply their own rules and procedures to resolve their internal conflicts, and that are not contrary to the Constitution and human rights recognized in international instruments" [4].

Indigenous justice and its legal expressions are the results of a history determined by historical-cultural changes that were made evident from colonization to recent changes in the constitutional sphere. This has as its main source the social and cultural history based on ancestral customs. The administration of justice in Ecuador is vested in the bodies of the Judicial Function and other bodies and functions that have this power as established by the Constitution of the Republic, depending on the case [5].

To this end, an entire regulatory framework has been developed that regulates their actions, made up of principles, norms, rules, and procedures, which must be observed by those who carry out this work, including those functions that use conciliation mechanisms as alternative means for conflict resolution, and justices of the peace. However, there is also constitutional recognition of other mechanisms for exercising justice whose procedure is not necessarily regulated, precisely because of its nature of application based on traditions (customs), this is what is called "indigenous justice", which has its origin and foundation in its ancestral roots for having exercised jurisdictional functions since time immemorial based on its customs and its own law, work carried out even before the colonization of the peoples of Latin America. Therefore, today it can be affirmed with certainty the existence of a

true "legal pluralism" in Ecuador [3].

Indigenous justice does not exist as a set of written normative statements that allow or prohibit some conduct, but are oral ancestral practices, based on their philosophies of life; for example, respect for nature and maintaining order in the environment where they live. For the application of indigenous justice, a basic written legal instrument and internal regulations of each community contemplated by the Law of Communes are established. The latter originally emerged as one of the prerequisites for the legal recognition of each commune, which has undergone a process of change and transformation over time [6].

The current Constitution recognizes the right of the authorities of indigenous peoples and communities to exercise jurisdictional functions, which implies powers to define their own rules of conduct, establish obligations, duties, rights, and guarantees, define offenses and correlative sanctions, as well as procedures for the knowledge, investigation, and sanction of the facts submitted to its jurisdiction. These are the same powers attributed to the ordinary jurisdiction, which is why it is of interest to identify how potential conflicts that arise between the two jurisdictions should be resolved, as well as the limits that the authorities of the indigenous peoples and communities whose jurisdiction must respect. is based on its traditional rules and not on written law as the ordinary jurisdiction [7].

The indigenous society has developed its procedure that has to be fulfilled in accordance with:

The first step is the notice or demand or "Willachina" which consists of informing the council leaders of everything that has happened: fights, gossip, robbery, and death. With this request, those involved must be summoned through an official letter that contains the names of the defendants, the day, time, and date on which the crime was committed, and the day on which the conflict will be resolved, which is done by the president of the communes, who must also take those involved to the town hall; from there it goes to the next stage [4].

The next stage is the investigation of the problem or "Tapuykuna" for this a variety of procedures are carried out such as the ocular inspection or verification of the fact, in the case of deaths, robberies, fights, testimonies are collected and raids are carried out, this is done by the leaders of the communities in the company of people of legal age, of recognized experience and honesty, who must present an oral report to the Assembly, the investigation also focuses on finding out whether or not those involved have been repeating offenders, which will help at the moment to impose the penalty.

Then there is a confrontation between the accused and the accuser or "Chimbapurana" that can lead to confrontation and confrontation of words between those involved. This is the most important step of the entire procedure, because, unlike the judicial trial, lawyers who represent the parties do not intervene in it, but it is the parties who speak as many times as necessary until everything is clear and there are no bad guys. understood when determining the responsibilities and sanctions [6].

Once all of the above is done, the imposition of the sanction or "Killpichirina" is carried out, which can be fines; return of stolen objects plus compensation; bath with cold water, nettle, whip, or whip; communal work; pulls off the ears; expulsion from the community or death is applied exceptionally, the latter has only been applied a few times in some tribes and has to do with cases of rape or murder. In the Ecuadorian territory, especially in the mountains, this sanction has not been applied, however, in the indigenous peoples of the east, there have been experiences in this regard. Sanctions are implemented according to the seriousness of the case. The execution of the sanction or "Paktachina" consists of the fulfillment of the sanctions that are mandatory [8].

The issue of indigenous justice is not new, but it is an issue that still needs to be studied in depth. Certain constitutions, including that of Ecuador, recognized collective rights and special rights of indigenous peoples, becoming a State with a plurality of legal systems. Faced with this reality, challenges for the Law appear, and new legal problems derived from that reality must be resolved. For example, the interpretation of principles that are enshrined in the Constitution and their link with the indigenous justice system [9]. Due to the above, it is proposed as an objective of the investigation to propose the most appropriate actions to mitigate the limitations of the application of indigenous justice in Ecuador.

2 Methods

2.1 Interviews

Structured interviews were prepared aimed at obtaining information on the real problem and issuing possible solutions, to obtain valid conclusions and support the results.

Population: a universe of individuals to contemplate for the study

Sample: the representative amount of the study population is to be determined through the following formula:

$$n = \frac{N\sigma^2 Z^2}{(N-1)e^2 + \sigma^2 Z^2} \quad (1)$$

Where:

n = the sample size

N = population size

σ = Standard deviation of the population that, generally when its value is not available, a constant value of 0.5

is usually used

Z = confidence level value, 95%

e = is the maximum margin of error that is allowed is 5%

2.2 Ishikawa diagram

The Ishikawa Diagram, being one of the effective and efficient quality tools in the actions of reducing a central problem, becomes a fundamental element, which makes it possible to examine the elements that intervene in the quality of the product/service through an interaction of cause and effect, helping to bring to light the causes of dispersion and also to order the relationship between the causes in a matter that may be focused on various fields: in the case of this investigation, on the limitations of indigenous justice. It is sometimes called the Ishikawa Diagram or Fishbone Diagram because it resembles the skeleton of a fish. It is an effective tool for studying processes and situations, and for developing a data collection plan. It is used to identify the possible causes of a specific problem. The graphic nature of the Diagram allows groups to organize large amounts of information about the problem and pinpoint possible causes. Finally, it increases the probability of identifying the main causes [10]. The Cause-and-Effect Diagram should be used when you can answer "yes" to one or both of the following questions:

1. Is it necessary to identify the main causes of a problem?
2. Are there ideas and/or opinions about the causes of a problem?

Often people closely associated with the problem under study have formed opinions about what causes the problem. These opinions may conflict or fail to express the main cause. The use of a Cause-and-Effect Diagram makes it possible to bring all these ideas together for study from different points of view. These diagrams are most effective after the process has been described and the problem is well defined. By this time, team members will have a good idea of what factors to include. They can also be used for purposes other than root cause analysis. The format of the tool lends itself to planning. For example, a group might brainstorm the “causes” of a successful event, such as a seminar, a conference, or a wedding. As a result, they would produce a detailed list grouped into one main category of things to do and to include for a successful event. [11]

It does not offer an answer to a question, as other tools do. Tools such as Pareto Analysis, Scatter Diagrams, and Histograms can be used to analyze data statistically. At the time of generating the Cause-and-Effect Diagram, it is usually unknown whether or not these causes are responsible for the effects. On the other hand, a well-prepared Cause and Effect Diagram is a vehicle to help teams have a common understanding of a complex problem, with all its elements and relationships clearly visible at whatever level of detail is required. [12]

2.3 PROMETHEE method

The PROMETHEE method is a non-compensatory method that handles classification problems, evaluating a set of alternatives under multiple criteria, which are often contradictory, it is explained in detail in [13]. The PROMETHEE I (partial classification) and PROMETHEE II (complete classification) methods were developed and published by JP Brans in 1982. Its name refers to the acronym Preference Ranking Organization Method for Enrichment Evaluation, and it is included within the relation-based methods of overclassification (outranking methods). The modeling establishes a structural preference between the alternatives, considering a preference function, defined by the decision-maker for each criterion, where the global index allows the partial and complete overcoming of the alternatives [14].

A multicriteria problem responds to a structure of type max $\{ g_1(a), g_2(a) \dots g_j(a)/a \in A\}$ where A is a finite set of alternatives $\{ a_1, a_2 \dots a_n\}$ and $\{ g_1(.), g_2(.) \dots g_n(.)\}$ a set of evaluation criteria. In general, this problem will be poorly conditioned since no alternative will maximize all the criteria, so a compromise solution must be reached. The PROMETHEE method is based on pairwise comparisons, so the difference in value between two evaluations of two alternatives for a given criterion will be taken into account. If this difference is small, a small preference or even indifference will be assigned if it is considered insignificant. The choice of a generalized criterion is reduced to the choice of the appropriate parameters, which can be considered a simple task. [14]

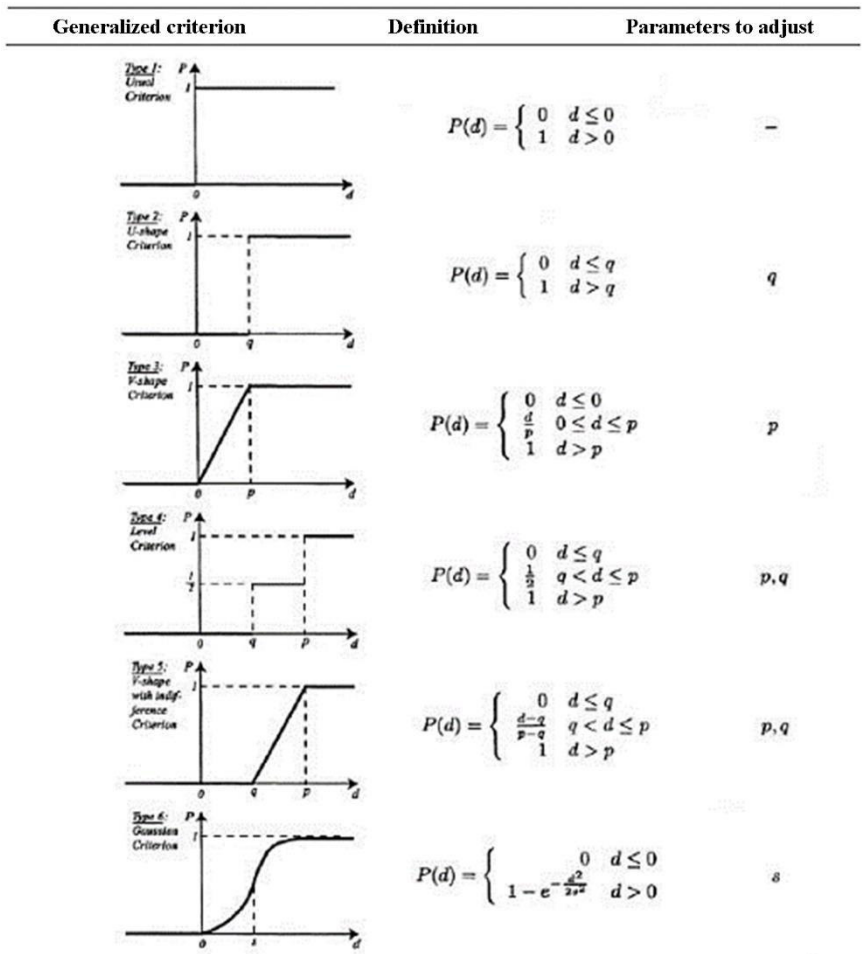


Figure 1: Definition of the criteria. Source: [13]

In each problem, an alternative *a* is confronted with the (n-1) remaining alternatives that define A:

$$\phi^{+}(a) = \frac{1}{n-1}\sum_{x \in a} \pi(a,x) \tag{2}$$

$$\phi^{-}(a) = \frac{1}{n-1}\sum_{x \in a} \pi(a,x) \tag{3}$$

Positive Relevance Flow and Negative Relevance Flow. The first indicates as an alternative *a* is relevant compared to the rest, it shows its dominating character. The higher, the better the alternative. The second shows its weakness, as it is dominated by the rest of the alternatives. The lower its value, the better the alternative [15].

PROMETHEE I: The Partial Classification

In this method, the ranking is obtained using the positive and negative streams of relevance. It is important to realize that if we used both flows separately, the classifications would not be the same, therefore this method uses an intersection of both. The method is prudent and does not decide which alternative is better, leaving the decision to the decision-maker. [27, 28]

PROMETHEE II: The complete classification

In this method, all the alternatives are comparable, although the information requires more study since when calculating the net flow as the subtraction of flows, a valuable amount of information is lost. In actual practice, both classifications should be used because although PROMETHEE II is easy to use, the incomparability analysis offered by PROMETHEE I can help make the appropriate decision. [29, 30]

Elaboration of the profiles of the alternatives

With the elaboration of the profiles of the alternatives, it is possible to appreciate the quality of an alternative according to the criteria and complete assessments, and to understand some of the results that can be obtained.

Mathematically it is the cross-product of the vector of profiles of an alternative and the vector of weighted weights.

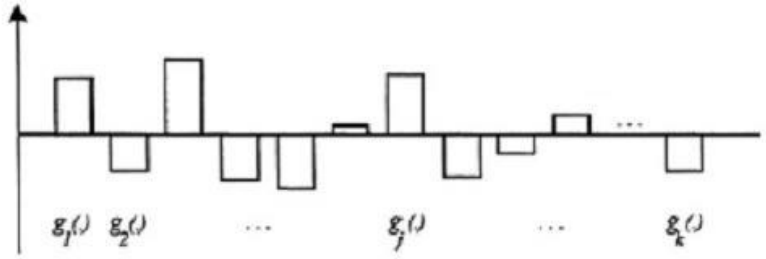


Figure 2: Representation of the profiles of alternatives. Source: [13]

2.4 VIKOR Method (VIseKriterijumskaOptimizacija I KompromisoResenje)

The VIKOR method was proposed by Serafín Opricovic in 1990. It determines the ranking of the alternatives using the aggregation function Q, which represents the "closeness to the ideal, calculated from the aggregation of the maximum utility function of group S and the function of individual regret R [16], [21], [22], [23]. Its application implies a compromise solution that is acceptable for conflict resolution.

- The decision-maker is willing to approve the solution closest to the ideal.
- There is a linear relationship between each criterion function and the utility of a decision-maker.
- The criteria are conflicting and not commensurable (different units).
- Alternatives are evaluated against all established criteria (performance matrix).
- The decision maker's preference is expressed by weights, given or simulated.
- The method can be started without interactive decision-maker participation, but the decision-maker is in charge of approving the final solution and their preference must be included.
- The proposed compromise solution (one or more) has a rate advantage.
- A stability analysis determines the weight stability intervals.

It is proposed as a compromise solution, to the best ranked alternative by measure Qj, if the condition of acceptable advantage and the condition of acceptable stability in decision-making are met. If any of these conditions are not satisfied, a set of compromise solutions must be proposed. [17], [18], [19], [20]
Steps:

a) Definition of the Decision Matrix with the respective weights (w_i) of each criterion.

b) Linear normalization of the decision matrix.

$$f_{ii}(\mathrm{x}) = \frac{\tilde{x}_{ij}}{\sqrt{}} \quad i = 1, \dots, m; j = 1, \dots, n \tag{4}$$

c) Determination of the best (f^*) and the worst (f^-) values in the evaluations of each criterion (i=1,2,...,n) and alternatives (j=1,2...,j) defined as follows:

$$f_j^* = Max_i f_{ij} \ , \ f_j^- = Min_i f_{ij} \ ; \ j = 1,2, \dots, n \tag{5}$$

$$f_j^* = Min_i f_{ij} \ , \ f_j^- = Max_i f_{ij} \ ; \ j = 1,2, \dots, n \tag{6}$$

$$f^* = \{f_1^*, f_2^*, f_3^*, \dots, f_n^*\} \tag{7}$$

$$f^- = \{f_1^-, f_2^-, f_3^-, \dots, f_n^-\} \tag{8}$$

d) Calculation of the measures S, R, and Q for each alternative.

$$S_j = \sum_{i=1} w_i \left(\frac{f_j^* - f_{ij}}{f_j^* - f_i^-} \right) \tag{9}$$

$$R_i = Max_j \left[w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)} \right] \tag{10}$$

Each of the obtained vectors generates a ranking by organizing their values from lowest to highest and with them, the Q values are calculated:

$$S^* = min_j S_j \tag{11}$$
$$S^- = max_j S_j$$

$$R^* = min_j R_j \tag{12}$$
$$R^- = max_j R_j$$

e) Verification of the acceptable advantage condition and the acceptable stability condition in decision making

f) Definition of the compromise solution(s).

$$Q_j = v \frac{S_j - S^*}{S^- - S^*} + (1 - v) \frac{R_j - R^*}{R^- - R^*} \tag{13}$$

3. Application of the methods

3.1 Cause and effect diagram

For the application of the method, an interview was conducted with jurists and judges about the limitations of indigenous justice in Ecuador. For this, the following question guide was used:

1. Do you consider that the application of indigenous justice in Ecuador has limitations?
2. In your opinion, what are the main limitations and how would you classify them?
3. What actions could be implemented to mitigate the limitations?

Sample calculation
n =134
n= sample.
N= population universe (200)
E= maximum admissible error. 5%
Z: Critical value corresponding to a confidence coefficient with which the investigation is to be carried out.
P: Population proportion of occurrence of an event
E: Sample error (difference between statistical and parametric)
To carry out the study, the following restrictions were handled:
E: 5% = 0.05 Z: 1.96 (value that corresponds to a coefficient of 95%).
P: 50% = 0.50 (since the value is not known, maximum variability is assumed)
Q: 1 -P = 0.50

Once the legal professionals were interviewed, their answers were processed, obtaining that the main limitations are:

1. Lack of means for indigenous communities to register legal activity
2. Insufficient training of officials on indigenous justice
3. Non-existence of a representation of indigenous people among the decision-makers of ordinary justice
4. Indigenous justice does not comply with what is legislated in the Constitution or international treaties to which Ecuador is a party.
5. Poor communication system through dialogues and conferences of judicial institutions, on the objective of Indigenous Justice, to increase knowledge of this issue among members of society.
6. The state does not consider indigenous justice as an immediate source of law
7. Lack of protection of ethnic minorities by the state
8. No law allows the indigenous community to act in a solvent manner and in turn set the necessary limits within each territory, to avoid violation of rights and impunity.
9. Need for a budget for communication and training actions.

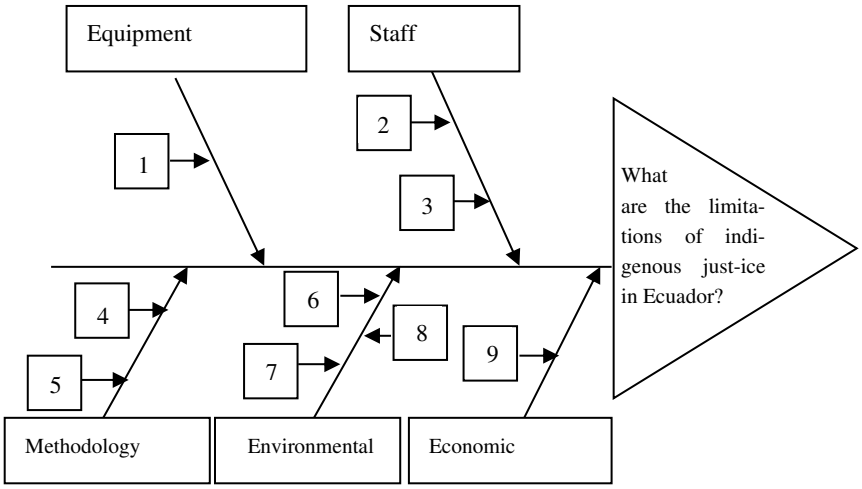


Figure 3: Cause-effect diagram. Source: own elaboration

The actions to respond to the limitations detected are:

1. Provide indigenous communities with the means to register legal activity
2. Train officials on indigenous justice and place a representation of indigenous people among the decision-makers of ordinary justice

3. Achieve compliance with what is legislated in the Constitution and the international treaties to which Ecuador is a party, by the indigenous communities, considering indigenous justice as an immediate source of law.
4. Strengthen the communication system through dialogues and conferences of judicial institutions on the objective of Indigenous Justice, to increase knowledge of this issue among members of society and encourage the protection of ethnic minorities by the state. [34, 35, 36]

Approve a Law that allows the indigenous community to act in a solvent manner and in turn set the necessary limits within each territory, to avoid violation of rights and impunity.

3.2 Application of the Promethee method

For the application of the method, the Promethee software is used, and the data is entered as follows (Figure 4):

Three criteria were defined:

1. The economic impact
2. societal impact
3. The political impact

From the analysis carried out in the software, the following results were obtained:

Figure 4 shows the introduction of the data in the software, in this case, the weight of each criterion is found if it is a criterion to minimize or maximize, the preference functions, and the evaluation for each of the 5 alternatives presented.

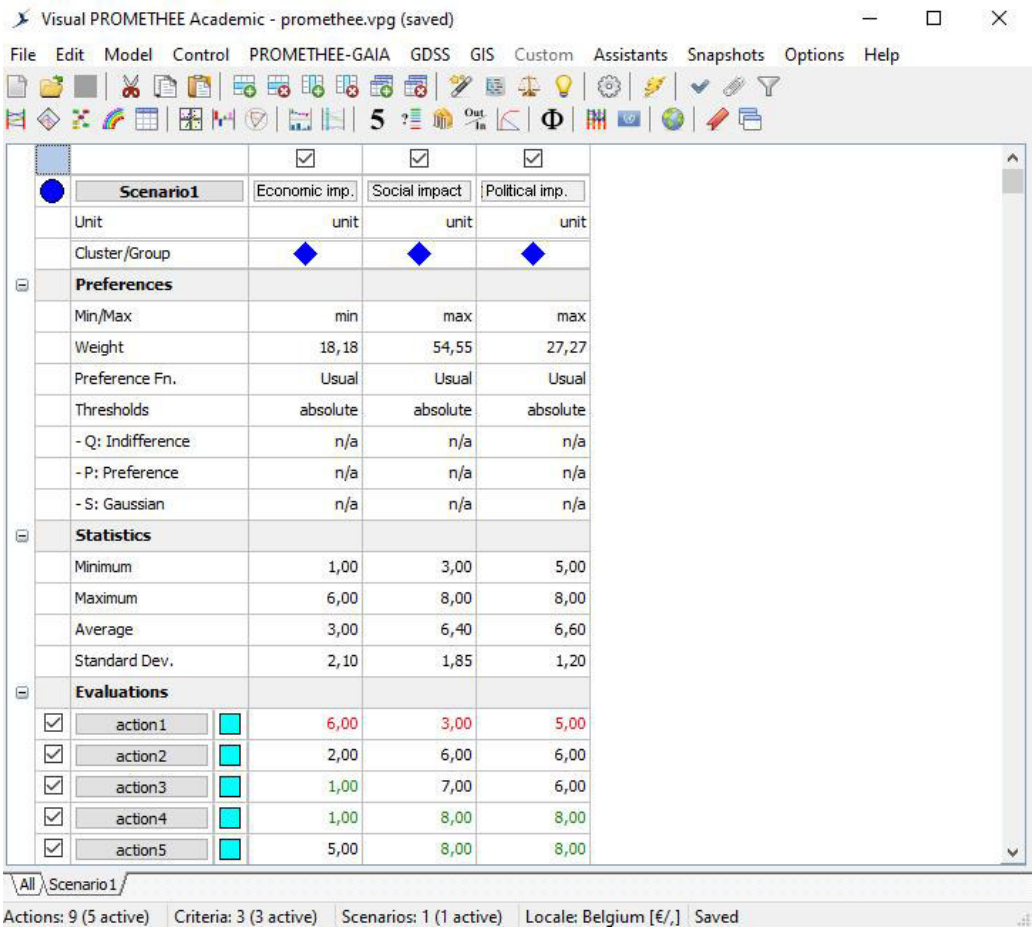


Figure 4: Entering the data in the software. Source: Own elaboration using the Promethee software

The Promethee I method, although it does not come to propose a decision (Figure 5), shows that the most convenient actions are 4, 5, and 3, which adequately respond to a greater number of criteria.

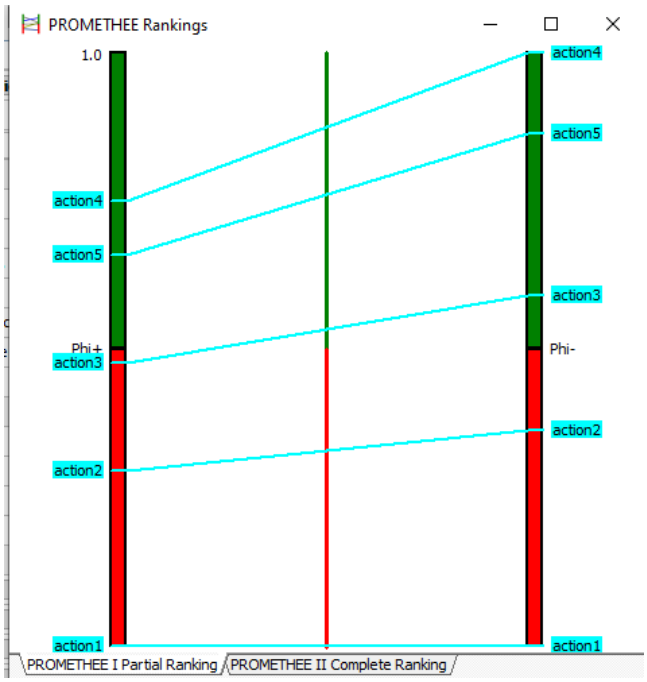


Figure 5: Results of the Promethe I method. Source: Own elaboration using the Promethee software

For its part, the Promethe II method confirms that the best alternatives are 4, 5, and 6, and the least desirable is action 1. As can be seen in figure 6. From the rainbow analysis (Figure 7), which is a mixture of the profiles of the alternatives, since it shows the impact of each one of them in the 3 chosen criteria, it can be seen that the optimal social, political and economic impact is achieved with the action 4, in the case of action 5, has a greater social and political impact, but to a lesser extent in the economic area, which is desirable since it is expected to minimize this aspect [24, 25, 26, 31, 32, 33]. As for action 3, it has a small impact on the 3 criteria. In the case of action 2, it has an unfavorable impact on all 3 criteria, although not as pronounced as action 1.

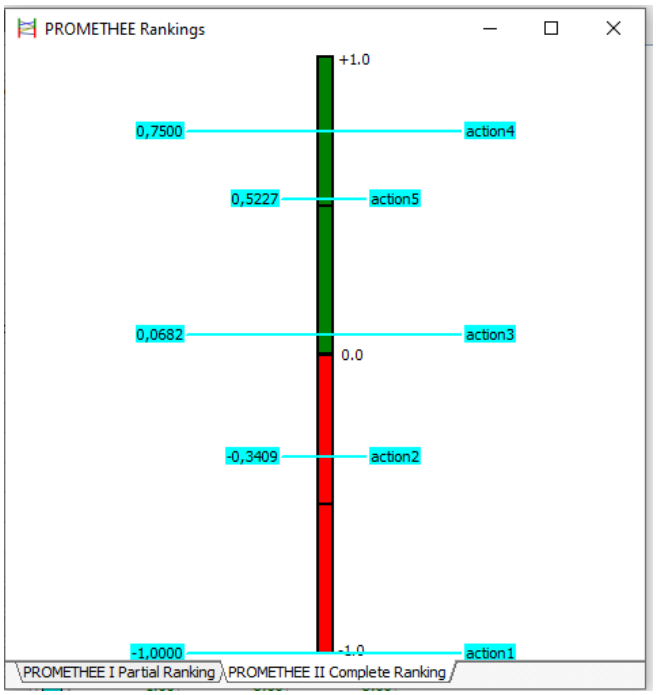


Figure 6. Results of the Promethe II method. Source: own elaboration using Promethee software

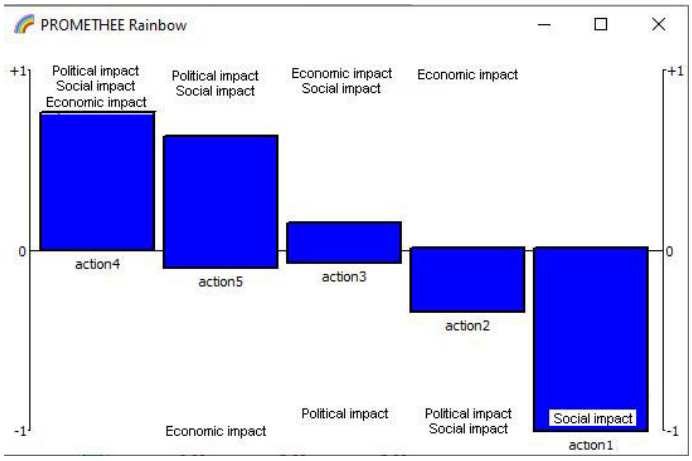


Figure 7: Rainbow analysis for each alternative. Source: own elaboration using Promethee software

3.3 Application of the Vikor method

In this study, 3 criteria and 5 alternatives are classified according to the VIKOR method. Table 1 shows the type of criterion and the weight assigned to each criterion.

	Name	Type	Weight
1	The economic impact	-	0.2
2	societal impact	+	0.8
3	The political impact	+	0.3

Table 1: Characteristics of the criteria. Source: own elaboration

	Criterion 1	Criterion 2	Criterion 3
Action 1	5.66666666666667	3.66666666666667	4.66666666666667
action 2	2	6	6.33333333333333
action 3	1	7	6.66666666666667
action 4	1.33333333333333	8	7.33333333333333
action 5	3.66666666666667	8	7.66666666666667

Table 2: Decision matrix. Source: own elaboration

	Criterion 1	Criterion 2	Criterion 3
Action 1	0.783	0.244	0.315
action 2	0.276	0.399	0.428
action 3	0.138	0.465	0.451
action 4	0.184	0.532	0.496
action 5	0.507	0.532	0.518

Table 3. Normalized decision matrix. Source: own elaboration.

	R	S
Action 1	0.8	1.3
action 2	0.369	0.545
action 3	0.185	0.285
action 4	0.033	0.048
action 5	0.114	0.114

Table 4: Hierarchy of alternatives. Source: own elaboration.

	Q
Action 1	1
action 2	0.418
action 3	0.193
action 4	0
action 5	0.079

Table 5: Q values. Source: own elaboration

Alternatives are ranked by sorting the S, R, and Q values in decreasing order so that the highest ranking is assigned to the alternative with the smallest VIKOR value. The results are three ranking lists. The following table presents the ranking list of the alternatives based on the S, R, and Q values

	R value	Rank in R	S value	Rank in S	Q value	Rank in Q
Action 1	0.8	5	1.3	5	1	5
action 2	0.369	4	0.545	4	0.418	4
action 3	0.185	3	0.285	3	0.193	3
action 4	0.033	1	0.048	1	0	1
action 5	0.114	2	0.114	2	0.079	2

Table 6: Classification list of alternatives. Source: own elaboration.

Propose a compromise solution

Propose a compromise solution of the alternative ($A^{(1)}$), which is the best ranked by measure Q (minimum) if the following two conditions are met:

- **Condition 1**. Acceptable advantage: $Q(A^{(2)}) - Q(A^{(1)}) \geq \frac{1}{m-1}$ where $A^{(1)}$ is the alternative with the first position and $A^{(2)}$ is the alternative with the second position in the ranking of the alternatives taking into account the Q value and m is the number of alternatives.
- **Condition 2**. Acceptable Stability in Decision Making: The Alternative $A^{(1)}$ must also be the best-ranked by S and/or R.

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

- **Solution 1.** Alternatives $A^{(1)}, A^{(2)}, \ldots, A^{(M)}$ if Condition 1 is not met; Alternative $A^{(M)}$ is determined by $Q\left(A^{(M)}\right) - Q\left(A^{(1)}\right) < \frac{1}{m-1}$ for a maximum M (the positions of these alternatives are "in proximity").
- **Solution 2.** Alternatives $A^{(1)}$ and $A^{(2)}$ if only condition 2 is not met.
- **Solution 3.** The alternative with the minimum value of Q will be selected as the best alternative if the 2 conditions are met.

The result of meeting the conditions is shown in the following table.

Condition 1	Non-acceptance
Condition 2	-
Selected solution	Solution 1

Table 7: Conditions survey results. Source: own elaboration

Then alternatives 4, 5, and 3 are the ones selected.

Conclusion

With the completion of this research, it is observed that the issue of indigenous justice and its application in Ecuador is an area that, despite being studied by several researchers, maintains its relevance given the social impact it entails. As Ecuador is a Plural State in legal matters, it is important to find a balance for the coexistence of ordinary and indigenous justice.

Through interviews with jurists and judges, the main limitations surrounding the application of indigenous justice and the actions that must be taken to mitigate its effects were defined. The representation of the limitations found in the cause-effect diagram allows visualizing each area where they belong, as well as if there is any sub-cause between them.

With the application of the Promethee and Vikor method, the same results are obtained, the chosen actions being to strengthen the communication system through dialogues and conferences of judicial institutions, with the objective of Indigenous Justice, to increase knowledge of this issue among members of society and encourage the protection of ethnic minorities by the state, approve a law that allows the indigenous community to act in a solvent manner and, in turn, set the necessary limits within each territory, to avoid violation of rights and impunity and ensure that indigenous communities comply with what is legislated in the Constitution and international treaties to which Ecuador is a party, considering indigenous justice as an immediate source of law.

References

[1] J. Smith. (2022). *Decolonization and Justice: An Introductory Overview*. Available: https://opentextbooks.uregina.ca/decolonizingjustice/chapter/decolonizing-restorative-justice/

[2] S. Lopez and S. Tapia, "Legal Colonialities: The Constitutionalisation of Indigenous Justice and the Continuity of Hegemonic Judicial Discourse in Ecuador.," *Rev. Derecho del Estado,* vol. 51, pp. 299-331, 2022.

[3] E. Diaz and A. Antúnez, "Constitutionalism in Latin America: indigenous justice and legal pluralism in Ecuador.," *Pensamiento Juridíco,* vol. 1, pp. 43-76, 2018.

[4] P. Vega, "Clashes between the Indigenous Justice System and Ordinary Law in Ecuador. ," *Acta Humana–Emberi Jogi Közlemények,* vol. 6, pp. 39-46, 2018.

[5] S. López Hidalgo and S. Tapia Tapia. (2022) Colonialities: The Constitutionalisation of Indigenous Justice and the Continuity of Hegemonic Judicial Discourse in Ecuador. *Revista Derecho del Estado*.

[6] L. Viaene, *Justicia transicional, el diálogo y la reflexividad crítica: tejiendo pensamientos.*, 2020.

[7] P. Gadhoke, P. Sanchez, M. Zajkowski, K. Taylor, and B. P. Brenton, "Minga, Participatory Action, and Social Justice: Framing a Decolonization Process for Principled Experiential Learning Among Indigenous Shuar Communities in Amazonian Ecuador.," *Journal of Experiential Education,* vol. 42, pp. 185-200, 2019.

[8] A. Luque, T. Ortega, and P. Carretero, "Indigenous justice in Ecuador: The case of the tuntatacto community. ," *Prisma Social Revista de Ciencias Sociales,* vol. 27, pp. 1-19, 2019.

[9] J. Guzmán, "Decolonizing Law and expanding human rights: Indigenous conceptions and the rights of nature in Ecuador.," *Deusto Journal of Human Rights,* pp. 59-86, 2019.

[10] B. Chokkalingam, S. Boovendravarman, R. Tamilselvan, and V. Raja, "Application of Ishikawa diagram to investigate significant factors causing rough surface on a sand casting. ," *Proc. Eng. Sci,* vol. 2, pp. 353-360, 2020.

[11] O. Abbasi, E. Noorzai, K. Gharouni Jafari, and M. Golabchi, "Exploring the causes of delays in construction industry using a cause-and-effect diagram: case study for Iran. Journal of architectural engineering," *26,* vol. 3, 2020.

[12] D. Ardianto and I. Eviyuliwati, "The Effect of Fishbone Diagram on Students' Writing of Analytical Exposition Text. ," presented at the In ICEMS 2019: Proceedings of the 5th International Conference on Education in Muslim Society (p. 268). European Alliance for Innovation. September-01 October 2019, Jakarta, Indonesia 2020.

[13] P. Ziemba, "NEAT F-PROMETHEE–A new fuzzy multiple criteria decision making method based on the adjustment of mapping trapezoidal fuzzy numbers," *Expert Systems with Applications,* vol. 110, pp. 363-380, 2018.

[14] T.-Y. Chen, "A novel PROMETHEE-based outranking approach for multiple criteria decision analysis with Pythagorean fuzzy information," *Ieee Access,* vol. 6, pp. 54495-54506, 2018.

[15] J. Witkowski, J. Marcinkowski, and M. Kiba-Janiak, "A comparative analysis of electronic freight exchanges in the United States and Europe with the use of the multiple criteria decision-making method "Promethee"." *European Research Studies Journal,* vol. 23, pp. 1-13, 2020.

[16] S. Zeng, S. Chen, and L. Kuo, "Multiattribute decision-making based on novel score function of intuitionistic fuzzy values and modified VIKOR method. ," *Information Sciences,* vol. 488, pp. 76-92, 2019.

[17] H. Paronyan, R. M. Carballido, and M. A. Matos, "Neutrosophic VIKOR for Proposal of Reform to Article 189 of the Integral Criminal Code in Ecuador," *Neutrosophic Sets and Systems,* vol. 37, pp. 287-294, 2020.

[18] Leyva, M., Estupiñán, J., Coles, W., & Bajaña, L. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, pp 130-135, 2021.

[19] Álvarez Gómez, G. A., Viteri Moya, J. R., Viteri Intriago, D. A., & Estupiñán Ricardo, J. "Integración de los procesos sustantivos para la mejora de la calidad del aprendizaje". Conrado, vol. 17 no. 80, pp 21-27, 2021.

[20] Vega Falcón, V., Alarcón Quinapanta, M., Yancha Villacís, M., & Estupiñán Ricardo, J. Medición del capital intelectual: Caso hotelero. Dilemas Contemporáneos: Educación, Política y Valores, no. 96, pp 1-19, 2019.

[21] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[22] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[23] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[24] González, I. A., Fernández, A. J. R., & Ricardo, J. E. "Violación del derecho a la salud: caso Albán Cornejo Vs Ecuador". Universidad Y Sociedad, vol. 13 no. S2, pp 60-65, 2021.

[25] Álvarez Gómez, S. D., Romero Fernández, A. J., Estupiñán Ricardo, J., & Ponce Ruiz, D. V. "Selección del docente tutor basado en la calidad de la docencia en metodología de la investigación". Conrado, vol. 17 no. 80, pp 88-94, 2021.

[26] Estupiñán Ricardo, J., Domínguez Menéndez, J. J., Barcos Arias, I. F., Macías Bermúdez, J. M., & Moreno Lemus, N. "Neutrosophic K-means for the analysis of earthquake data in Ecuador". Neutrosophic Sets and Systems, vol. 44 no. 1, pp. 29, 2021.

[27] Acuña, B. P., & Von Feigenblatt, O. F. "La lengua y la literatura en el aula del futuro enmarcado en el aprendizaje personalizado. In Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones" (pp. 13-24). Ediciones Octaedro, 2022.

[28] von Feigenblatt, O. F., Calderon, R. D., & MacDonald, T. "The Case for an Eclectic and Flexible Leadership Research Agenda: Dealing with Social Justice and Diversity in the 21st Century Workplace". Centro Sur, vol. 6 no. 1, pp 130-142, 2022.

[29] von Feigenblatt, O. "Mediation for management: Dealing with Conflict in the Workplace". Innovaciones de Negocios, vol. 18 no. 35, pp 113-119, 2021.

[30] von Feigenblatt, O. F. "Un estudio de caso sobre la competencia diplomática entre la República Popular China y la República de China (Taiwán): La experiencia de la República de Costa Rica de 1995 a 2010". Dilemas contemporáneos: Educación, Política y Valores. Vol. 9no. (Edición especial), pp 1-19, 2021.

[31] H. Paronyan, R. Meléndez Carballido, Y. G. Calva Vega & N. V. Quevedo Arnaiz. "Derecho de autodeterminación: Caso de Nagorno-Karabaj". Universidad y Sociedad, vol. 14 no. S5, pp 108-116, 2022.

[32] G. J. Silva Andrade, P. O. Piray Rodríguez & D. A . Silva Andrade. "El Legaltech como herramienta Jurídica-Tecnológica en la eficiencia de la Administración Pública." Universidad y Sociedad, vol. 14 no. S5, pp 130-136, 2022.

[33] G. M. Mancheno Salazar, J. L. Guaranga Chafla & V. Y. Pilco Villigua. "Derechos condicionados de las personas con Discapacidad dentro del ámbito laboral". Universidad y Sociedad, vol. 14 no. S5, pp 148-157, 2022.

[34] O. R. Aldaz Bombón, F. M. Pozo Hernández & J. H. Almeida Blacio. "Empresas envasadoras de agua y su gestión de calidad en Santo Domingo de los Tsáchilas. Ecuador". Universidad y Sociedad, vol. 14 no. S5, pp 158-165, 2022.

[35] J. E. Montes De Oca Sánchez, B. G. Valle Fiallos & R. Comas Rodríguez. "1. Energía solar como responsabilidad empresarial en servidores turísticos. Baños – Tungurahua". Universidad y Sociedad, vol. 14 no. S5, pp 166-176, 2022.

[36] Y. G. Calva Vega, J. M. Pazos Rivas & S. A. Montecé Giler. "Estudio de normativa infraccional en las contravenciones penales contra agentes del control del orden público en Ecuador". Universidad y Sociedad, vol. 14 no. S5, pp 201-209, 2022.

Received: August 08, 2022. **Accepted:** October 09, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of Legal Fissures in Family Protection

Mónica Isabel Mora Verdezoto [1], Carlos Ramiro Hurtado Lomas [2], Eugenio Javier Escobar Gonzales [3] and Carmen Marina Méndez Cabrita [4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. Email: ua.monicamora@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. Email: ui.carloshurtado@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. Email: ur.eugenioescobar@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. Email: ut.carmenmmc56@uniandes.edu.ec

Abstract. The family is a social construction, whose structure and functions change according to the political, social, and economic moment and geographical region in which it develops. It is the natural and fundamental element of society and therefore has the right to protection by society and the State. The family today is not the same as in previous centuries, the so-called globalization, which represents this continuous movement of knowledge and customs, ideologies, and policies in all areas, allows reflection on the changes that have arisen against the concept of family and its diversity, as well as its protection. The objective of this work is to determine the factors that affect the protection of the family and the effects caused by legal fissures. Through the use of the neutrosophic topsis method, the result is to propose the implementation of a family code that recognizes and regulates the different family structures, as well as their protection.

Keywords: Family, customs, diversity, protection.

1 Introduction

The family is the institution that best fulfills the essential functions for the development of every human being. In international legal agreements, the family unit is not clearly defined, and therefore in many countries, the emergence of new family forms that occur in the current era is not considered. Therefore, when evaluating the protection of families, they find gaps that must be filled by regulations, mainly civil and family.

For legal science, the integral protection of the members of each family structure, as well as of the human group itself, represents a permanent challenge, which must be faced in order to be consistent with its main regulatory purposes. This translates into the protection and legal guarantee that is granted to individuals in society and the situations that in practice are verified day by day.

The protection of the family consists mainly in establishing a bond where there are values such as love, respect, solidarity, and mutual help, but especially where the rights and duties of each of the members that comprise it are respected and responsibly fulfilled [1]. Also, the protection of the state, the right to constitute it, the recognition of marriage, the correlative duty of health assistance, education, food, and the rights of women as heads of the family are established.

In Ecuador, the right to live with a family is defined in article 45 of the Constitution [2] which indicates that children and adolescents have the right to have a family and enjoy family and community life; to social participation; respect for their freedom and dignity; to be consulted on matters that affect them. Article 45 also takes into account the perspective and cultural context of their peoples and nationalities, among other relevant aspects, such as the right to receive information about their parents or absent relatives [3].

The family is not a static institution. Indeed, it is a very dynamic entity since it goes through cycles caused by the departure or arrival of some of its members, and these cycles or stages, depending on the magnitude, can give rise to its reorganization. The breakup of the parents and the subsequent integration of a new spouse in the family unit would be the main causes of an important family change, at least in relation to the non-common children who were minors [4].

The protection of the family is entrusted to the entire society, which through its representatives and by virtue of family law, intends to protect interests other than the individual of the members of each family, and which are related to the interests of the group. During childhood, the figure of parents is very important and vital for children. Throughout the different stages of development, they need to receive the support, affection, and protection of their

parents, since they are the closest people to them, both physically and emotionally, so it is recommended that parents protect the mental and emotional health of their children [5].

One of the main obligations of the family is the protection of children. Therefore, the state must promote responsible motherhood and fatherhood, through the comprehensive development and protection of the rights of sons and daughters. This is precisely the notion promoted by the state regarding the right of children to have a family. On the other hand, an obligation is established, in terms of protecting and caring for the elderly, legally sanctioned in cases of abandonment of older adults [6], [18].

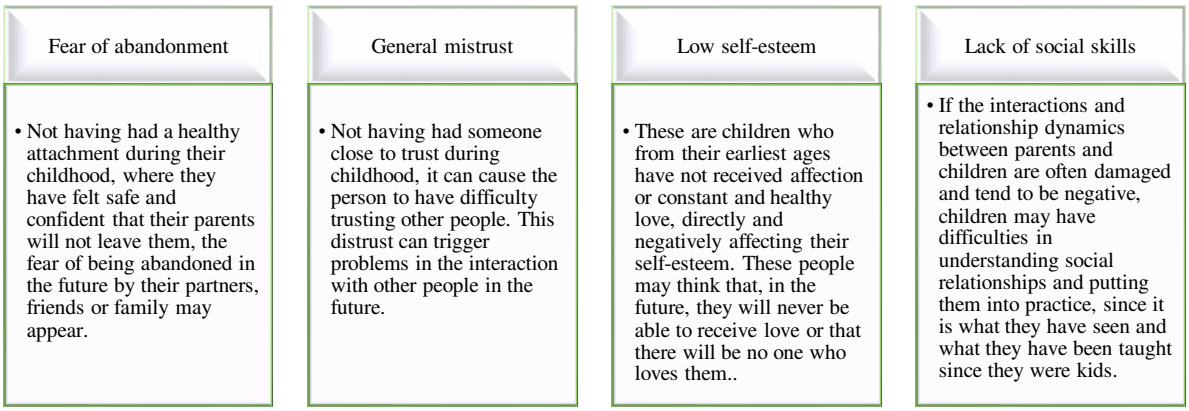


Figure 1. Some consequences of the lack of family affection. Source: own elaboration.

In family structures, parents or guardians are those who are legally and socially recognized as the authority and model to direct, protect, educate, train, and organize the lives of children up to a certain age, in which they can look after themselves. It should be emphasized that the intervention of parents or guardians in the lives of minors will be affected and will influence depending on the socio-historical context in which the family develops. In addition, the people who are in charge of supporting the family have the right to fair remuneration for their work, this remuneration must cover the needs of the family.

The Latin American Constitutions have had great advances in terms of the elaboration of new laws and codes that seek the well-being of the family, as an important nucleus of society, which establishes it in an egalitarian, pluralistic, democratic, and fair manner, qualities that are reflected in the relationship between spouses within the family and, on the other hand, the relationship between parents and children. The Constitution of Ecuador considers the family as a fundamental nucleus of society and although there is no independent body of norms that regulate everything related to the family, provisions can be found that try to protect the family as an institution.

The international instruments for the protection of rights deduce the obligation of the states to protect and assist the family as the natural and fundamental element of society so that it becomes responsible for the education and upbringing of children. An inconvenience arises when talking about the protection of the different forms of the family since the Ecuadorian legislation does not have a Family Code, and since this is the most important institution in society, the legal norms need to be ordered, unified, and coded.

As one of the different forms of family, there is the reconstituted family, this is probably the most frequent today due to the growing tendency to separation and divorce. In these new families, there is a more complex network of relationships, given that not only do the father, the mother and the children interact in the family setting, but one of the parents lives outside that nucleus, but that does not stop him from exerting their influence as well. The members generate rights and obligations and the normative ignorance of the rights of these relatives, united among themselves by affection, objectives, and deployment of family roles, is unequal and inequitable.

The permanence of the marital or extramarital union as a regulated source of the so-called assembled family must be an element to be considered by the legislative body, to regulate what is appropriate and thus recognize successor rights to fathers, mothers, and related children. Maintaining legal ignorance of a growing social situation like this turns the law into a judge of moral situations and not a regulatory system of natural human behavior.

The main role of the states is to grant a guarantee of protection to human rights, compliance with their Constitutions, and the various international instruments, which still do not fully recognize the evolution that the structure of families has undergone in the postmodern context. Therefore, it is verified that these must be modified to be consistent with reality, and as a consequence, they must distinguish and seek adequate protection and the various forms of existing families.

For the analysis of the factors that affect the protection of the family, it is defined, as a problem situation: the legal fissures and the lack of regulations regarding the various forms of family. The main objective is to define the main factors that affect the protection of the family. Specific objectives: Determine the factors that affect the analyzed variable, measure and model the variable, and finally define the potential alternatives based on eradicating the variables that affect compliance with the protection of the family, as a principle of the Right to the family.

2 Materials and Methods

2.1 Neutrosophic Statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E will occur, the probability that event E will not occur, and the probability of indeterminacy (not knowing whether event E will occur or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x)$, where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x. Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [7], neutrosophic estimation, neutrosophic regression, etc.

It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and to the methods to analyze them. Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns [8].

Neutrosophic logic [9], neutrosophic sets, and neutrosophic probabilities and statistics have a wide application in various research fields and constitute a novel study reference in full development. Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data [10].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers 11], while "I" is the indeterminate part of the neutrosophic number N.

Here, $I_N \in [I_L, I_U]$ & $X_N \in [X_L, X_U]$ is a neutrosophic random variable of size $n_N \in [n_L, n_U]$. The variable $X_{iN} \in [X_{iL}, X_{iU}]$ has two parts: the lower value X_{iL} a classical part, and the upper-value $X_{iU}I_N$ an indeterminate part having an interval of indeterminacy $I_N \in [I_L, I_U]$ [12].

Similarly, the mean neutrosophic $X_N \in [X_L, X_U]$ is defined as follows:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

(2)

Where $X_U = \sum_{i=1}^{nL}(X_{il}/nl)$ and $X_L = \sum_{i=1}^{n_U}(X_{iu}/n_u)$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows:

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\left[\begin{matrix}\min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{matrix}\right], I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$\boldsymbol{S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2]} \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows.

$$\boldsymbol{CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U]} \tag{5}$$

2.2 TOPSIS method

TOPSIS *(Technique for Order Preference by Similarity to Ideal Solution)*. This technique is characterized by its effectiveness and the simplicity of its principle in solving multi-criteria decision problems. In the case of TOPSIS, the selection is based on finding the alternative that is closest to the ideal solution and, in turn, is further away from the worst solution. It allows combining several heterogeneous attributes in a single dimensionless index, and this is because the attributes under evaluation are very possibly expressed in different units or scales [13], [14], [16], [22], [23], [24], [25].

TOPSIS is based on the concept that the selected alternative must have the smallest Euclidean distance to an ideal solution and the largest Euclidean distance to an anti-ideal solution. So, the order of preference of the alternatives can be determined through a series of comparisons of these distances. Both solutions, the ideal and the anti-ideal, are fictitious. [15], [17], [19], [20], [21]

The ideal solution is a solution for which all attribute values correspond to the optimal values of each attribute contained in the alternatives; the anti-ideal solution is the solution for which all attribute values correspond to the least desired values of each attribute contained in the alternatives. In this way, TOPSIS provides a solution that is not only the closest to a hypothetically better solution but also the farthest from the hypothetically worse one. The process is described below, [26]:

1. Determine the objective and identify the attributes to be evaluated.
2. Prepare a matrix based on the information available on the attributes. Each row corresponds to an alternative and each column to an attribute. The element of the array represents the non-normalized value of the attribute j_{th} for the alternative i_{th}.
3. Calculate the normalized decision matrix R_{ij}. This is obtained by dividing each attribute value by the square root of the sum of the squares of each attribute value X_J. This is represented mathematically by equation (6):

$$Rij = \frac{x_{ij}}{\sqrt{\sum_{m=1}^{k} x_{mj}^2}} \tag{6}$$

4. Determine the relative importance or weight of each attribute with respect to the objective. This gives rise to a set of weights such that $\sum w_j = 1$. The weights are generally based on expert judgment and should reflect the relative importance assigned to the attributes of evaluated performance. The range of possible values of $w_j$will only be limited by the ability of the elements of the decision group to distinguish the relative importance of the analyzed performance attributes.w_j
5. Obtain the normalized and weighted matrix V_{ij}. This is done by multiplying each element in the columns of the matrix R_{ij} by its corresponding weight w_j. Therefore, the elements of the normalized and weighted matrix are expressed by equation 7:

$$V_{ij} = w_j * R_{ij} \tag{7}$$

6. Obtain the ideal and anti-ideal solution: The ideal solution can be expressed as (8) and the anti-ideal as (9). V_j^+ indicates the ideal value of the attribute considered among the values of the attributes for the different alternatives, while V_j^- indicates the worst value of the attribute considered among the values of the attributes for the different alternatives.
7.

$$V^+ = \{V_1^+, V_2^+, V_3^+, \ldots., V_j^+\} \tag{8}$$

$$V^- = \{V_1^-, V_2^-, V_3^-, \ldots., V_j^-\} \tag{9}$$

8. Calculate the Euclidean distances of each alternative to the ideal and anti-ideal solutions using the following equations:

$$D_i^+ = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^+)^2} \tag{10}$$

$$D_i^- = \sqrt{\sum_{j=1}^{j} (V_{ij} - V_j^-)^2} \tag{11}$$

9. The relative closeness Pi of a particular alternative to the ideal solution is expressed by (12):

$$P_i = \frac{D_i^-}{(D_i^+ + D_i^-)} \tag{12}$$

10. In this step, a set of alternatives is generated in descending order according to the value of Pi, having as the best alternative the one with the highest value of Pi.
11. In this article, linguistic terms will be associated with SVNN, so that the experts can carry out their evaluations according to the corresponding scale (Table 1).

Linguistic term	SVNN
Very Weak (VW)	(0.10, 0.75, 0.85)
Weak (W)	(0.25, 0.60, 0.80)
Medium Weak (MW)	(0.40, 0.70, 0.50)
Medium (M)	(0.50, 0.40, 0.60)
Medium Strong (MS)	(0.65, 0.30, 0.45)
Strong (S)	(0.80, 0.10, 0.30)
Very Strong (VS)	(0.95, 0.05, 0.05)

Table 1. Linguistic terms according to the strength of the weight in the alternatives. Source: own elaboration.

3 Results

The techniques described above are applied as follows. For the protection of the family and due to the complexity and indeterminacy of the data, it was decided to apply neutrosophic statistics for the modeling of the analyzed variable.

From the processing of the information and the consensus of the experts, the factors that most affect the protection of the family (Table 2) and the variable to be modeled were determined.

Variable analyzed: family protection, for a sample of n=150 for each factor (f)

Code	Factors Affecting Family Protection
a	Absence of a legal status
b	Violation of human rights
c	Insufficient economic remuneration
d	Impact of emotional support
e	Lack of regulation of social coexistence.

Table 2. Determining factors in the protection of the family. Source: own elaboration

For the development of the statistical study, the neutrosophic frequencies of the determining factors in the protection of the family, of all the members that make up the family nucleus, are analyzed. For each factor, an affectation is analyzed in days that make up the set of affectations to ensure that education is for everyone.

Days	Neutrosophic frequencies				
	a	b	c	d	e
0-150	[83 ; 159]	[73 ; 140]	[72 ; 147]	[75 ; 155]	[83 ; 150]

Table 3. Factors that affect compliance with the protection of the family. Source: own elaboration

The effects of factors on compliance with family protection are studied in Table 3, for 150 days, with an occurrence level of [0;2] for each factor per day. There is a total indeterminacy level of a=76, b=67, c=75, d=80, e=67, with a representativeness level of [44.66%; 51.61%], on days when 2 affectations per factor were recorded. A greater incidence of 50% is observed in the factors of insufficient economic remuneration and violation of human rights. As a result of the existing indeterminacy, the use of neutrosophic statistics is necessary for its greater understanding.

4 Neutrosophic Statistical Analysis

For the modeling of the data of the affectations that have an impact on the protection of the whole family, it will be possible to understand what factor implies a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic averages are calculated, and for the study of the variations of the affectations, the values of the neutrosophic standard deviation $S_N \in [S_L; S_U]$. To determine which affectation requires a greater incidence in the analyzed variable, the values $CV_N \in [CV_L\ ;\ CV_U]$ are calculated (figure 2).

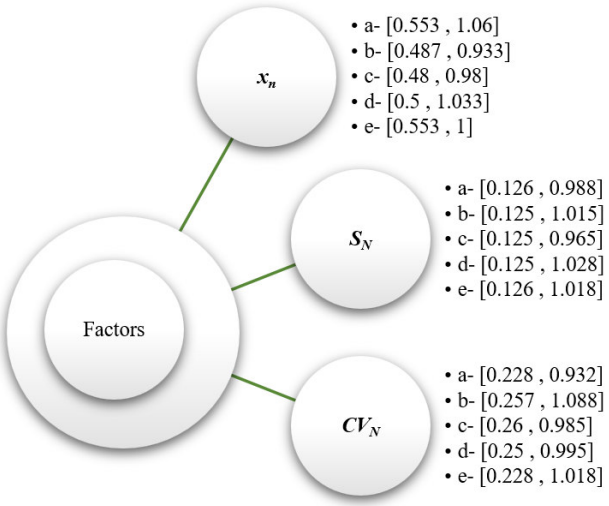


Figure 2. Neutrosophic statistical analysis of incidences in the protection of the family. Source: own elaboration.

It is observed that the non-existence of legal status has higher incidence values than the other factors. This means that this factor is, on average, the one that most affects compliance with the protection of the family. In affirmation, the value of CV_{No} this factor is lower compared to the rest. This means that the result of factor a has a negative and more significant impact than the other factors on the variable being analyzed (Table 4).

5 Comparative analysis

To determine the associated referent uncertainty measure for $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ and $CV_N \in [CV_L\ ;\ CV_U]$ to the form of neutrosophic numbers (Table 5), it is observed that the CV_N values range from 0.228 to 0.932, with a measure of indeterminacy of 75.5. This generates a negative impact to comply with the reforms to the legal frameworks for better fulfillment of family law as an unavoidable necessity for the development of people as a community, as well as its influence on other affectations. It is required that the governing bodies focus on a higher level of monitoring of the regulations and policies for the formation of new modalities and family structures.

Factors	$\bar{x}_N$	Y_N	CV_N
a	$0.553 + 1.06\ I; I \in [0; 47.8]$	$0.126 + 0.988\ I; I \in [0; 87.2]$	$0.228 + 0.932\ I; I \in [0; 75.5]$
b	$0.487 + 0.933\ I; I \in [0; 47.8]$	$0.125 + 1.015\ I; I \in [0; 87.7]$	$0.257 + 1.088\ I; I \in [0; 76.4]$
c	$0.48 + 0.98\ I; I \in [0; 51.0]$	$0.125 + 0.965\ I; I \in [0; 87.0]$	$0.26 + 0.985\ I; I \in [0; 73.6]$
d	$0.5 + 1.033\ I; I \in [0; 51.6]$	$0.125 + 1.028\ I; I \in [0; 87.8]$	$0.25 + 0.995\ I; I \in [0; 74.9]$
e	$0.553 + 1I; I \in [0; 44.7]$	$0.126 + 1.018\ I; I \in [0; 87.6]$	$0.228 + 1.018\ I; I \in [0; 77.6]$

Table 5. Neutrosophic forms with measure of indeterminacy. Source: own elaboration.

6 TOPSIS Analysis

TOPSIS modeling is used to determine the possible alternatives based on the use of the regulations and policies for the formation of the different families. The strategies to be evaluated are focused on monitoring the norms and policies for the formation of the different families and promoting the following parameters:

- ✓ There are no economic policies in support of different family structures
- ✓ There is no family code to recognize and regulate the different family structures
- ✓ It prevents a better understanding of the socio-economic and family environment in which they live and develop day by day
- ✓ Generates intra- and extra-family violence
- ✓ Encourages the culture of conflict of power of the strongest over the weakest
- ✓ Lack of basic principles of family coexistence.

A1- Economic policy
A2-Lack of regulations

A3- Social environment
A4-Violence
A5- Power struggle
A6- Family coexistence

The results are shown in the following tables:

Alternatives	Submit economic policies	Submit a code for current families	Regulate social relations	Present policies to eradicate all types of violence	Regulate the fundamental bases of organization	Ensuring compliance with human rights
A1	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)	(0.25, 0.60, 0.80)	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)	(0.80, 0.10, 0.30)
A2	(0.65, 0.30, 0.45)	(0.80, 0.10, 0.30)	(0.50, 0.40, 0.60)	(0.65, 0.30, 0.45)	(0.65, 0.30, 0.45)	(0.65, 0.30, 0.45)
A3	(0.95, 0.05, 0.05)	(0.25, 0.60, 0.80)	(0.25, 0.60, 0.80)	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)	(0.95, 0.05, 0.05)
A4	(0.65, 0.30, 0.45)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.80, 0.10, 0.30)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)
A5	(0.95, 0.05, 0.05)	(0.80, 0.10, 0.30)	(0.25, 0.60, 0.80)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)
A6	(0.95, 0.05, 0.05)	(0.65, 0.30, 0.45)	(0.50, 0.40, 0.60)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)	(0.10, 0.75, 0.85)

Table 6. Table of the weights assigned by the experts to each criterion. Source: own elaboration

Alternatives	Submit economic policies	Submit a code for current families	Regulate social relations	Present policies to eradicate all types of violence	Regulate the fundamental bases of organization	Ensuring compliance with human rights
A1	0.12909	0.03907	0.08025	0.01111	0.01252	0.12867
A2	0.19466	0.04639	0.04494	0.01676	0.01888	0.16339
A3	0.19466	0.01367	0.04494	0.01676	0.01888	0.19402
A4	0.12909	0.00781	0.02568	0.01411	0.00318	0.03268
A5	0.19466	0.03907	0.04494	0.00282	0.00318	0.03268
A6	0.19466	0.03077	0.08025	0.00282	0.00318	0.03268

Table 7. Weighted normalized matrix. Source: own elaboration.

Alternative	d-	d+	Ri	Order
Economic policy	0.05099	0.06597	0.43595	5
Lack of regulations	0.11550	0	1	1
social environment	0.11198	0.03272	0.77387	4
Violence	0.04739	0.07607	0.38385	6
Power fight	0.11391	0.00732	0.93957	2
family life	0.11265	0.01562	0.87818	3

Table 8. Matrix of the distances and calculation of the Ri for each alternative. Source: own elaboration.

As a result, it is preferred to promote alternative 1, related to the lack of regulations, depending on the deficiency to be eradicated. The family has evolved, therefore, the law has to adjust to it, just as the constitutional norm cannot stop accepting these new forms of family coexistence. It must take to the constitutional text, the fundamental bases of the organization of the family in a special chapter in which the systematization, the order, the evolution, the respect, and the idiosyncrasy are taken care of.

- Propose to the governing bodies and the state a family code that relates the open recognition of the existence of mixed, reconstituted, or complex families and expressly establish rights and obligations among its members, without moralism or unlawful criteria incompatible with respect for human rights.
- Propose an amendment to the constitution without failing to consider other regulations of a secondary nature to recognize the basic principles of coexistence, which translate into human rights.

Conclusion

The family is commonly defined as a group of people united among themselves by ties of marriage or by kinship, either by blood or affinity, who live under the same roof and with common interests and rights, and duties

between them, assisting each other in the care of their lives. That is why each person cannot invent the family, since it is not only a legal institution to which man must adapt and protect, but it is a natural institution in which the state intervenes in its regulation for the common good.

The analysis of the answers of the experts on the legal fissures in the protection of the family defined in six variables allows visualizing the need to implement a new code from the evaluation of neutrosophic criteria. The result of the modeling of the neutrosophic TOPSIS method has been defined as a variable to promote the proposal of a code that protects and regulates the formation of different families thus eliminating any type of violence that is generated by the lack of regulations. The objective of a new family code will facilitate not only the protection of the family but also the coexistence and psychosocial development of the members of the family nucleus.

It is a challenge for the law to regulate this new form of socio-family interaction, not to continue ignoring it as before, since this has only brought about situations of imbalance, as a specialized branch. It is family law that today has the challenge of reshaping its approach to new forms or family models. It is, therefore, in the light of the law as a social tool, and in compliance with its principles, to contemplate in its normative body this special situation of a family nature that, in a different time from the one initially regulated, requires in an equal manner the objective standardization of their rights, without discriminatory prejudices of character or moral origin.

References

[1] G. R.E.A., "THE HUMAN RIGHTS FROM THEIR PERSPECTIVE OF THE ECUADORIAN LEGISLATION," *Universidad y Sociedad,* vol. 14, pp. 498-503, 2022.

[2] H. Caballero, L. Paz Enrique, and E. Hernández Alfonso, "Publicaciones universitarias del Ecuador y enfoque de género en proyectos productivos internacionales," *Revista Conrado,* vol. 14, p. https://conrado.ucf.edu.cu/index.php/conrado/article/view/823, 10/18 2018.

[3] N. Y. Torres-Soto, V. Corral-Verdugo, and N. S. Corral-Frías, "The relationship between self-care, positive family environment, and human wellbeing," *Wellbeing, Space and Society,* vol. 3, p. 100076, 2022/01/01/ 2022.

[4] D. Umberson and M. B. Thomeer, "Family Matters: Research on Family Ties and Health, 2010 to 2020," *Journal of Marriage and Family,* vol. 82, pp. 404-419, 2020.

[5] L. Waters, "Using positive psychology interventions to strengthen family happiness: A family systems approach," *The Journal of Positive Psychology,* vol. 15, pp. 1-8, 07/21 2020.

[6] P. Vanleerberghe, N. De Witte, C. Claes, R. L. Schalock, and D. Verté, "The quality of life of older people aging in place: a literature review(Review)," *Quality of Life Research.* vol. 26, pp. 2899-2907, 2017.

[7] Y. Alhasan, "The neutrosophic integrals and integration methods," *Neutrosophic Sets and Systems,* vol. 43, pp. 290-301, 2021.

[8] W. B. Vasantha, I. Kandasamy, and F. Smarandache, "Algebraic Structure of Neutrosophic Duplets in Neutrosophic Rings < Z U I>,< Q U I> and < R U I.> " *Neutrosophic Sets and Systems,* vol. 23, pp. 85-95, 2018.

[9] E. González-Caballero, M. Leyva-Vázquez, and F. Smarandache, " On neutrosophic uninorms [Article]," *Neutrosophic Sets and Systems,* vol. 45, pp. 340-348.

[10] S. H. S. Al-Subhi, I. Pérez Pupo, R. García Vacacela, P. Y. Piñero Pérez, and M. Y. Leyva Vázquez, "A New Neutrosophic Cognitive Map with Neutrosophic Sets on Connections, Application in Project Management. ," *Neutrosophic Sets and Systems,* vol. 22. , pp. 63-75, 2018.

[11] R. Refaat and I. M. El-Henawy, "Innovative method to evaluate quality management system audit results' using single value neutrosophic number," *Cognitive Systems Research,* vol. 57, pp. 197-206, 2019.

[12] U. Afzal, H. Alrweili, N. Ahamd, and M. Aslam, "Neutrosophic statistical analysis of resistance depending on the temperature variance of conducting material," *Scientific Reports,* vol. 11, p. 23939, 2021/12/14 2021.

[13] R. G. Ortega, M. L. Vázquez, J. A. S. Figueiredo, & , and A. Guijarro-Rodriguez. (2018) Sinos river basin social-environmental prospective assessment of water quality management using fuzzy cognitive maps and neutrosophic AHP-TOPSIS. *Neutrosophic Sets and Systems*. 160–171. Available: http://fs.unm.edu/NSS2/index.php/111/article/view/408

[14] A L. Santillán Molina, N. V. Vinueza Ochoa & C. F Benavides Salazar. "La infracción al deber objetivo de cuidado en el proceso de Hardening". Universidad y Sociedad, Vol. 14 Num. S2, pp- 364-372, 2022.

[15] M. M Vidal del Río & A. A. Monsalve Guamán. "Babesiosis humana, una zoonosis emergente". Universidad y Sociedad, Vol. 14 Num. S2, pp- 358-363, 2022.

[16] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[17] Ricardo, J. E., Villalva, M. I. M., Padilla, Z. A. O., & Hurtado, L. A. C. "Filosofía de la comunicación, complemento necesario en el aprendizaje de las Ciencias Sociales". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 3 no. 2, pp 39-52, 2018.

[18] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[19] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[20] Leyva, M., Estupiñán, J., Coles, W., & Bajaña, L. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, pp 130-135, 2021.

[21] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.

[22] von Feigenblatt, O. F., & Linstroth, J. P. "Applied history and the teaching of leadership: a case for the use of historical case studies in leadership programs". Universidad y Sociedad, vol. 14 no. S3, pp 433-438, 2022.

[23] E. J. Naranjo Luzuriaga, L. A Crespo Berti, Luis Ramiro Ayala Ayala & N. García Arias. "Uso indebido de marcas en las plataformas digitales que limitan las actividades económicas". Universidad y Sociedad, vol. 14 no. 4, pp 675-682, 2022.

[24] G. R. Navas Espín, D. Peña Suárez, N. D. Silva Álvarez & M. P. Mayorga. "Recaudación tributaria para la educación en el Ecuador por la emergencia del Covid-19 en 2020". Universidad y Sociedad, vol. 14 no. 4, pp 619-627, 2022.

[25] M. C. Villarreal Ger, & C. E. Pozo Hernández. "Síndrome de fragilidad en adultos mayores de la Asociación Jesús el Buen Pastor en San Gabriel, Cantón Montúfar en Ecuador". Universidad y Sociedad, vol. 14 no. 4, pp 609-618, 2022.

[26] Mora, J. F. M., & Añez, J. C. D. J. A. (2022). Vulnerabilidades en la contratación pública en empresas del sector públicas en Ecuador. Universidad y Sociedad, vol. 14 no. 4, pp 598-608, 2022.

Received: August 09, 2022. **Accepted:** October 09, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Study of Gender Identity Models in Teaching Practices

Julio Alfredo Paredes López [1], Iyo Alexis Cruz Piza [2], Luis Rodrigo Miranda Chávez [3] and Miguel Ángel Guambo Llerena [4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.julioparedes@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.iyocruz@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. E-mail: up.luismiranda@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.miguelguambo@uniandes.edu.ec

Abstract. Sexual orientation and gender identity are essential aspects of a person's life and are under the protection framework of human rights. However, both categories continue to present themselves as a repeated reason for acts of discrimination, violence, and oppression, even through normative subjection. Education must highlight values such as coexistence, diversity, cooperative learning, and empathy to prevent heterosexism. Teachers must have training that guarantees safe, trustworthy, and safe learning spaces for all students, where they have the right to develop and socialize without exclusion. That is why the study is focused on analyzing the consensus and acceptance of experts on the factors that affect gender identity in the educational field based on the analysis of the neutrosophic statistical method. It was concluded that a reform of the current regulations should be carried out and training programs on human rights should be implemented to eliminate entrenched prejudices.

Keywords: discrimination, diversity, exclusion, human rights, neutrosophy.

1 Introduction

Gender roles are the set of roles and functions that make up the pre-established model of being a man or a woman in a given society. To speak of masculine and feminine in these societies, it is necessary to consider the specific political, economic, and territorial aspects and problems that the peoples and communities face. It is relevant to recognize and transform the different areas through which discrimination is manifested, two of them being of fundamental importance: the legal-regulatory field and the educational field.

In Ecuador, although the rights to equality and non-discrimination have been included in both domestic and international law, their effective fulfillment does not materialize in practice, which is reflected in many ways. There have been efforts by the state, but there are still practices, policies, and even regulations that become discriminatory based on sexual orientation. The foundation of these practices is associated with the persistence of cultural and ideological constructions based on heterosexism and heteronormativity.

With the Constitution of the year 2008, for the first time facets of the human personality, such as sexual orientation and gender identity, are called by their names in a series of articles. It is established not only that these human characteristics cannot be a reason for discrimination, but that the people who are part of the gender diversity have a series of rights that assist them. In this way, the contained legal discrimination ends, that which consists in not naming, avoiding the look, or passing sideways in front of reality [1].

Despite both conceptual and cultural advances regarding the recognition of sexual and gender diversity, there are still conservative positions against the possibility of having a sexual orientation other than heterosexual or constructing their gender identity outside of the pattern assigned to their biological sex. One of the difficulties that these families may encounter is the encounter with institutions or officers with conservative positions and who carry out discriminatory actions.

Gender discrimination also occurs in education, once inside the educational system it greatly affects especially women, but also men [2]. It is also related to other variables, such as ethnic, religious, social, or sexual orientation. Gender inequality in education can be considered a social problem that affects the world.

Initial education prioritizes the importance of the infant's first years of life. The environment where it develops is vital, here the boys and girls become active builders of their social world, a universe that reproduces the

defining characteristics of the adult framework that surrounds them. To facilitate gender-sensitive teaching, curricula and textbooks should be free from bias and promote equality in gender relations [3].

The elimination of gender violence in educational centers and their environments is a fundamental element to guarantee the human right to education and promote a safe and equitable learning environment for all people. The first step to improve interaction in the classroom is to reflect on one's gender stereotypes and recognize their role as educators and shapers of values. It is necessary to apply a methodology that is inclusive and representative.

It is education that promotes a pedagogical, training, critical, dynamic, participatory, and creative action plan. This is aimed at creating experiences and learning that cause an approximation between knowledge, reality, and the production of meaning of the educational subject. In addition, a series of knowledge and skills that affect their personal and citizen identity is expanded [4].

At the regional level, there continues to be little incorporation in national regulatory frameworks of protection against discrimination based on gender identity as an expressly recognized category and even more incipient in educational regulatory frameworks and public policies.

The school is the diffuser institution of the guidelines in terms of life regulations. If the school promulgated the values of inclusion, respect, and acceptance of difference, the results regarding positions that support the equal rights of gay, lesbian and trans people could vary more towards acceptance than rejection. Education must highlight values such as coexistence, diversity, cooperative learning, and empathy to prevent heterosexism. Promote training that guarantees safe, trustworthy and safe learning spaces for all students, where they have the right to develop and socialize without exclusion [3].

Based on the analysis referred to in the study and the level of indeterminacy existing in the neutrosophic statistical data, this study focuses on:

- The problem situation: discrimination based on gender identity in education.
- Main objective: to analyze the consensus and acceptance of experts on the factors that affect gender identity in the educational field.
- Specific objectives:
  - ✓ Determine the factors and degrees of recommendations for preventive practices by teachers
  - ✓ Carry out the measurement and modeling of the neutrosophic variable
  - ✓ Present potential alternatives, by evaluating the existing uncertainties of the analyzed variable.

Structure of the study:

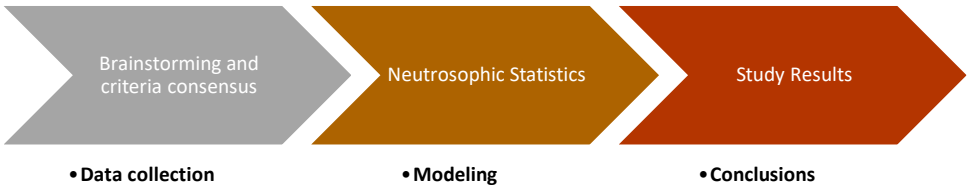


Figure 1: Study structure. Source: own elaboration.

2 Materials and methods

2.1 Neutrosophic statistics

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and to the methods to analyze them. Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns [5,6, 20].

Neutrosophic logic is an addition or advancement of fuzzy logic, intuitionistic logic, paraconsistent logic, and tri-valued logic that uses imprecise values. In neutrosophic logic, the entire logical variable (x) is defined by the ordered triplet denoted by x= (t, i, f), (t) the degree of truth, (f) the degree of untruth, and (i) be the degree of indeterminacy. The Indeterminate (I) is classified in contradiction and uncertainty and obtains an addition of Belnap's four-valued logic. Also, (I) is contradictory, not true, and not known and gets the five value logic [7].

In a refined general neutrosophic logic, (T) can be divided into subcomponents (T1, T2, ..., Tp) and (I) into (I1, I2, ..., Ir) and (F) into (F1, F2,...,Fs) where [$p + r + s = n \geq 1$]. Furthermore: T, I, and/or F (or any of their

subcomponents Tj, Ik, and/or Fl) can be countable or uncountable infinite sets. As an example: a statement can be between [0.4, 0.6] true, {0.1} or between (0.15, 0.25) indeterminate and 0.4 or 0.6 false.

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics [8]. The neutrosophic probability of event E is the probability that event E occurs, the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = (T(x), I(x), F(x))$, where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic logic [9], neutrosophic sets, and neutrosophic probabilities and statistics have a wide application in various research fields and constitute a novel study reference in full development. Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data [10], [11], [12], [17], [21], [24].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers [5], while "I" is the indeterminacy part of the neutrosophic number N [11], [16], [22], [23]. Here $I_N \in [I_L, I_U]$ & $X_N \in [X_L, X_U]$ is a neutrosophic random variables of size $n_N \in [n_L, n_U]$. The variable $X_{iN} \in [X_{iL}, X_{iU}]$ has two parts: the lower value X_{iL} a classical part, and the upper-value $X_{iU}I_N$ an indeterminate part having an interval of indeterminacy $X_{iU}I_N$. Similarly, the mean neutrosophic $X_N \in [X_L, X_U]$ is defined as follows:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

Where $X_U = \sum_{i=1}^{nL}(X_{il}/nl)$ and $X_L = \sum_{i=1}^{n_U}(X_{iu/}\, n_u)$ (2)

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows:

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\left[\begin{matrix}\min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{matrix}\right], I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$\boldsymbol{S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in \left[S_L^2, S_U^2\right]} \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows.

$$\boldsymbol{CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U]} \tag{5}$$

3 Results

To determine the level of integration, a neutrosophic statistical analysis is performed for gender identity. The techniques described above are applied as follows.

From the processing of the information and the consensus of the experts, then it is proceeded to define the variable to be modeled (Table 1) and determine the factors that most affect gender identity (Table 2).

Variable	Coding	Sample	Scale
Analyze the factors that affect gender identity in the educational field	IIG	100	$[0;\ 1], \forall\ F_n$ IIG = 0 (false) IGI = 1 (True) $0 \leq IIG \geq 1$(Indetermination of IIG level)

Table 1. Variable Characteristics IIG. Source: own elaboration.

Code	Factors Affecting Gender Identity
a	Gender stereotypes
b	Equality and non-discrimination
c	Teacher Perspectives
d	Discriminatory or violent behavior
e	Legal-regulatory frameworks and educational public policies

Table 2. Determining factors in gender identity. Source: own elaboration

When modeling the variable with the use of neutrosophic statistics, the relative frequencies are obtained to determine the level of IIG in the factors, $F_n = \{F_a, F_b, F_c, F_d, F_e\}$ in the sample analyzed (Table 3). It is observed that for F_e there is a higher incidence of occurrence of 77%, in the lack of regulations on gender equality and educational policies.

Days	Cumulative Absolute Neutrosophic Frequencies				
	a	b	c	d	e
0-100	[0 , 10]	[0 , 2]	[0, 3]	[0, 8]	[0.77]

Table 3. Accumulated absolute neutrosophic frequencies of the level of IIG. Source: own elaboration.

To obtain the level of IIG in each factor, as the measure of indeterminacy for each investigation on a scale of $0 \leq \text{IIG} \geq 1$, it was decided to analyze the variable from the relative neutrosophic frequency $F_n = \{F_a, F_b, F_c, F_d, F_e\}$ (Table 4).

Days	Neutrosophic Frequencies				
	a	b	c	d	e
1	[0 ; 0]	[0.02 ; 0.04]	[0.03 ; 0.03]	[0.08 ; 0.16]	[0 ; 0.77]
2	[0 ; 0.1]	[0 ; 0.02]	[0.03 ; 0.03]	[0.08 ; 0.16]	[0.77 ; 0.77]
3	[0 ; 0]	[0 ; 0]	[0.03 ; 0.06]	[0.08 ; 0.16]	[0 ; 0.77]
4	[0 ; 0]	[0.02 ; 0.02]	[0 ; 0]	[0.08 ; 0.08]	[0.77 ; 0.77]
5	[0 ; 0]	[0 ; 0.02]	[0.03 ; 0.03]	[0.08 ; 0.08]	[0 ; 0.77]
6	[0 ; 0]	[0 ; 0]	[0.03 ; 0.03]	[0 ; 0]	[0.77 ; 0.77]
7	[0 ; 0]	[0.02 ; 0.04]	[0 ; 0.03]	[0 ; 0]	[0.77 ; 1.54]
8	[0 ; 0.1]	[0 ; 0]	[0 ; 0.03]	[0.08 ; 0.08]	[0 ; 0]
9	[0.1 ; 0.2]	[0 ; 0.02]	[0.03 ; 0.03]	[0.08 ; 0.08]	[0.77 ; 1.54]
10	[0.1 ; 0.1]	[0 ; 0.02]	[0 ; 0.03]	[0 ; 0]	[0 ; 0]
11	[0 ; 0]	[0 ; 0.02]	[0.03 ; 0.06]	[0 ; 0.08]	[0.77 ; 1.54]
12	[0.1 ; 0.2]	[0 ; 0]	[0.03 ; 0.03]	[0.08 ; 0.16]	[0 ; 0.77]
13	[0 ; 0.1]	[0 ; 0.02]	[0.03 ; 0.06]	[0 ; 0]	[0.77 ; 1.54]
14	[0 ; 0]	[0.02 ; 0.02]	[0.03 ; 0.06]	[0.08 ; 0.08]	[0.77 ; 0.77]
15	[0.1 ; 0.2]	[0 ; 0]	[0 ; 0]	[0 ; 0.08]	[0.77 ; 1.54]

Days	Neutrosophic Frequencies				
	a	b	c	d	e
16	[0 ; 0.1]	[0 ; 0]	[0 ; 0]	[0 ; 0]	[0.77 ; 0.77]
17	[0.1 ; 0.1]	[0.02 ; 0.04]	[0 ; 0.03]	[0.08 ; 0.08]	[0.77 ; 1.54]
18	[0 ; 0]	[0.02 ; 0.04]	[0.03 ; 0.06]	[0.08 ; 0.08]	[0.77 ; 0.77]
19	[0.1 ; 0.2]	[0 ; 0]	[0 ; 0]	[0 ; 0.08]	[0 ; 0]
20	[0 ; 0]	[0.02 ; 0.04]	[0 ; 0.03]	[0 ; 0]	[0.77 ; 1.54]
0-100	[4.9; 10]	[0.84 ; 2]	[1.5 ; 3]	[3.84; 8]	[36.96 ; 77]

Table 4. Neutrosophic relative frequencies. Source: own elaboration.

Of the relative neutrosophic frequencies observed for IIG, it is found that for 100 days there is a level of total indeterminacy of $a = 5.1, b = 1.16, c = 1.5, d = 4.16, e = 40.04$, with a level of representativeness $[50\%; 58\%]$, on the days that are registered 1.54 relatively, with a higher incidence of 52% for the lack of normativity in gender equality and educational policies.

4 Neutrosophic Statistical Analysis

In the first stage, for the modeling results, the IIG level is observed for the study of new phenomena with low reference information (table 5).
For the analysis of the representative mean based on the values of $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the neutrosophic means are calculated and for the study of the variations of IIG, they are determined by the values of the neutrosophic standard deviation $S_N \in [S_L; S_U]$, to determine in which factor there is a greater IIG consistency and accuracy in gender identity for each $CV_N \in [CV_L\ ;\ CV_U]$.

Factors	$\bar{x}_N$	S_N	CV_N
a	0.049 + 0.1I	0.001 + 0.108 I	0.02 + 1.08 I
b	0.008 + 0.02 I	0 + 0.021 I	0 + 1.05 I
c	0.015 + 0.03 I	0 + 0.032 I	0 + 1.067 I
d	0.038 + 0.08 I	0.001 + 0.078 I	0.026 + 0.975 I
e	0.37 + 0.77 I	0.074 + 0.763 I	0.2 + 0.991 I

Table 5. Neutrosophic statistical analysis of the level of IIG in gender identity. Source: own elaboration.

Table 5 shows the level of incidence of gender identity and teaching practices. It should be borne in mind that the factor of Legal-regulatory frameworks and educational public policies is dominant for the right to gender equality, however, it is necessary to know in the IIG neutrosophic set what level of representation and indeterminacy in the condition $\forall\ F_n,\ [1 - F_e]$. This means that for the given condition, the factor is, on average, the one that most affects the right to equality of gender identity, more than the other factors analyzed. About the CV value, it can be expressed that for $CV_{Ne}\ and\ CV_{Nd}$, the corresponding factors, are lower compared to the rest. This represents that the result provided implies reforming the current regulations. (Figure 2).

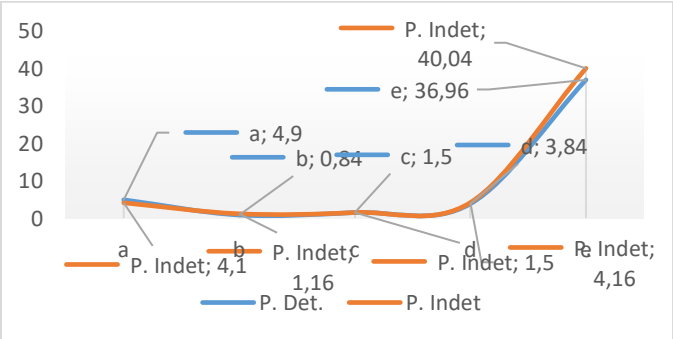


Figure 2. IIG level neutrosophic bubble chart. Source: own elaboration.

5 Comparative Analysis

To determine the associated referent indeterminacy measure for para $\overline{x} = \in [\overline{x}_L; \overline{x}_U]$, $S_N \in [S_L; S_U]$ and $CV_N \in [CV_L\ ;\ CV_U]$ to the form of neutrosophic numbers (Table 6). In the results obtained, it is observed that for the values CV_N range from 0 to 0.20 with an uncertainty measure of 79.8%, generated by factor (a) and 97.3% in factor (d). Although CV_Nneeds to use the lowest percentage level of uncertainty to obtain more precise and more homogeneous results, in this case, it would be to reform current regulations to achieve stronger results. [13], [15], [18]

However, experts need to know the best option for indeterminacy in the condition $\forall\ F_n,\ [1 - F_e]$, the analysis focuses on the factor of discriminatory or violent behavior with 97.3%.

Factors	$\bar{x}_N$	S_N	CV_N
a	$0.049 + 0.1I; I \in [0; 51.0]$	$0.001 + 0.108\ I; I \in [0; 99.1]$	$0.02 + 1.08\ I; I \in [0; 98.1]$
b	$0.008 + 0.02I; I \in [0; 60.0]$	$0 + 0.021\ I; I \in [0; 100]$	$0 + 1.05\ I;\ I \in [0; 100]$
c	$0.015 + 0.03I; I \in [0; 50.0]$	$0 + 0.032I; I \in [0; 100]$	$0 + 1067\ I;\ I \in [0; 100]$
d	$0.038 + 0.08\ I; I \in [0; 52.5]$	$0.001 + 0.078\ I; I \in [0; 98.7]$	$0.026 + 0.975\ I; I \in [0; 97.3]$
e	$0.37 + 0.77\ I; I \in [0; 51.9]$	$0.074 + 0.763\ I; I \in [0; 90.3]$	$0.2 + 0.991\ I; I \in [0; 79.8]$

Table 6. Neutrosophic forms with a measure of indeterminacy for IIG in investigations. Source: own elaboration.

4 discussion

The result defines to modify the legal-regulatory frameworks and educational public policies so it is established that the experts agree on reforming the regulations in force, including the Organic Law of the Ombudsman so that it is not only an observer of due process but also has the power to sanction according to the case that arises. Thus, not only would greater strength be granted to a figure that watches over respect for human rights.

For the equality and non-discrimination groups and discriminatory or violent behaviors, there is a level of indeterminacy or contradiction among experts on gender identity. Indeterminacy studies must be carried out for each sub-element and analyze the degree of belonging that influences to modify the sociocultural patterns of behavior of society. [14], [19]

The results of the satisfaction of the experts with legal-regulatory frameworks and educational public policies were reaffirmed by the experts' answers to the open questions. Among the most frequent opinions, are the contradictions of the experts on equality and non-discrimination in the observance of human rights, although the results of projects in the field of education help the reflection of current researchers and serve as a guide for the improvement of their research strategies by providing elements that define the contradictions and indeterminacies of the experts to reach the desired consensus.

The indeterminacy and contradiction between the experts reflect that for the human being to adapt to new things is not always simple, much less when it comes to sociocultural behavior patterns of society, which usually change the pre-established schemes about how things are supposed to work. This is why even more effort is needed to gain acceptance and eliminate discriminatory or violent behaviour.

Establish the necessary judicial and administrative mechanisms to ensure that any lesbian, gay, bisexual, transgender, or intersex person who is a victim of violence and discrimination has effective access to compensation, compensation for the damage caused, or another fair, prompt, and effective means of compensation.

Ensure, through suitable means, that the principle of equality is complied with in practice and people are not discriminated against and guarantee through the courts that effective protection is given to people from the LGBTI community who have been discriminated against.

Implement training programs so that those who dispense justice receive sufficient information on the human rights of the LGBTI population.

Promote knowledge and observance of the human rights of the LGBTI population in society. This must be done at the level of colleges and schools, through sex education that emphasizes how diverse and complex human sexuality is.

Modify the sociocultural patterns of behavior of society to eradicate the structural homophobia that it suffers. This will also be achieved with education in rights that counteracts and eliminates entrenched prejudices, customs, and all kinds of practices that base their premise on inferiority.

Conclusion

Building gender equality is not reduced to substituting one letter for another, it is the fact of considering the differences and making visible what has been invisible for so many years. It is suggested to consider the limitations that the female gender has as the male since the states must adopt all the necessary measures to guarantee access to education under equal conditions and the equal treatment of students, staff, and teachers within the education system.

The application of neutrosophic statistics allows experts to represent indeterminacy as part of their knowledge and complementary evaluations. The levels of indeterminacy are displayed in the acceptance of proposing to modify the current regulations so that it is not only an observer of due process but also has the power to sanction according to the case that arises. Thus, not only would greater strength be granted to a figure that watches over respect for human rights. In addition to generating information that helps authorities, directors, teachers, students, and the educational community, in general, to reflect on the importance of approaching education from a human rights perspective, particularly from a gender perspective. Bear in mind that the levels of indeterminacy present high levels that only materialize in sectors with a certain level of information and good use of the applied tools, as demonstrated in the discriminatory or violent behavior factor.

The relevance of education and the educational community in the fight against violence and discrimination can be very high. This must be done at the level of colleges and schools, through sex education that emphasizes how diverse and complex human sexuality is. This will also be achieved with rights education that counteracts and eliminates entrenched prejudices, customs, and all kinds of practices that base their premise on the inferiority, unworthiness, or abnormality of people belonging to the LGBTI community. Therefore, a reform to the current standard must be carried out together with the implementation of training. This would help create greater awareness in the general population and strengthen the fight against these existing discriminatory practices.

References

[1] H. Caballero, L. Paz Enrique, and E. Hernández Alfonso, "Publicaciones universitarias del Ecuador y enfoque de género en proyectos productivos internacionales," *Revista Conrado,* vol. 14, p. https://conrado.ucf.edu.cu/index.php/conrado/article/view/823, 10/18 2018.

[2] C. N. González, Leyva, C. M., Faggioni, K. M., & Álvarez, P. J. (2018)., "Comparative study of artificial intelligence techniques for the diagnosis of diseases in livestock. CISCI 2018 - Decima Septima Conferencia Iberoamericana en Sistemas, Cibernetica e Informatica. Decimo Quinto Simposium Iberoamericano en Educacion," *SIECI 2018 - Memorias,* 2018.

[3] M. Preinfalk-Fernández, "La Educación Sexual en el Sistema Educativo Formal Costarricense," *Revista Tempos e Espaços em Educação,* vol. 9, pp. 103-112, 09/07 2016.

[4] N. Y. Torres-Soto, V. Corral-Verdugo, and N. S. Corral-Frías, "The relationship between self-care, positive family environment, and human wellbeing," *Wellbeing, Space and Society,* vol. 3, p. 100076, 2022/01/01/ 2022.

[5] R. Refaat and I. M. El-Henawy, "Innovative method to evaluate quality management system audit results' using single value neutrosophic number," *Cognitive Systems Research,* vol. 57, pp. 197-206, 2019.

[6] E. Haktanır and C. Kahraman, "Interval-valued neutrosophic failure mode and effect analysis," *Journal of Intelligent & Fuzzy Systems,* vol. 39, pp. 6591-6601, 2020.

[7] U. G and N. Sivasubramaniam, "Impact of Neutrosophic Statistics on Acceptance Sampling Plans -A Review," *The International journal of analytical and experimental modal analysis,* vol. XIV, pp. 890-896, 07/11 2022.

[8] A. Alaita and M. Aslam, "Analysis of Covariance under Neutrosophic Statistics," *Journal of Statistical Computation and Simulation,* vol. 00, p. 00, 07/29 2022.

[9] E. González-Caballero, M. Leyva-Vázquez, and F. Smarandache, " On neutrosophic uninorms [Article]," *Neutrosophic Sets and Systems,* vol. 45, pp. 340-348, 2021.

[10] S. H. S. Al-Subhi, I. Pérez Pupo, R. García Vacacela, P. Y. Piñero Pérez, and M. Y. Leyva Vázquez, "A New Neutrosophic Cognitive Map with Neutrosophic Sets on Connections, Application in Project Management. ," *Neutrosophic Sets and Systems,* vol. 22. , pp. 63-75, 2018.

[11] Ş. Özlü and F. Karaaslan, "Hybrid similarity measures of single-valued neutrosophic type-2 fuzzy sets and their application to MCDM based on TOPSIS," *Soft Computing,* vol. 26, pp. 4059-4080, 2022/05/01 2022.

[12] I A. Cruz Piza, L. J. Bajaña Bustamante & M. O Morales Campoverde. "Derechos de la naturaleza en Ecuador". Universidad y Sociedad, Vol. 14 Num. S2, pp- 351-357, 2022.

[13] R. A. Diaz Vásquez & A. R. León Yacelga. "La gestión de producción del hato lechero de la finca "Playa Alta" del cantón Tulcán a través de una aplicación Web". Universidad y Sociedad, Vol. 14 Num. S2, pp-344-250, 2022.

[14] R. A. Diaz Vásquez & A. R. León Yacelga. "Alternativa tecnológica de seguridad comunitaria en tiempos actuales". Universidad y Sociedad, Vol. 14 Num. S2, pp- 337-343, 2022.
[15] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021
[16] Ricardo, J. E., Villalva, M. I. M., Padilla, Z. A. O., & Hurtado, L. A. C. "Filosofía de la comunicación, complemento necesario en el aprendizaje de las Ciencias Sociales". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 3 no. 2, pp 39-52, 2018.
[17] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.
[18] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[19] Leyva, M., Estupiñán, J., Coles, W., & Bajaña, L. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, pp 130-135, 2021.
[20] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.
[21] von Feigenblatt, O. F. "Education, culture, and underdevelopment: Haiti's tragic failure". Universidad y Sociedad, vol. 14 no. 3, pp 604-611, 2022.
[22] M. Alfaro Matos, R. Meléndez Carballido, H. Paronyan & K. E Carrión León. "Efectos de la implementación de estrategias educativas para prevenir la violencia contra el hombre en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 732-741, 2022.
[23] I. A. Cruz Piza, M. E. Gaspar Santos & M. J. Calderón Velásquez. "Determination of the association of qualitative variables related to juvenile delinquency factors". Universidad y Sociedad, vol. 14 no S4, pp 721-731, 2022.
[24] M. R. Aguilar Martínez, V. J. Hernández Alvarado & E. L. Hernández Ramos. "Design and application of a procedure for the selection of a pool of judges". Universidad y Sociedad, vol. 14 no. S4, pp 709-720, 2022.

Received: August 10, 2022. **Accepted:** October 10, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the State Negotiation System

Jessica Jasmin Cellán Palacios [1], Fausto Danilo Guaigua Vízcaino [2], José Ignacio Cruz Arboleda [3] and Héctor Edin Lozano Rojas[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.jessicacellan@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.faustoguaigua@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.josecruz@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador: E-mail: docentetp84@uniandes.edu.ec

Abstract. State negotiations constitute for each nation the support for the development of society from the acquisition of resources and services. Public contracting has an economic and social impact, where public officials must ensure that they are complied with according to the law. However, public officials have violated the legal principles of public procurement to acquire benefits or personal services without legal support. In studies carried out in Ecuador, this phenomenon has been analyzed in relation to the variability of uncertainties in which public officials understand the regulations. That is why this paper focuses on analyzing and defining the levels of indeterminacy present in the neutrosophic variable that affects the functioning of state negotiation. For the modeling of the study, the use of neutrosophic statistics is suggested to detect the uncertainties of the variable in each dimension. Among the neutrosophic results, the undue use of government policies in state negotiation processes is obtained as the only criterion.

Keywords: state negotiation, neutrosophic statistics, society.

1 Introduction

Public contracts are characterized by special elements where the state legal person intervenes. State negotiations have as their object a public purpose or that of the State Administration for social welfare. State negotiations generate a contractual obligation between public sector entities and suppliers or contractors.

Public negotiations constitute contracting and acquisition operations of products and services carried out by state entities for the welfare of society [1]. The operations must be regulated by specific laws, to guarantee the proper functioning of the public sector, and in particular, transparency and accountability to society (WTO, 2020). To make payment in state negotiations, a payment agreement is made as a legal and effective solution mechanism. With this, the pending assets are fulfilled and they protect the responsibility of paying the fair price of the new service when there has been a budget affectation [2-4]. Public institutions, in exceptional cases to achieve their proposed objectives, receive goods, services, or works from third parties, without contractual support [5].

Most of the deficiencies in the state negotiations come from misuse in the interpretation of the regulations that govern the process. Negative effects such as corruption germinate before these scenes, legal confusion, or omission of the law. Corruption is an element that has been part of administrative contracting since the latter exists. Separating them may be imperative, but at the same time necessary, since corruption has a strong relationship with public contracting, where the public budget is damaged, affecting society.

Public entities make their request to meet needs that lead to payment for the consideration provided. Payments between non-state third parties include the preference for loose budgets to execute millionaire contracts that violate Ecuadorian contracting principles.

The freedom that state institutions have to execute contracts has led to evident corruption complaints in Ecuador. Officials and former government officials have been detected, where the cases have not concluded the analysis and the vast majority have not been tried. These inaccuracies bring with them the repetition of the crime of corruption in the Ecuadorian nation.

Corruption is not new in Ecuador or the world, it is born in all existing cultures and remains with the administration from the first known precarious forms of government. The effects that corruption has caused on societies and the national treasury are unquantifiable and in the same proportion, there are countless efforts to combat this evil that has accompanied the state as a shadow. It is a phenomenon that has become internationalized, has been perfected, and has managed to adapt to different circumstances. Therefore, it is necessary to address the negative effects of state negotiation, by assuming that, although there is an international doctrine, tools must be worked on to deal with contractual illegalities.

Starting from identifying the existing deficiencies, the study requires neutrosophy to visualize the uncertainties that cause corruption in state negotiation. Therefore, the present study has as:

- Main objective: to define the levels of indeterminacy in the functioning of the state negotiation.

- Specific objectives:

  - ❖ Determine the criteria that affect the proper functioning of state negotiation with their respective dimensions that affect the variable analyzed,
  - ❖ Carry out the measurement and modeling of the variable,
  - ❖ Define the dimension with the greatest impact on the functioning of state negotiation.

2 Materials and methods

2.1 Neutrosophic Statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that the event E occurs [6], the probability that the event E does not occur, and the probability of indeterminacy (not knowing if the event E occurs or not) [7]. In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called neutrosophic distribution: $NP(x) = (T(x), I(x), F(x))$, where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression [8], etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them [9, 10, 11, 16, 17, 19].

Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns.

Finally, Neutrosophic Logic, Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a novel study reference in full development [12, 13, 14, 15, 18, 20, 21, 22, 23, 24].

Neutrosophic Descriptive Statistics encompasses all the techniques for summarizing and describing the characteristics of neutrosophic numerical data.

Neutrosophic Numbers are numbers of the form $N = a + bI$, where a and b are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number N.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval. Follow the neutrosophic mean of the variable by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\ \ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ \ n_N \in [n_l, n_u], \tag{2}$$

However, for the calculation of neutral squares (NNS), it can be calculated as follows.

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\left[\begin{matrix}\min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{matrix}\right], I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows.

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U] \quad (5)$$

The neutrosophic argumentation coefficient evaluates the criteria through Linguistic Terms with NNVU of consensus of justification of the expert opinion, (see table 1).

Linguistic term	SVNN
Unaffected (U)	(1,0,0)
Almost unaffected (AU)	(0.9, 0.1, 0.1)
Very low affectation (VLA)	(0.8,0,15,0.20)
Low affectation (LA)	(0.70,0.25,0.30)
Slight affectation (SA)	(0.60,0.35,0.40)
Affects (A)	(0.50,0.50,0.50)
Moderately affected (MA)	(0.40,0.65,0.60)
Severely affected (SA)	(0.30,0.75,0.70)
Very affected (VA)	(0.20,0.85,0.80)
High affectation (HA)	(0.10,0.90,0.90)
Extremely Affected (EED)	(0,1,1)

Table 1: Linguistic terms that represent the weight of the factors. Source: own elaboration.

3 Method development

3.1 Data Collection and Characteristics of the Neutrosophic Variable

The variability of the data and criteria obtained determines the use of neutrosophic statistics for modeling. The level of indeterminacy in the functioning of state negotiation requires analysis at the dimensional level and the level of subsets of the study variable. For the neutrosophic study, it is defined as:

- Variable to model: levels of indeterminacy in the functioning of state negotiation.
- Variable coding: FSN
- Neutrosophic scale: $[0;\ 1]$. Weights are calculated based on the linguistic terms in Table 1.

For the neutrosophic statistical modeling, the experts are presented with eight criteria that affect the correct functioning of state negotiation. The studied variable is analyzed from the neutrosophic set and its relationships between subsets. For each criterion, a dimension is established with a code to be used in the modeling (Table 2). The data for the modeling visualize the use of the public budget in works and purchase of resources. For data processing, feedback was provided from studies at the Universidad de Los Andes.

Code	Criteria	Code	Dimension
C1	Corruption in payment agreements	E	Economic
C2	Image of bad payer at international level	E	Economic
C3	Policies of the government of the day that hinder the hiring process	P	Political
C4	Increase in public debt	E	Economic
C5	Violations in the contracting processes.	L	Legal
C6	Losses of the technological autonomy of the nation	T	Technological
C7	High interest rates imposed by creditors	E	Economic
C8	Budget cuts in social works	S	Social

Table 2: Crites that affect the proper functioning of state negotiation with their respective dimensions. Source: own elaboration.

3.2 Neutrosophic analysis at the dimensional level

For neutrosophic dimensional analysis, the use of neutrosophic statistics is required. It is required to evaluate a neutrosophic sample to determine the critical points between dimensions and their level of indeterminacy. For the development of the study, the dimensions of the neutrosophic variable FSN were visualized in the analyzed sample (see Table 3).

For the development of the study, a sample of 80 experts in public negotiation issues is used. Each expert is allowed to assess each dimension based on the criteria that comprise it. The answers of the experts must be represented in linguistic terms according to their representation (see table 1). Neutrosophic frequencies are plotted from expert responses.

No	E	P	L	T	S
1	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
2	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]
3	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0,0.95,1)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]
4	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0,0.95,1);(0.3,0.75,0.8)]
5	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]
6	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]
7	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
8	[(0,0.95,1);(0,0.95,1)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
9	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]
10	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0,0.95,1);(0.4,0.5,0.55)]
11	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
12	[(0.4,0.5,0.55);(1,0.05,0)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
13	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]
14	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]
15	[(0.4,0.5,0.55);(1,0.05,0)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
16	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
17	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.4,0.5,0.55)]
18	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]
19	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]
20	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
21	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]
22	[(0,0.95,1);(0,0.95,1)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0,0.95,1);(0.2,0.8,0.85)]
23	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
24	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0,0.95,1);(0.4,0.5,0.55)]
25	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]
26	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]
27	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
28	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
29	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]

No	E	P	L	T	S
30	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]
31	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
32	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]
33	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]
34	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]
35	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
36	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]
37	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
38	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]
39	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]
40	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]
41	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]
42	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
43	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
44	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]
45	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]
46	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]
47	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]
48	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]
49	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]
fifty	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
51	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]
52	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
53	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]
54	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
55	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
56	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]
57	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]
58	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]

No	E	P	L	T	S
59	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
60	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
61	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
62	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
63	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
64	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0,0.95,1)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]
65	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]
66	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
67	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]
68	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0,0.95,1);(0.4,0.5,0.55)]
69	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
70	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0,0.95,1);(0,0.95,1)]
71	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]
72	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0,0.95,1);(0.4,0.5,0.55)]
73	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
74	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]
75	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]
76	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]
77	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
78	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(1,0.05,0)]
79	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]
80	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0,0.95,1);(0.3,0.75,0.8)]
1-80	**[(0.3,0.75,0.8);(0.5,0.45,0.53)]**	**[(0.2,0.8,0.85);(0.4,0.5,0.55)]**	**[(0.3,0.75,0.8);(0.5,0.45,0.53)]**	**[(0.2,0.8,0.85);(0.4,0.5,0.55)]**	**[(0.3,0.75,0.8);(0.4,0.5,0.55)]**

Table 3: Neutrosophic frequency of FSN dimensions. Source: own elaboration.

The results obtained from the analysis of the neutrosophic frequency present an indeterminacy level close to 0.5. The result defines in what proportion the factor influences the stability of democracy in Ecuadorian society according to the sample analyzed. From the results it is observed the dimension:

- The economic and legal dimensions range from affected to severely affected when the FSN variable is analyzed. The analysis of the statistical frequencies represents that in the negotiations in the public sector there are economic elements that lead to the committing of economic crimes. While, legally, each economic actor violates legal regulations that lead to the malfunction of public negotiations.
- The political and technological dimensions present a certain relationship, although both are moderately affected to highly affected. This relationship means that in the relations of each nation there are policies aimed at directing large-scale public works. Although the security of technology has been violated to favor personal interests over society.

- The social dimension is in a state between moderately affected and severely affected. This dimension visualizes the problems in which the malfunction of public negotiations affects society. Poverty is a reflection of the mismanagement of the public debt and the public budget.

To measure the uncertainty value of each factor, the associated referent uncertainty measure is calculated for $\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in [S_L; S_U]$ and $CV_N \in [CV_L\ ;\ CV_U]$ in the form of neutrosophic numbers (Table 4).

Dimensions	$\bar{x}_N$	Y_N	CV_N	I ∈		
				$\bar{x}_N$	Y_N	CV_N
E	0.286 + 0.534 I	0.014 + 0.347 I	0.049 + 0.65 I	46.40	96.00	92.50
P	0.211 + 0.474 I	0.017 + 0.334 I	0.081 + 0.705 I	55.50	94.90	88.50
L	0.255 + 0.514 I	0.016 + 0.322 I	0.063 + 0.626 I	50.40	95.00	89.90
T	0.239 + 0.504 I	0.015 + 0.329 I	0.063 + 0.653 I	52.60	95.40	90.40
S	0.26 + 0.481 I	0.015 + 0.306 I	0.058 + 0.636 I	45.90	95.10	90.90

Table 4: Neutrosophic forms with the measure of indeterminacy. Source: own elaboration.

The values CV_N range from 0.049 to 0.081 with the measure of indeterminacy of [0.885; 0.925]. It is generated by a sample of [0;80] questionnaires and statistical information, obtained from 80 experts (Figures 1 and 2). Therefore, it is required to evaluate the most affected dimension where the variable becomes indeterminate.

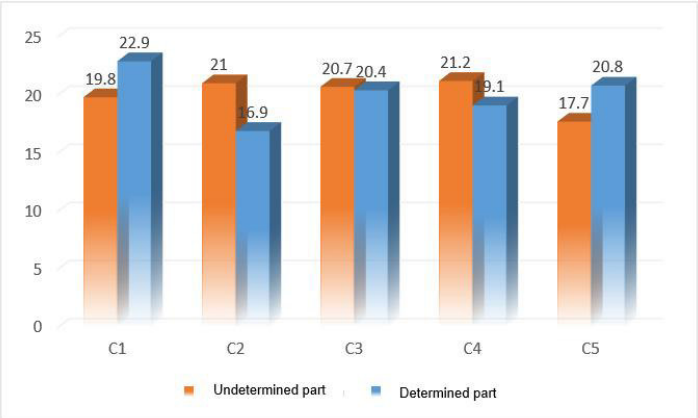


Figure 1: Neutrosophic bar chart of incidents for online business development. Source: own elaboration.

Figure 1 shows that the levels of indeterminacy are between [17.7; 21.2], while in the determination of the variable they are located between [16.9; 22.9]. The levels of indeterminacy for the analyzed sample are included in the dimensions for the displayed ranges. It is evident that for experts on public procurement issues, these dimensions play a fundamental role. The balance of each dimension leads to a good performance in matters of state negotiation. The levels of indeterminacy define the cause of the variety in the states of the variable.

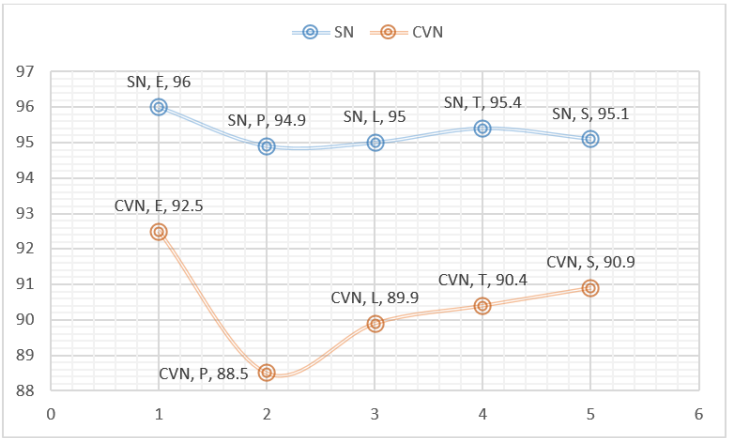


Figure 2: Value of uncertainty in S_N and CV_N for each dimension. Source: own elaboration.

From the result of the analysis of the neutrosophic frequencies, the political dimension with the greatest affectation is determined, as the subset with the greatest incidence in the process of public negotiations in the country. This dimension has as its sole criterion the policies of the government in power that hinder the hiring process and reflects a unique characteristic within the subset. This criterion is seen in several countries that, by making the hiring process difficult, leads to a chain reaction in the adjoining dimensions.

It is proposed to minimize the uncertainties of this dimension, and reduce the possible criteria to arise:

- Evaluate the regulations that govern state negotiation processes and propose regulations to apply a negotiation system that complies with contracting laws,
- Endorse by the officers that the regulations are complied with the processes of acquisition of goods or services or execution of works,
- The acquisition of goods, services, or works fostered by favorable policies must be approved and justified under equal conditions in the national and international markets.

Conclusion

Once the investigation was concluded, the following conclusions could be reached:

The application of neutrosophy allows obtaining results of a variable with a certain level of indeterminacy. In the study of state negotiations or public negotiations, various criteria that affect various dimensions of the proper functioning of the contracting process are disseminated. To guarantee the full execution of public contracts and compliance with regulations, each undetermined criterion must be analyzed.

The analysis of the neutrosophic statistics arrived that the variable has indeterminate elements that affect the proper functioning of the negotiations in the public sector. Of the results obtained, it refers to the political dimension, with a level of indeterminacy of 88.5% in relation to state negotiations. It should be noted that the indeterminacy of the variable in the political dimension directly affects the other dimensions. The explanation is given from the fact that the policies aimed at public negotiations affect economic results, the relaxation of laws, and have a direct effect on society.

The neutrosophic statistical analysis yields a lower value of CV to the policies of the government in power that hinder the hiring process since it is the only criterion within the dimension. Therefore, it is suggested to carry out a deeper study of each neutrosophic factor at the neutrosophic subset level. Although, when determining the political dimension, it is suggested that the governing bodies that govern the state's public negotiation process create the mechanisms for its proper functioning. For this, the public administration must dedicate efforts to implement actions that benefit the proper use of public resources, to satisfy the needs of citizens.

References

[1] Y. Gruzkiy, "Formation of the institute of public procurement in Ukraine," *Researchgate,* vol. 23, pp. 4-9, 2021.

[2] Y. Hruzky, "Comparative analysis of classifications of public procurement," *University Economic Bulletin,* vol. 50, pp. 24-32, 08/31 2021.

[3] C. Z. Murillo, J. R. Hechavarría Hernández, & , and M. L. Vázquez, "Multicriteria Analysis in the Proposed Environmental Management Regulations for Construction in Aurora, Guayas, Ecuador. ," *In Advances in Intelligent Systems and Computing.,* vol. 965, pp. 101-113, 2020.

[4] L. Crouch, K. King, A. Olefir, H. Saeki, & , and T. Savrimootoo, "Taking Preprimary Programs to Scale in Developing Countries: Multi-source Evidence to Improve Primary School Completion Rates.," *International Journal of Early Childhood,* vol. 52, pp. 159-174, 2020.

[5] OMC. (2020). *Organización Mundial del Comercio. Obtenido de Contratación pública.* Available: http://www.wto.org/spanish/tratop_s/gproc_s/gproc_s.htm

[6] R. P. Alava, J. M. Murillo, R. B. Zambrano, & , and M. I. Zambrano Vélez, "PEST Analysis Based on Neutrosophic Cognitive Maps: A Case Study for Food Industry," *Neutrosophic Sets and Systems,* vol. 21, p. 10, 2018.

[7] K. P. Teruel, CedeñoCedeñ, J., Gavilanez, H. L., Diaz, C., & Vázquez, M. L., "A framework for selecting ccloud computing services based on consensus under single valuedvalued neutrosophicneutrosophic numbers. ," *Neutrosophic Sets and Systems,* vol. 22, pp. 38-40, 2018.

[8] U. Afzal, H. Alrweili, N. Ahamd, and M. Aslam, " Neutrosophic statistical analysis of resistance depending on the temperature variance of conducting material," *Scientific Reports,* vol. 11, p. 23939, 2021.

[9] J. Estupiñan Ricardo, M. E. Llumiguano Poma, A. M. Arguello Pazmiño, A. D. Albán Navarro, Martín stévez, L., , and N. Batista Hernandez, "Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador. ," *Neutrosophic Sets & Systems,* vol. 26, pp. 55-61, 2019.

[10] U. G and N. Sivasubramaniam, "Impact of Neutrosophic Statistics on Acceptance Sampling Plans -A Review," *The International journal of analytical and experimental modal analysis,* vol. XIV, pp. 890-896, 07/11 2022.

[11] N. G. Arias;, N. Q. Arnaiz;, S. G. Villamarín;, and M. C. Borbor., "Neutrosociology for the analisys of the Pros and Cons of Life Series in Uniandes, Ecuador.," *Neutrosophic Sets and Systems* vol. 34, 2020.

[12] E. B. Prado Calderón, W. A. Cacpata Calle & A. S. Gil Betancourt. "Sistemas de votación, su impacto sobre el comportamiento de los votantes y los resultados electorales". Universidad y Sociedad, Vol. 14 Num. S2, pp- 330-336, 2022.

[13] D. A. Freire Muñoz & D. S. Diaz López. "Método de fermentación y secado para el beneficio de la obtención del chocolate blanco a partir del cacao criollo (Theobroma cacao L.), ecuatoriano". Universidad y Sociedad, Vol. 14 Num. S2, pp- 323-329, 2022.

[14] P. E. Salas Medina & R. Acosta Lizano. "Análisis del uso del marketing digital ante la emergencia sanitaria Covid-19 en la industria turística de Ambato, provincia de Tungurahua". Universidad y Sociedad, Vol. 14 Num. S2, pp- 315-322, 2022.

[15] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[16] Ricardo, J. E., Vázquez, M. Y. L., Palacios, A. J. P., & Ojeda, Y. E. A. "Inteligencia artificial y propiedad intelectual". Universidad y Sociedad, vol. 13 no. S3, pp 362-368, 2021.

[17] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[18] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[19] Álvarez Gómez, G. A., Viteri Moya, J. R., Viteri Intriago, D. A., & Estupiñán Ricardo, J. "Integración de los procesos sustantivos para la mejora de la calidad del aprendizaje". Conrado, vol. 17 no. 80, pp 21-27, 2021.

[20] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.

[21] von Feigenblatt, O. F., Peña-Acuña, B., & Cardoso-Pulido, M. J. "Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones". Ediciones Octaedro, 2022.

[22] Loor, M. E. A., Siquilanda, C. F. R., Córdova, F. A. G., & Cordova, M. E. V. (2022). Derecho cívico y patriótico: el voto facultativo general en el Ecuador. Universidad y Sociedad, 14(S4), 701-708.

[23] L. Toapanta Jiménez, A. E. Bailón Zúñiga, R. C. Ilaquiche Licta, & L. A. Crespo Berti. "Derecho a la igualdad de la mujer embarazada en el ámbito laboral público y privado en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 693-700, 2022.

[24] H. Paronyan, A. E. Mosquera Nieto, W. A. Cacpata Calle & P. M. Vaca Acosta. "Anacronismo en los derechos para contraer segundas o ulteriores nupcias". Universidad y Sociedad, vol. 14 no. S4, pp 682-692, 2022.

Received: August 11, 2022. **Accepted:** October 11, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Element Res Nullius in Adoption Procedures

Mónica Isabel Mora Verdezoto[1], José Ignacio Cruz Arboleda[2], Carlos Alfredo Medina Riofrio[3] and Víctor Hugo Lucero Salcedo[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. Email: ua.monicamora@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. Email: ui.josecruz@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. Email: up.carlosmedina@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. Email: ut.victorlucero@uniandes.edu.ec

Abstract. Adoption arises to combat homelessness and orphanhood in childhood and adolescence, a social problem that humanity has faced over the years. With the emergence of children adoption regulations, the Ecuadorian State has regulated the adoption process to guarantee the adopter a suitable, permanent, and definitive family. Although much progress has been made at the national level, some obstacles delay the process of the regulatory entities. For this, the present work aims to determine the factors that originate the res nullius element in the adoption process. For the modeling and due to the characteristics of the variable, the use of neutrosophic statistics is necessary. As a result, it is observed that families interested in adopting lack a legal culture about the needs of adopted children. Causes that generate a low knowledge of the regulations due to ignorance or poor training and advice.

Keywords: adoption, res nullius, neutrosophy, neutrosophic statistics.

1 Introduction

The Ecuadorian State defines that the purpose of adoption is to guarantee a suitable family [1]. Minors or adolescents shall have the right to their development, in a family, school, social, and community environment of affection and security [2]. This environment will allow the satisfaction of their social, affective-emotional, and cultural needs, with the support of national and local intersectoral policies [3].

Currently, there are factors such as the delay in the declaration of adoptability and the lack of knowledge of adopters about the regulations and rules that govern each stage. In some cases, the duration of the adoption process has been extended beyond what the regulations establish. These people have not been able to carry out speedy compliance with the procedures. This term which is not determined in any element or regulation is called *res nullius*.

It is called res nullius to the state that "is in no man's land" in the classic description. Although it constitutes an element that is characterized as a variable of a neutrosophic nature, these elements, which often cannot be classified by the variety of states they possess, are called neutrosophic elements [4].

Therefore, this neutrosophic study has as its main objective: to determine the factors that originate the res nullius element in the adoption process and as specific objectives:

- ✓ Determine the factors that affect the analyzed variable
- ✓ Carry out the measurement and modeling of the variable
- ✓ Propose potential alternatives to reduce the res nullius effect.

2 Materials and methods

2.1 Neutrosophic Statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E will occur, the probability that event E will not occur, and the probability of indeterminacy (not knowing whether event E will occur or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+ [5].

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution [6]:

$$NP(x) = (T(x), I(x), F(x)),$$

Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, the neutrosophic probability distribution [7, 8, 11, 15, 16], neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and to the methods to analyze them. Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns.

Finally, Neutrosophic Logic, Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a novel study reference in full development. Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data. Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number. [9], [10], [12], [13], [14], [18], [19], [20]

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Follow the neutrosophic mean of the variable by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}\ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu}\ n_N \in [n_l, n_u], \tag{2}$$

However, for the calculation of neutral squares (NNS), it can be calculated as follows.

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\left[\begin{matrix}\min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{matrix}\right], I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows.

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U] \tag{5}$$

The neutrosophic argumentation coefficient evaluates the criteria through Linguistic Terms with SVNN of consensus of justification of the expert opinion, (see table 1).

Linguistic Term	SVNN	Linguistic Term Neutrosophic Knowledge Quotient (NKQ)
No Influence (NI)	(1,0,0)	Full knowledge of the subject of study (FK)
Nearly No Influence (NNI)	(0.9, 0.1, 0.1)	Very very good in the subject of study (VVGK)
Very Low Influence (VLI)	(0.8,0,15,0.20)	Very good in the subject of study (VGKS)
Low Influence (LI)	(0.70,0.25,0.30)	Good at study subject (GK)
Slight Influence (SI)	(0.60,0.35,0.40)	Fairly good in the subject of study (FGK)
Influence (I)	(0.50,0.50,0.50)	Know the subject of study (K)
Moderately Influence (MI)	(0.40,0.65,0.60)	Moderately poorly knows the subject of study (MPK)
Severely influence (SI)	(0.30,0.75,0.70)	Poorly knows the subject of study (PK)
Very Influential (VI)	(0.20,0.85,0.80)	Very poorly knows the subject of study (VPK)
High Influence (HI)	(0.10,0.90,0.90)	Very very poorly knows the subject of study (VVPK)
Extremely Influential (EI)	(0,1,1)	Null knowledge of the subject of study (NK)

Table 1: Linguistic terms that represent the weight of the factors. Source: own elaboration.

For the definitive selection of the experts, the coefficient of neutrosophic expert competence (K_N) was used, calculated from:

Definition 1. Let A = (a, b, c) a SVNN, the score function S of a SVNN, based on true membership degree, undetermined membership degree, and false membership degree is defined by the following Equation :

$$S(K_N) = \frac{1 + a - 2b - c}{2} \tag{6}$$

Where $S(K_N) \in [-1, 1]$ and when applying equation (1), the following is obtained:

$$K_N = \{\langle x, u_K(x), r_K(x), v_K(x)\rangle : x \in X\}$$

In this coefficient, two factors were averaged, the knowledge coefficient (K_{CN}) and the argumentation coefficient (K_{aN}).

$$K_N = \frac{1}{2}(K_{aN} + K_{cN}) \tag{7}$$

Where $S(K_{aN})$ and $S(K_{cN}) \in [-1, 1]$ and when applying equation (1), the following is obtained:

$$K_{aN} = \{\langle x, u_{Ka}(x), r_{Ka}(x), v_{Ka}(x)\rangle : x \in X\}$$

$$K_{cN} = \{\langle x, u_{Kc}(x), r_{Kn}(x), v_{Kn}(x)\rangle : x \in X\}$$

The so-called neutrosophic knowledge coefficient is determined by the information that the expert himself presents about the object of study. It is determined through a self-assessment process on a scale to establish knowledge of the subject analyzed and the object of study (see Table 1). The Neutrosophic Argumentation coefficient evaluates the criteria through Linguistic Terms with SVNN of consensus of justification of the expert opinion, (see Table 2). From the weighted sum of values obtained in a series of elements of Influence determined by the experience obtained through its activity and practice, knowledge of the state of the matter at a national and international level, intuition about the topic addressed, technology knowledge, and study of works and publications on the subject of study. [17]

The evaluation of the answers of the experts establishes as an objective criterion the coefficient of neutrosophic expert competence with a required critical level established for a certain value. The evaluation and validation of the criteria use the neutrosophic scale to achieve greater objectivity in the treatment of information that allows the evaluation of the criteria individually (see Table 2).

Linguistic term	SVNN	Linguistic term to evaluate Criterion	Linguistic term to evaluate K_{AN} and K_N
Very Adequate (VA)	(0.9;0.1;0.1)	Indispensable	Very High (MA)
Fairly Adequate (FA)	(0.75;0.25;0.20)	Very useful	High (A)
Adequate (A)	(0.50;0.5;0.50)	Useful	Mean (M)
Poorly Adequate (PA)	(0.35;0.75;0.80)	little useful	Low (B)
Not Adequate (NA)	(0.10;0.90;0.90)	Useless	Very Low (MB)

Table 2: Neutrosophic linguistic terms to validate the criteria between subsets. Source: own elaboration.

3 Method development

3.1 Data Collection and Characteristics of the Neutrosophic Variable

The variability of the data and criteria obtained determines the use of neutrosophic statistics for modeling. The level of indeterminacy existing in the elements present in the adoption process requires analysis at the dimensional level and the level of subsets of the study variable. For the neutrosophic study, the following is defined:

- Neutrosophic variable: factors that originate the res nullius element in the adoption process (ERNA).
- Variable coding: ERNA

- Neutrosophic scale: Weights are calculated based on the linguistic terms in Table 1.

3.2 Selection and validation of the experts to participate in the study

The modeling of neutrosophic statistics requires selecting the experts with the highest level of knowledge on adoption issues. Therefore, experts are required to have more weight in their decision to define what factor affects the res nullius element in the adoption process. For them, it was decided to determine the neutrosophic argumentation coefficient based on the experience obtained in the adoption processes (see Table 3).

Expert	Profile	Kc	Ka	K	Assessment
E1	PSYCHOLOGY	(0.6,0.35,0.4)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E2	ACADEMIC	(0.9,0.1,0.1)	(0.50,0.5,0.50)	(0.75,0.25,0.20)	HIGH
E3	ACADEMIC	(0.1,0.9,0.9)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E4	ACADEMIC	(0.5,0.5,0.5)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E5	FISCAL	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E6	ACADEMIC	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E7	DOCTOR	(0.7,0.25,0.3)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E8	JUDGE	(0.9,0.1,0.1)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E9	FISCAL	(0.9,0.1,0.1)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E10	DOCTOR	(0,1,1)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E11	ACADEMIC	(0.9,0.1,0.1)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E12	ACADEMIC	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E13	DOCTOR	(1,0,0)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	VERY HIGH
E14	PSYCHOLOGY	(0.7,0.25,0.3)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E15	ACADEMIC	(0.6,0.35,0.4)	(0.35,0.75,0.80)	(0.50,0.5,0.50)	MEDIUM
E16	ACADEMIC	(0.6,0.35,0.4)	(0.35,0.75,0.80)	(0.50,0.5,0.50)	MEDIUM
E17	FISCAL	(0.6,0.35,0.4)	(0.35,0.75,0.80)	(0.50,0.5,0.50)	MEDIUM
E18	DOCTOR	(0.5,0.5,0.5)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	LOW
E19	ACADEMIC	(0.1,0.9,0.9)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E20	ACADEMIC	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E21	ACADEMIC	(0.2,0.85,0.8)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E22	ACADEMIC	(0,1,1)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E23	FISCAL	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E24	PSYCHOLOGY	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E25	FISCAL	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E26	ACADEMIC	(1,0,0)	(0.50,0.5,0.50)	(0.75,0.25,0.20)	HIGH
E27	ACADEMIC	(1,0,0)	(0.35,0.75,0.80)	(0.50,0.5,0.50)	MEDIUM
E28	FISCAL	(0.6,0.35,0.4)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E29	ACADEMIC	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E30	ACADEMIC	(0.2,0.85,0.8)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E31	ACADEMIC	(0.7,0.25,0.3)	(0.35,0.75,0.80)	(0.50,0.5,0.50)	MEDIUM
E32	DOCTOR	(0.1,0.9,0.9)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E33	ACADEMIC	(0.3,0.75,0.7)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E34	FISCAL	(1,0,0)	(0.50,0.5,0.50)	(0.75,0.25,0.20)	HIGH
E35	PSYCHOLOGY	(0.3,0.75,0.7)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E36	ACADEMIC	(0.1,0.9,0.9)	(0.9,0.1,0.1)	(0.50,0.5,0.50)	MEDIUM
E37	ACADEMIC	(0.4,0.65,0.6)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E38	ACADEMIC	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E39	DOCTOR	(0.1,0.9,0.9)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW

Expert	Profile	Kc	Ka	K	Assessment
E40	DOCTOR	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E41	ACADEMIC	(0.1,0.9,0.9)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E42	ACADEMIC	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E43	ACADEMIC	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E44	ACADEMIC	(0.9,0.1,0.1)	(0.35,0.75,0.80)	(0.50,0.5,0.50)	MEDIUM
E45	ACADEMIC	(0.9,0.1,0.1)	(0.35,0.75,0.80)	(0.50,0.5,0.50)	MEDIUM
E46	ACADEMIC	(0.2,0.85,0.8)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E47	PSYCHOLOGY	(0.2,0.85,0.8)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E48	PSYCHOLOGY	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E49	FISCAL	(0.7,0.25,0.3)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E50	ACADEMIC	(0.4,0.65,0.6)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	LOW
E51	ACADEMIC	(0.6,0.35,0.4)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E52	ACADEMIC	(0.9,0.1,0.1)	(0.50,0.5,0.50)	(0.75,0.25,0.20)	HIGH
E53	ACADEMIC	(0.5,0.5,0.5)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	LOW
E54	FISCAL	(0.2,0.85,0.8)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E55	ACADEMIC	(0.5,0.5,0.5)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E56	ACADEMIC	(0.3,0.75,0.7)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E57	DOCTOR	(0.4,0.65,0.6)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E58	DOCTOR	(0.2,0.85,0.8)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E59	PSYCHOLOGY	(0.7,0.25,0.3)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	HIGH
E60	ACADEMIC	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E61	ACADEMIC	(0.1,0.9,0.9)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E62	ACADEMIC	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E63	PSYCHOLOGY	(0.6,0.35,0.4)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E64	ACADEMIC	(0.3,0.75,0.7)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E65	PSYCHOLOGY	(0,1,1)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E66	ACADEMIC	(0.6,0.35,0.4)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E67	DOCTOR	(0.2,0.85,0.8)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E68	ACADEMIC	(0.5,0.5,0.5)	(0.9,0.1,0.1)	(0.50,0.5,0.50)	MEDIUM
E69	ACADEMIC	(0.2,0.85,0.8)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	LOW
E70	ACADEMIC	(0.5,0.5,0.5)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E71	ACADEMIC	(0.7,0.25,0.3)	(0.50,0.5,0.50)	(0.75,0.25,0.20)	HIGH
E72	ACADEMIC	(0.7,0.25,0.3)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E73	ACADEMIC	(0.9,0.1,0.1)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	MEDIUM
E74	FISCAL	(0,1,1)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E75	DOCTOR	(0.2,0.85,0.8)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E76	ACADEMIC	(0.3,0.75,0.7)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	MEDIUM
E77	ACADEMIC	(0.3,0.75,0.7)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW
E78	ACADEMIC	(1,0,0)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	VERY HIGH
E79	ACADEMIC	(1,0,0)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	VERY HIGH
E80	ACADEMIC	(0,1,1)	(0.50,0.5,0.50)	(0.35,0.75,0.80)	LOW

Table 3: Determination of the coefficient of neutrosophic expert competence. Source: own elaboration.

Due to the difficulty of the object of investigation, an assessment of competence of "high" was assigned when the expert's neutrosophic coefficient was established above a high value (see table 4). The resulting group of experts is made up of 6 academics, 1 doctor, 1 prosecutor, and 1 psychologist for a total of 9 experts.

Profile	Very high	High	Medium	Low	Very low	Total
Academic	2	4	28	15	0	49
Doctor	1	0	3	7	0	11
Fiscal	0	1	6	3	0	10
Judge	0	0	1	0	0	1
Psychologist	0	1	5	3	0	9
Total	3	6	43	28	0	80

Table 4: Qualification of the experts according to the competence coefficient. Source: own elaboration.

For the analysis of the neutrosophic variable, the use of neutrosophic statistics is required. It is necessary to evaluate a neutrosophic sample to determine the factors that originate the res nullius element in the adoption (see Table 7). For the development of the study, 5 groups of 80 people were interviewed about the study variable. Among the most frequently asked questions were, *what were the most common obstacles in the adoption process?*

The interviewees were given possible answers that they should use to qualify the factor that affects the res nullius element in adoption (see Table 1). In each response, the person was given the option to give more than two answers in different contexts (different regions or institutions). To obtain the data, the groups were separated to obtain a variety of criteria for the neutrosophic variable ERNA in the analyzed sample (see Table 5).

No	G1	G2	G3	G4	G5
1	[(0.1,0.9,0.9);(0.4,0.65,0.6)]	[(0.1,0.9,0.9);(0.3,0.75,0.7)]	[(0.1,0.9,0.9);(0.4,0.65,0.6)]	[(0.2,0.85,0.8);(0.6,0.35,0.4)]	[(0.5,0.5,0.5);(0.6,0.35,0.4)]
2	[(0.1,0.9,0.9);(0.2,0.85,0.8)]	[(0.2,0.85,0.8);(0.2,0.85,0.8)]	[(0.4,0.65,0.6);(0.6,0.35,0.4)]	[(0.3,0.75,0.7);(0.4,0.65,0.6)]	[(0.1,0.9,0.9);(0.5,0.5,0.5)]
3	[(0.3,0.75,0.7);(0.3,0.75,0.7)]	[(0.4,0.65,0.6);(0.5,0.5,0.5)]	[(0,1,1);(0.5,0.5,0.5)]	[(0.2,0.85,0.8);(0.6,0.35,0.4)]	[(0.4,0.65,0.6);(0.7,0.25,0.3)]
4	[(0.5,0.5,0.5);(0.9,0.1,0.1)]	[(0.3,0.75,0.7);(0.7,0.25,0.3)]	[(0,1,1);(0.2,0.85,0.8)]	[(0,1,1);(0,1,1)]	[(0,1,1);(0,1,1)]
5	[(0.4,0.65,0.6);(0.5,0.5,0.5)]	[(0.1,0.9,0.9);(0.3,0.75,0.7)]	[(0.2,0.85,0.8);(0.2,0.85,0.8)]	[(0.5,0.5,0.5);(0.5,0.5,0.5)]	[(0.3,0.75,0.7);(0.5,0.5,0.5)]
6	[(0.3,0.75,0.7);(0.3,0.75,0.7)]	[(0.4,0.65,0.6);(0.4,0.65,0.6)]	[(0,1,1);(0.4,0.65,0.6)]	[(0.2,0.85,0.8);(0.6,0.35,0.4)]	[(0.5,0.5,0.5);(0.5,0.5,0.5)]
7	[(0.4,0.65,0.6);(0.5,0.5,0.5)]	[(0.1,0.9,0.9);(0.4,0.65,0.6)]	[(0,1,1);(0.4,0.65,0.6)]	[(0,1,1);(0,1,1)]	[(0.3,0.75,0.7);(0.4,0.65,0.6)]
8	[(0.5,0.5,0.5);(0.6,0.35,0.4)]	[(0.3,0.75,0.7);(0.7,0.25,0.3)]	[(0.5,0.5,0.5);(0.9,0.1,0.1)]	[(0.2,0.85,0.8);(0.2,0.85,0.8)]	[(0.4,0.65,0.6);(0.9,0.1,0.1)]
9	[(0,1,1);(0.1,0.9,0.9)]	[(0.4,0.65,0.6);(0.5,0.5,0.5)]	[(0,1,1);(0.2,0.85,0.8)]	[(0.5,0.5,0.5);(0.7,0.25,0.3)]	[(0.3,0.75,0.7);(0.5,0.5,0.5)]
10	[(0.2,0.85,0.8);(0.5,0.5,0.5)]	[(0.2,0.85,0.8);(0.5,0.5,0.5)]	[(0,1,1);(0.2,0.85,0.8)]	[(0,1,1);(0.5,0.5,0.5)]	[(0.4,0.65,0.6);(0.6,0.35,0.4)]
11	[(0.5,0.5,0.5);(0.5,0.5,0.5)]	[(0.3,0.75,0.7);(0.3,0.75,0.7)]	[(0.2,0.85,0.8);(0.2,0.85,0.8)]	[(0.3,0.75,0.7);(0.4,0.65,0.6)]	[(0.5,0.5,0.5);(0.5,0.5,0.5)]
1-80	**[(0.2,0.85,0.8);(0.4,0.65,0.6)]**	**[(0.2,0.85,0.8);(0.4,0.65,0.6)]**	**[(0.1,0.9,0.9);(0.4,0.65,0.6)]**	**[(0.2,0.85,0.8);(0.4,0.65,0.6)]**	**[(0.2,0.85,0.8);(0.5,0.5,0.5)]**

Table 5: Neutrosophic frequency of ERNA dimensions. Source: own elaboration.

Each group explains how the factor in the res nullius element affects the adoption process. From the results obtained, the following are the res nullius element in the adoption process (see Table 6).

Code	Items	Group that chooses the criterion	Neutrosophic res nullius element
C1	Time dilation of the adoption process	G1, G2, G3, G4, G5	Variation over time of what is legislated. Adopters wait longer than what is legislated. A space in time with res nullius neutrosophic characteristics is created where this variable behaves in an indeterminate way.
C2	Ignorance of the adoption process	G1, G2, G4	People in their eagerness to adopt lack certain knowledge necessary to start the adoption process. A neutrosophic res nullius element is created where knowing: What knowledge is enough to face the process?

Code	Items	Group that chooses the criterion	Neutrosophic res nullius element
C3	Dilation in the declaration of adoption	G1, G2, G3, G4, G5	The answer is not included in the classical numbering, it can only be answered from neutrosophy. In several judges, there are dissimilar periods to give the verdict. Although it is regulated, various elements delay when the person receives the court ruling influence. Those time spaces diverge in couples, institutions, localities, and other neutrosophic elements present in any sample.
C4	Under counseling	G3, G5	The question is: How prepared is a person to face the adoption process? There is no answer outside of neutrosophy that encompasses such terms.
C5	Lack of skills in candidates	G1, G2, G3, G4, G5	The vast majority of adopters report that when they began the adoption process, they were unable to do so because they did not meet the suitability requirements. These requirements may vary or increase over the years. Therefore it is a variable that varies in time and place.
E6	Contradiction in regulations	G1, G2, G3, G4	The interpretation of regulations leads to a neutrosophic understanding of each official. It is an element that varies from legendary times.
E7	divergence between zones	G3	Even if the nation applies a regulation, there is a high neutrosophic probability that it will be applied differently in each region.
E8	Irregularities in procedures	G5	There is a high probability of bureaucracy in the procedures. Adopters report that they have carried out adoption procedures where the information to be delivered differs in different locations.

Table 6: Res nullius elements determined by the groups surveyed. Source: own elaboration.

The results obtained from the analysis of the neutrosophic frequency present an indeterminacy level close to 0.5. The result defines in what proportion the factor influences the RNAE variable according to the sample analyzed (see Table 7). From the results, the average range of occurrence is observed for each group:

Cluster	Occurrence in the ERNA variable	Observations
G1 G2 G4	Very influential to moderately influential	The answers given by these groups are in the same neutrosophic dimension. It states that, if a criterion is given by a group that is in the same dimension, the groups within this subset will be present. It only has three states.
G3	Highly influential to moderately influential	This group belongs to the same dimension, and although it intersects with other dimensions, it has unique characteristics. Within its same dimension, it has four states.
G5	From very influential to influential	

Table 7: Neutrosophic statistical analysis of the average of the RNAE variable by groups. Source: own elaboration.

Because each group defines more than one criterion to evaluate in the studied variable, it is decided to analyze the neutrosophic set and its relationships between subsets. For this, it is necessary to validate the criteria obtained from the surveyed groups, based on the experience of the experts in the adoption processes (see Table 8). The validation allows obtaining the existing uncertainties in each criterion that originate the res nullius element in the adoption process. For each criterion, a scale is used in the modeling (see Table 2) and data processing, the frequency, and the neutrosophic statistical probability in each subset (see Tables 8, 9, and 10).

Expert	C1	C2	C3	C4	C5	C6	C7	C8
E2	(0.9,0.1,0.1)	(0.10,0.90, 0.90)	(0.75,0.25, 0.20)	(0.75,0.25, 0.20)	(0.9,0.1,0.1)	(0.10,0.90, 0.90)	(0.10,0.90, 0.90)	(0.9,0.1,0.1)
E13	(0.75,0.25, 0.20)	(0.9,0.1,0.1)	(0.75,0.25, 0.20)	(0.75,0.25, 0.20)	(0.35,0.75, 0.80)	(0.75,0.25, 0.20)	(0.10,0.90, 0.90)	(0.10,0.90, 0.90)
E26	(0.10,0.90, 0.90)	(0.9,0.1,0.1)	(0.10,0.90, 0.90)	I	(0.75,0.25, 0.20)	(0.75,0.25, 0.20)	(0.35,0.75, 0.80)	(0.75,0.25, 0.20)
E34	(0.35,0.75, 0.80)	(0.35,0.75, 0.80)	(0.10,0.90, 0.90)	(0.9,0.1,0.1)	(0.75,0.25, 0.20)	(0.35,0.75, 0.80)	(0.35,0.75, 0.80)	

E52	(0.9,0.1,0.1)	(0.10,0.90, 0.90)	(0.75,0.25, 0.20)	(0.35,0.75, 0.80)	I	(0.10,0.90, 0.90)	(0.9,0.1,0.1)	(0.75,0.25, 0.20)
E59	(0.10,0.90, 0.90)	I	(0.75,0.25, 0.20)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	I	(0.35,0.75, 0.80)	I
E71	(0.9,0.1,0.1)	I	(0.10,0.90, 0.90)	I	I	(0.75,0.25, 0.20)	I	(0.10,0.90, 0.90)
E78	(0.75,0.25, 0.20)	(0.75,0.25, 0.20)	(0.35,0.75, 0.80)	(0.10,0.90, 0.90)	I	(0.9,0.1,0.1)	(0.10,0.90, 0.90)	(0.10,0.90, 0.90)
E79	(0.75,0.25, 0.20)	(0.9,0.1,0.1)	(0.35,0.75, 0.80)	(0.75,0.25, 0.20)	(0.10,0.90, 0.90)	I	(0.9,0.1,0.1)	(0.10,0.90, 0.90)

Table 8: Criteria validation level. Source: own elaboration.

The analysis highlights that:

- For criteria C2, C4, C5, C6, C7, and C8, there is a level of indeterminacy between the given evaluations, with a higher incidence in factor C5.
- Expert E71 (academic) identified four of the six criteria with a high level of indeterminacy (C2, C4, C5, and C7)

Indicators	(0.9;0.1;0.1)	(0.75;0.25;0.20)	(0.50;0.5;0.50)	(0.35;0.75;0.80)	(0.10;0.90;0.90)
C1 (1)	0.3333	0.6667	0.6667	0.7778	1,0000
C2 (2)	0.3333	0.4444	0.6667	0.7778	1,0000
C3 (3)	0.0000	0.4444	0.4444	0.6667	1,0000
C4 (4)	0.2222	0.5556	0.7778	0.8889	1,0000
C5 (5)	0.2222	0.4444	0.7778	0.8889	1,0000
C6 (6)	0.1111	0.4444	0.6667	0.7778	1,0000
C7 (7)	0.2222	0.2222	0.3333	0.6667	1,0000
C8 (8)	0.1111	0.3333	0.5556	0.5556	1,0000

Table 9: Relative frequency, neutrosophic cumulative probability. Source: own elaboration

Indicators	(0.9;0.1;0.1)	(0.75;0.25;0.20)	(0.50;0.5;0.50)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	Average	N- Avg.	SVNN	Order
C1 (1)	-0.43	0.43	0.43	0.76	3.50	0.94	**-0.29**	(0.75;0.25;0.20)	2
C2 (2)	-0.43	-0.14	0.43	0.76	3.50	0.82	**-0.17**	(0.75;0.25;0.20)	4
C3 (3)	-3.50	-0.14	-0.14	0.43	3.50	0.03	**0.62**	(0.35;0.75;0.80)	
C4 (4)	-0.76	0.14	0.76	1.22	3.50	0.97	**-0.32**	(0.75;0.25;0.20)	1
C5 (5)	-0.76	-0.14	0.76	1.22	3.50	0.92	**-0.27**	(0.75;0.25;0.20)	3
C6 (6)	-1.22	-0.14	0.43	0.76	3.50	0.67	**-0.02**	(0.50;0.5;0.50)	
C7 (7)	-0.76	-0.76	-0.43	0.43	3.50	0.40	**0.25**	(0.50;0.5;0.50)	
C8 (8)	-1.22	-0.43	0.14	0.14	3.50	0.43	**0.22**	(0.50;0.5;0.50)	
Cut points	**-1.14**	**-0.15**	**0.30**	**0.72**	**3.50**	**0.65**	**= N**		
						N =	**0.65**		

Table 10: Calculation of cut-off points and scale of neutrosophic indicators. Source: own elaboration.

The determination of the degree of neutrosophic relevance of each subset by the experts indicates that criteria C3, C6, C7, and C8 should not be included in the study as the factors that originate the res nullius element in the adoption process. The neutrosophic statistical analysis determines that the following criteria are factors that originate the res nullius element in the adoption process:

C4. Under counseling: Y_N (0.017 + 0.195 I); CVN (0.076 + 0.661 I) for I = 88.50% (lower CVN, because it is the element with the highest incidence)

C1. Time dilation of the adoptive process: SN (0.014 + 0.163 I); NVC (0.054 + 0.629 I) for I= 91.40%

C5. Lack of skills in the candidates: S_N (0.016 + 0.182 I); NVC (0.065 + 0.746 I) for I= 91.30%

C2. Ignorance of the adoption process: Y_N (0.016 + 0.165 I); CVN (0.061 + 0.635 I) for I= 90.40%

Partial solutions to mitigate the res nullius effect in the adoption process:

Foundations, entities, and organizations must conduct and guide training and counseling programs through conferences, courses, meetings, and workshops where adopters clear up doubts about the process.

The regulatory institutions (Ministry of Social Welfare, National Council for Children and Adolescents, Technical Adoption Units, Judge) that direct the process must work with society in their training and preparation to

achieve a legal culture in society (especially for adopters who make up a family for the adoptee) through the various channels of communication in a precise and direct way, where the feeling of disappointment, misinformation, and disappointment in the adopters does not surface.

Conclusion

Neutrosophic statistics allows and determines the factors that originate the res nullius element in the adoption process. The consensus of the experts yielded that the factors with the highest incidence were under counseling and ignorance of the adoption process. The one in the study of the neutrosophic subset refers as the main factor the low advice to the candidates for adopters with an average of 0.97 for the neutrosophic value of (0.75; 0.25; 0.20). While at the level of the set or neutrosophic dimension, a CVN (0.076 + 0.661 I) is obtained for 88.50% indeterminacy. It was detected that the legal norms that protect the process present fissures that originate the res nullius element, breaches, and in the case of the rights of the adoptee, they are not fully regulated. Therefore, the use of basic alternatives focused on compliance with regulations and the training of adopters is recommended. Include the role of institutions in promoting the child adopted from a foster family without falling into extensive processes that give rise to the res nullius element.

References

[1] J. Sánchez Rodríguez, T. a. Morillo Lesme, and C. Riera Quintana, "Evaluating the affective needs of adopted children: demonstrations of psychomotor expressiveness. ," *Revista Española de Pedagogía,* vol. 76, no. 269, pp. 157-173, 2018, doi: https://doi.org/10.22550/REP76-1-2018-08.

[2] E. B. N. Arias, B. M. G. Nuñez, L. N. Fernández, and J. M. R. Pupo, "CRISP-DM and K-means neutrosophic in the analysis of risk factors for hearing loss in children. CRISP-DM y K-means neutrosofía en el análisis de factores de riesgo de pérdida de audición en niños," *Neutrosophic Computing and Machine Learning (NCML): An lnternational Book Series in lnformation Science and Engineering. Volume 16/2021,* p. 73, 2021.

[3] L. Gouveia, E. Magalhães, and V. S. Pinto, "Foster families: A systematic review of intention and retention factors," *Journal of Child and Family Studies,* vol. 30, no. 11, pp. 2766-2781, 2021.

[4] I. Cáceres, C. Moreno, M. Román, and J. Palacios, "The social competence of internationally-adopted and institutionalized children throughout childhood: a comparative and longitudinal study," *Early Childhood Research Quarterly,* vol. 57, July, pp. 260-270, 2021/10/01/ 2021, doi: https://doi.org/10.1016/j.ecresq.2021.07.002.

[5] R. P. Alava, J. M. Murillo, R. B. Zambrano, & , and M. I. Zambrano Vélez, "PEST Analysis Based on Neutrosophic Cognitive Maps: A Case Study for Food Industry," *Neutrosophic Sets and Systems,* vol. 21, no. 1, p. 10, 2018.

[6] K. P. Teruel, CedeñoCedeñ, J., Gavilanez, H. L., Diaz, C., & Vázquez, M. L., "A framework for selecting ccloud computing services based on consensus under single valued neutrosophic numbers. ," *Neutrosophic Sets and Systems,* vol. 22, no. 1, pp. 38-40, 2018.

[7] U. Afzal, H. Alrweili, N. Ahamd, and M. Aslam, " Neutrosophic statistical analysis of resistance depending on the temperature variance of conducting material," *Scientific Reports,* vol. 11, no. diciembre, p. 23939, 2021.

[8] S. E. Bonilla Veloz & M. Y. M. Y. Muñoz Medina. "Diseño de dieta para el tratamiento de enfermedades mentales en Ambato". Universidad y Sociedad, vol. 14 no. S2, pp- 285-289, 2022.

[9] D. M. Sandoval Malquín & D. M. Sandoval Pozo. "El Cuadro de Mando Integral como herramienta de planificación financiera para la Compañía de Transporte de Carga Contrancarchi SA". Universidad y Sociedad, vol. 14 no. S2, pp 277-284, 2022.

[10] D. M. Sandoval Malquín & D. M. Sandoval Pozo. "Estrategias financieras en tiempo de crisis para las Pymes de la ciudad de Tulcán". Universidad y Sociedad, vol. 14 no. S2, pp 268-276, 2022.

[11] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[12] Ricardo, J. E., Vázquez, M. Y. L., Palacios, A. J. P., & Ojeda, Y. E. A. "Inteligencia artificial y propiedad intelectual". Universidad y Sociedad, vol. 13 no. S3, pp 362-368, 2021.

[13] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[14] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[15] Álvarez Gómez, G. A., Viteri Moya, J. R., Viteri Intriago, D. A., & Estupiñán Ricardo, J. "Integración de los procesos sustantivos para la mejora de la calidad del aprendizaje". Conrado, vol. 17 no. 80, pp 21-27, 2021.

[16] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.

[17] von Feigenblatt, O. F., Calderon, R. D., & MacDonald, T. "The Case for an Eclectic and Flexible Leadership Research Agenda: Dealing with Social Justice and Diversity in the 21st Century Workplace". Centro Sur, vol. 6 no. 1, pp 130-142, 2022.

[18] J. B. Intriago Hidalgo, I. X León Rodríguez, J. L. Maldonado Cando & J. X Iglesias Quintana. "Vulneración del Principio de Celeridad en los procesos investigativos y judiciales en los casos de violencia psicológica en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 649-656, 2022.

[19] B. D. Coronel Casanova, Y. G. Calva Vega, J. O. Jácome Cordones & B. D. C. Viteri Naranjo. "La vulneración de derechos de los afiliados al Instituto Ecuatoriano de Seguridad Socia"l. Universidad y Sociedad, vol. 14 no. S4, pp 641-648, 2022.

[20] C. F. Rey Siquilanda, E. A. Rengel Delgado, F. A. Garcés Córdova & E. M. Vásquez Llerena. "La defensa técnica gratuita a la víctima en contravenciones penales flagrantes en la Legislación ecuatoriana". Universidad y Sociedad, vol. 14 no. S4, pp 634-640, 2022.

Received: August 12, 2022. **Accepted:** October 11, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Use of NeutroAlgebra for the Analysis of the Poor State of the Social Rehabilitation System in Babahoyo

Marcelo Raúl Dávila Castillo[1], Robert Alcides Falconí Herrera[2], Luis Andrés Crespo Berti[3] and Oscar Fabian Villacrés Duche[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.marcelodavila@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.robertfalconi@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.luiscrespo@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.oscarvillacres@uniandes.edu.ec

Abstract. The objective of this work was to use the NeutroAlgebra theory to determine the factors with the highest incidence in the poor state of the social rehabilitation system in Ecuador. For this purpose, a survey was applied to a group of 56 experts in the field from the canton of Babahoyos. Neutrosophic Logic based on SVNS was applied to the DEMATEL method. The application of this method made it possible to determine the causal relationships between the initial elements and to focus the efforts of the interview on the causal elements of the main problems. Through the use of NeutroAlgebra it was possible to determine that, although in general, the results were satisfactory, unfavorable responses were observed in relation to the budget to carry out the different activities, the increase in crime in the country, as well as the lack of good prison reforms. The results allowed the fulfillment of the objectives and demonstrated the usefulness of neutrosophic logic in real-life problems.

Keywords: NeutroAlgebra, social rehabilitation, Ecuador.

1. Introduction

Faced with the advancement of various fields of research and the need to model increasingly complex problems that are associated with real life, the need to assume more varied criteria and alternatives has become more prevalent in all scientific fields. The presence of uncertain data or measurements has generated a great need to establish effective mechanisms for data measurement and has even given rise to new theories and fields of measurement [1].

In this scenario, a series of new theories emerged intending to provide a feasible solution to such drawbacks. In 1995, Smarandache extended paradoxism (based on opposites) to a new branch of philosophy called Neutrosophy. This new science was based on the study of the relationship between opposites and their neutrality. Neutrosophy is also an extension of Dialectic (characterized by the dynamics of opposites in Philosophy), and ancient Chinese Yin-Yang Philosophy (also based on opposites: masculine/feminine, good/bad, heaven/earth, etc.) which was founded and studied two and a half millennia before the Dialectics of Hegel and Marx [2].

After the initial contributions made by Smarandache, several neutrosophic notions have followed that provide a reasonable mathematical framework for dealing with indeterminate and inconsistent information [3]. Given its importance and applicability in multiple forms of science, engineering, and society, various specialists have expanded the neutrosophic model to extend its practical application [4]. These theories have shown multiple applications in engineering, computer science, administrative work, medical research, biology, psychology, social sciences, etc.

An example of this is the contribution made by [5], who extended the gray relational analysis method to the neutrosophic environment and applied it to the selection of the investment sector. Secondly, [2] developed the TODIM method using aggregate weight operators. On the other hand, the study carried out by [6] showed a new approach for multi-attribute group decision-making problems in the single-valued neutrosophic setting. In this way, they were used to catalog the alternatives according to certain criteria. This allowed the expression of expert opinion based on the information provided.

In 2019, due to the need to more accurately reflect reality, Smarandache first introduced the NeutroDefined and AntiDefined laws, as well as the NeutroAxiom and AntiAxiom, inspired by Neutrosophy, giving birth to new research fields called NeutroStructures and AntiStructures [7]. In this sense, the consideration of a given classical algebraic axiom began, defining for the first time, the neutrosophic triplet corresponding to this Axiom, (Axiom,

NeutroAxiom, AntiAxiom) [3].

In this sense, while the classical Axiom is 100% or totally true, the Neutral Axiom is partially true and partially false, which implies that the degrees of truth and falsehood are both > 0; while the AntiAxiom is 100% or totally false [8]. In this way, a (classical) algebraic structure is an algebraic structure that deals only with (classical) axioms, which are totally true. So, a NeutroAlgebraic Structure is an algebraic structure that has at least one NeutroAxiom and no AntiAxiom. While an AntiAlgebraic Structure is an algebraic structure that has at least one AntiAxiom [9].

These NeutroAlgebraic and Antialgebraic Structures were introduced, after being ignored by classical algebraic structures. Since, in the applications of everyday life, the laws that characterize them are not necessarily well defined or known, and the properties/theories that govern them might be only partially true and partially false (a mixture of truth and falsehood) [10].

Constitutionally, the social rehabilitation system of Ecuador has the purpose of achieving the comprehensive rehabilitation of people criminally sentenced to be reintegrated into society. Likewise, the protection of persons deprived of liberty and the guarantee of their rights are sought. In this sense, it is established that the system will have as a priority the development of the capacities of the criminally sentenced persons to exercise their rights and fulfill their responsibilities upon regaining their freedom.

However, most of the current Social Rehabilitation Centers do not provide the adequate conditions required by persons who are in prison, to enjoy a dignified life. Nor do they offer the ideal infrastructure to carry out rehabilitation programs and priority attention during the period of stay in detention centers. The system of corruption that operates in the Ecuadorian prison system, overcrowding, and poor living conditions, among other factors, has made it increasingly difficult to maintain control within the prisons.

In this sense, the present work has the objective of using the NeutroAlgebra theory to determine the factors of greater incidence in the deficient state of the social rehabilitation system of Ecuador. To carry out this study, it is decided to use and apply the survey to a group of experts in the field from the canton of Babahoyo.

To carry out the present study, the use of the linguistic scale is taken into account, which is a tool more natural for the human being, and that allows to express more reliably what is meant. For this, some notions of NeutroAlgebra are used. As a complementary method for decision-making, the DEMATEL method is used, in its neutrosophic variant. This method is a valuable tool for classifying the relationships between the objects, which makes it highly effective for data analysis and classification, in the decision-making process, etc. [11].

2. Prelims

Definition 1: Let X be a given nonempty space (or simply set) included in a universe of discourse U. Let <A> be an item (concept, attribute, idea, proposition, theory, etc.) defined on the set X. Through the process of neutrosophication, we split the set X into three regions [two opposite ones <A> and <antiA>, and one neutral (indeterminate) <neutA> between them], regions which may or may not be disjoint – depending on the application – but they are exhaustive (their union equals the whole space).

A NeutroAlgebra is an algebra that has at least one NeutroOperation or one NeutroAxiom (axiom that is true for some elements, indeterminate for other elements, and false for other elements).

NeutroAlgebra is a generalization of Partial Algebra, which is an algebra that has at least one Partial Operation, while all its Axioms are totally true (classical axioms).

Definition 2: A function $f: X \to Y$ is called a Partial Function if it is well-defined for some elements in X, and undefined for all the other elements in X. Therefore, there exist some elements $a \in X$ such that $f(a) \in Y$ (well-defined), and for all other element $b \in X$ we have $f(b)$ is undefined [12], [22], [24].

Definition 3: A function $f: X \to Y$ is called a NeutroFunction if it has elements in X for which the function is well-defined {degree of truth (T)}, elements in X for which the function is indeterminate {degree of indeterminacy (I)}, and elements in X for which the function is outer-defined {degree of falsehood (F)}, where $T, I, F \in [0, 1]$, with $(T, I, F) \neq (1, 0, 0)$ that represents the (Total) Function, and $(T, I, F) \neq (0, 0, 1)$ that represents the Anti-Function.

Classification of Functions

i) (Classical) Function, which is a well-defined function for all the elements in its domain of definition.

ii) NeutroFunction, which is a function partially well-defined, partially indeterminate, and partially outer-defined in its domain of definition.

iii) AntiFunction, which is a function outer-defined for all the elements in its domain of definition.

Definition 4: A (classical) Algebraic Structure (or Algebra) is a nonempty set A endowed with some (totally well-defined) operations (functions) on A, and satisfying some (classical) axioms (totally true) - according to the Universal Algebra [12].

Definition 5: A (classical) Partial Algebra is an algebra defined on a nonempty set PA that is endowed with some partial operations (or partial functions: partially well-defined, and partially undefined). While the axioms (laws) defined on a Partial Algebra are all totally (100%) true [12], [27].

Definition 6: A NeutroAxiom (or Neutrosophic Axiom) defined on a nonempty set is an axiom that is true for some set of elements {degree of truth (T)}, indeterminate for other sets of elements {degree of indeterminacy (I)}, or false for the other set of elements {degree of falsehood (F)}, where $T, I, F \in [0,1]$, with $(T, I, F) \neq (1,0,0)$ that represents the (classical) Axiom, and $(T, I, F) \neq (0,0,1)$ that represents the AntiAxiom [12], [23].

Classification of Algebras [9]

- A (classical) Algebra is a nonempty set CA that is endowed with total operations (or total functions, ie true for all set elements) and (classical) Axioms (also true for all set elements).
- A NeutroAlgebra (or NeutroAlgebraic Structure) is a nonempty set NA that is endowed with: at least one NeutroOperation (or NeutroFunction), or one NeutroAxiom that is referred to the set (partial-, neutral-, or total-) operations.
- An AntiAlgebra (or AntiAlgebraic Structure) is a nonempty set AA that is endowed with at least one AntiOperation (or AntiFunction) or at least one AntiAxiom.

Additionally, the PROSPECTOR function is defined in the MYCIN expert system in the following way; it is a mapping from $[-1,1]^2$ into $[-1,1]$ with the formula [13], [27]:

$$P(x,y) = \frac{x+y}{1+xy} \tag{1}$$

This function is a uninorm [14], with neutral element 0, thus it fulfills commutativity, associativity, and monotonicity. Here we respect the condition that $P(-1,1)$ and $P(1,-1)$ are undefined.

Otherwise, for convenience $P(x,y)$ is extended to $\bar{P}(x,y)$ such that:

$\bar{P}(x,y) = P(x,y)$ for all $(x,y) \in [-1,1]^2 \setminus \{(-1,1),(1,-1)\}$,

$\bar{P}(-1,1) = \bar{P}(1,-1) = undefined$,

$\bar{P}(undefined, undefined) = undefined$.

$$\bar{P}(undefined, x) = \bar{P}(x, undefined) = \begin{cases} \text{undefined, if } x > 0 \\ x, \text{ if } x \leq 0 \end{cases}.$$

Definition 7: Let S be a finite set defined as $S = \left\{(x,y): x, y \in \left\{\frac{k}{10}, undefined\right\},\ k \in \mathbb{Z} \cap [-10,10]\right\}$.

The operator $\odot$ is defined for every $(x,y) \in S$, such that [15]:

1. If $\bar{P}(x,y)$ is not undefined, then $\odot\, y = \frac{round(\bar{P}(x,y)*10)}{10}$, where *round* is the function that outputs the integer nearest to the argument.
2. If $\bar{P}(x,y)$ is undefined then $x \odot y = undefined$.

Then $\odot$ is a finite NeutroAlgebra. This is because $\odot$ is commutative and associative for the subset of elements of S without any undefined component, but it is not associative otherwise.

E.g., if $a = -0.9$, $b = 0.8$, $c = undefined$, then $a \odot (b \odot c) = a$ and $(a \odot b) \odot c = -0.4 \neq a$, therefore associativity is a NeutroAxiom.

Function *round* is used for guarantying $\odot$ is an inner operator.

In this case, Caley tables are used to generate data at the same scale used in the input data. To do this, these elements are multiplied by 10, so that input values can be obtained in a range from -10 to 10. Table 1 shows the results of this operation.

x ⊙ y	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	I	1	2	3	4	5	6	7	8	9	10
-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	I
-9	-10	-10	-10	-10	-10	-10	-10	-9	-9	-9	-9	-9	-9	-9	-8	-8	-7	-7	-5	-4	0	10
-8	-10	-10	-10	-10	-9	-9	-9	-9	-9	-8	-8	-8	-8	-7	-7	-6	-5	-4	-2	0	4	10
-7	-10	-10	-10	-9	-9	-9	-9	-8	-8	-7	-7	-7	-6	-6	-5	-4	-3	-2	0	2	5	10
-6	-10	-10	-9	-9	-9	-8	-8	-8	-7	-7	-6	-6	-5	-5	-4	-3	-1	0	2	4	7	10
-5	-10	-10	-9	-9	-8	-8	-8	-7	-6	-6	-5	-5	-4	-3	-2	-1	0	1	3	5	7	10
-4	-10	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4	-4	-3	-2	-1	0	1	3	4	6	8	10
-3	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4	-3	-3	-2	-1	0	1	2	4	5	7	8	10
-2	-10	-9	-9	-8	-7	-6	-6	-5	-4	-3	-2	-2	-1	0	1	2	3	5	6	7	9	10
-1	-10	-9	-8	-7	-7	-6	-5	-4	-3	-2	-1	-1	0	1	2	3	4	5	6	8	9	10
I	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	I	I	I	I	I	I	I	I	I	I	I
0	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10
1	-10	-9	-8	-6	-5	-4	-3	-2	-1	0	1	I	2	3	4	5	6	7	7	8	9	10

2	-10	-9	-7	-6	-5	-3	-2	-1	0	1	2	I	3	4	5	6	6	7	8	9	9	10
3	-10	-8	-7	-5	-4	-2	-1	0	1	2	3	I	4	5	6	6	7	8	8	9	9	10
4	-10	-8	-6	-4	-3	-1	0	1	2	3	4	I	5	6	6	7	8	8	9	9	10	10
5	-10	-7	-5	-3	-1	0	1	2	3	4	5	I	6	6	7	8	8	8	9	9	10	10
6	-10	-7	-4	-2	0	1	3	4	5	5	6	I	7	7	8	8	8	9	9	9	10	10
7	-10	-5	-2	0	2	3	4	5	6	6	7	I	7	8	8	9	9	9	9	10	10	10
8	-10	-4	0	2	4	5	6	7	7	8	8	I	8	9	9	9	9	9	10	10	10	10
9	-10	0	4	5	7	7	8	8	9	9	9	I	9	9	9	10	10	10	10	10	10	10
10	I	10	10	10	10	10	10	10	10	10	10	I	10	10	10	10	10	10	10	10	10	10

Table 1: Cayley's table of multiplying by 10.⊙

2.1 Neutrosophic DEMATEL using single-valued neutrosophic sets (SVNS)

Definition 8 Let X be a space of points (objects) with generic elements in X denoted by x. A single-valued neutrosophic set (SVNS) A in X is characterized by truth-membership function $TA(x)$, indeterminacy-membership function $IA(x)$, and falsehood membership function $FA(x)$. Then, an SVNS A can be denoted by $A = \{x, TA(x), IA(x), FA(x)\ x \in X\}$, where $TA(x), IA(x), FA(x) \in [0,1]$ for each point x in X. Therefore, the sum of $TA(x), IA(x)$ and $FA(x)$ satisfies the condition $0 \leq TA(x) + IA(x) + FA(x) \leq 3$.

Definition 9 Let $Ek = (T_k, I_k, F_k)$ be a neutrosophic number defined for the rating of the k-th decision-maker. Then, the weight of the k-th decision-maker can be written as:

$$\psi_k = \frac{1-\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(F(x))^2]/3}}{\sum_{k=1}^{p}\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(F(x))^2]/3}} \quad (2)$$

Further, in achieving a favorable solution, group decision-making is important in any decision-making process. In the group decision-making process, all the individual decision-maker assessments need to be aggregated into one aggregated neutrosophic decision matrix. This can be done by using a single-valued neutrosophic weighted averaging (SVNWA) aggregation operator as proposed by Ye [16], [26].

Definition 10 [16] Let $D^{(k)}=(d_{ij}^{(k)})_{mxn}$ be the single-valued neutrosophic decision matrix of the k-th decision-maker and $\psi = (\psi_1\psi_2, \ldots, \psi_p)^T$ be the weight vector of decision-maker such that each $\psi_k \in [0,1], D = (d_{ij})_{mxn}$ where

$$d_{ij} = \langle 1 - \prod_{k=1}^{p}\left(1 - T_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(I_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(F_{ij}^{(p)}\right)^{\psi_k}\rangle \quad (3)$$

Definition 11 ([6], [17]) Deneutrosophication of SVNS Ñ can be defined as a process of mapping Ñ into a single crisp output $f: Ñ \rightarrow \psi^*$ for $x \in X$. If Ñ is discrete set then the vector of tetrads $Ñ = \{(x \mid TÑ(x), IÑ(x), FÑ(x)) \mid x \in X\}$ is reduced to a single scalar quantity $\psi * \in X$ by deneutrosophication. The obtained scalar quantity $\psi * \in X$ best represents the aggregate distribution of three membership degrees of neutrosophic element $TÑ(x), IÑ(x), FÑ(x)$. Therefore, the deneutrosophication can be obtained as follows.

$$\psi^* = 1 - \sqrt{[(1 - T_k(x))^2 + (I_k(x))^2 + (\mathrm{F}(x))^2]/3} \quad (4)$$

Decision-making normally involves human language or linguistic variables, as it is commonly referred to. A linguistic variable simply represents words or terms used in human language. Therefore, this linguistic variable approach is a convenient way for decision-makers to express their assessments. Ratings of criteria can be expressed by using linguistic variables such as very influent (VI), influent (I), low influent (LI), not influent (NI), etc. Linguistic variables can be transformed into SVNSs as shown in Table 1.

Integer	Linguistic variable	SVNNs
0	No influence / Not important	(0.1,0.8,0.9)
1	Low influence/important	(0.35,0.6,0.7)
2	Medium influence/important	(0.5,0.4,0.45)
3	High influence/important	(0.8,0.2,0.15)
4	Very high influence/important	(0.9,0.1,0.1)

Table 2: Linguistic variable and Single-Valued Neutrosophic Numbers (SVNNs). Note: Source:[6]

To carry out the DEMATEL method in its neutrosophic variant, follow the steps outlined below [18]:

- Identify the elements of study: Through the application of semi-structured interviews to a population of interest and brainstorming, a set of influential factors in the subject under study is determined. [19]The

experts are then asked to evaluate the direct influence between the factors through paired comparisons, using the score shown in Table 2.

- Determine the relative importance of the experts: The group of experts has its importance values based on their level of experience and knowledge in the decision problem. Therefore, the weight of each decision-maker may be different from that of other deciders. The weight of each decision-maker is considered with linguistic variables and is transmitted in SVNN to later be identified using equation (2).
- Convert the linguistic evaluations given by the experts into SVNN: From the individual neat integer matrices obtained from the experts' evaluations, the individual neutrosophic matrices of the decision makers are constructed according to what is indicated in Table 2.
- Obtaining the initial direct relation matrix: To obtain the initial direct relation matrix that is in the form of neat numbers, the neutrosophic matrices of the individual decision-makers must be added and deneutrosophied using equations (3) and (4) respectively. [20], [25], [28], [29], [30]
- Identify cause-effect relationships between factors using the DEMATEL method: Based on the aggregate direct relationship matrix A obtained in step 4, the total relationship matrix T can be easily calculated using equations (5-7) as shown below:

$$D = A * S \tag{5}$$

Where

$$S = \frac{1}{\max\limits_{1\le i\le n} \sum_{j=1}^{n} a_{ij}} \tag{6}$$

Y

$$T=D*(ID)-1 \tag{7}$$

where I is the identity matrix. From this, the cause-effect relationship diagram $(ri + ci, ri - ci)$ is constructed.

- Analyze the cause-effect relationship diagram. The (ri+ci) is called “Prominence” and measures the degree of central role that the factor or criterion plays within the system. While (ri −ci) is called “Relationship” and is the effect produced by the factor or criterion in the system. If (ri -ci) >0, the factor or criterion is located in the group of causes. If (ri -ci) <0 the factor or criterion is located in the group of effects.

2.2 Methodology

In consultation with the specialists and through the revision of the base documents, the following elements are selected for the study:

- Increase in crime in the country and corruption inside prisons
- overcrowding
- Poor state of facilities and equipment in detention centers
- Lack of security personnel
- Lack of a good prison reform
- Weakening of the institutionality of the Ministry of Justice and Human Rights
- Insufficient budget to carry out the different projects
- More restrictive reforms in the Comprehensive Organic Criminal Code (COIP) of 2014

Taking these elements into account, the DEMATEL method is used to determine the possible causal relationships between these elements. The result of this analysis allows the focus of the interview to be carried out on the issues of greatest impact and relevance that are the true causes of the crisis, according to the selected experts. Five specialists who make up the working group are involved in this analysis. [21]

Subsequently, a questionnaire is applied to a sample of experts with years of experience in the field of study. The interview conducted with these experts is carried out through the use of linguistic variables. These allow a better understanding of the data, as well as a more accurate evaluation by the participants.

A group of 56 experts is selected to answer the questions prepared for the study. Each one of them is asked to rate the statements shown using a positive scale, up to 10 points if they have a favorable opinion on the subject analyzed. On the contrary, if they have an unfavorable opinion, they should make the rating on a scale of -10 to -1.

v_{ij}, $(i = 1,2,\dots,56;\ j = 1,2,\dots,n)$ is denoted as the evaluation of the i-th expert on the j-th aspect.

Subsequently, the calculation of $\bar{v}_i = \left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}, \frac{\sum_{j=1}^{n^0} v_{ij}^0}{n^0}, \frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$ is made, where the positive responses of the i-th official on the j-th aspects are neutral, therefore, $\frac{\sum_{j=1}^{n^0} v_{ij}^0}{n^0} = 0$ and v_{ij}^- are negative responses. On the other hand n^+, n^0 and n^- are the numbers of positive, neutral, and negative responses, respectively. This new treatment guarantees greater precision in the results than the simple calculation of the arithmetic mean.

Afterward, $\hat{v}_i = round\left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}\right) \odot round\left(\frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right)$ is calculated. In case both $round\left(\frac{\sum_{j=1}^{n^+} v_{ij}^+}{n^+}\right) = 10$ and $round\left(\frac{\sum_{j=1}^{n^-} v_{ij}^-}{n^-}\right) = -10$, it is defined that $\hat{v}_i = -10$.

The decision process is performed in two different situations:

1. If less than 30% of the respondents give conflicting results for each fixed j, that is, if there are 30 or fewer pairs of $(-10,10)$ or $(10,-10)$ values, these values are removed for aggregation.
2. Otherwise, the j-th aspect evaluates to "undefined" and why such a contradiction exists should be checked in more detail.

When the first case exists, the aggregation of $\hat{v}_i$ is calculated using $\odot$

3. Results

The application of the proposed method allowed to determine the existence of causality between the elements initially evaluated. Table 3 shows a summary of the main elements of interest that shed light on this topic.

Query elements	Ri+Ci	Ri-Ci
The weakening of the institutionality of the Ministry of Justice and Human Rights	8,572	0.106
Insufficient budget to carry out the different projects	6,501	0.037
Overcrowding	6.86	-0.254
The most restrictive reforms in the Comprehensive Organic Criminal Code (COIP) of 2014	6,739	-0.021
Increase in crime in the country and corruption inside prisons	7,449	0.979
The lack of a good prison reform	8.38	0.612
Poor state of facilities and equipment in detention centers	6,094	-1,246
Lack of security personnel	5,329	-0.213

Table 3: Results of the application of the DEMATEL method. Source: own elaboration.

As can be seen, the weakening of the institutionality of the Ministry of Justice and Human Rights, the deficient budget to carry out the different projects, the increase in crime in the country and corruption inside the prisons, as well as the lack of a good prison reform constitute the elements with the greatest relationship within the system studied. The relationship values indicate strong causality, meaning that these four items were more strongly associated with causative items than the others.

Taking into account what was previously analyzed, the interview to be applied to the sampled experts was more widely influenced by these 4 elements. In this way, it was possible to delve more strongly into causal elements whose elimination or minimization has a greater impact. In this sense, each of the four elements was broken down into 5 questions that seek to determine the level of status, according to the interviewees. Table 4 shows a summary of the main elements obtained, after compiling and tabulating the information.

		Scores			
Items	**Questions**	**[-10, -5)**	**[-5,0)**	**[0, 5)**	**[5, 10]**
The weakening of the institutionality of the Ministry of Justice and Human Rights	1	15	15	12	14
	2	13	11	21	11

	3	10	18	20	8
	4	6	10	21	19
	5	15	9	18	14
Insufficient budget to carry out the different projects	6	21	11	12	12
	7	23	9	21	3
	8	19	14	19	4
	9	17	20	15	4
	10	8	15	13	20
Increase in crime in the country and corruption inside prisons	11	24	12	15	5
	12	16	21	19	0
	13	16	14	20	6
	14	16	24	8	8
	15	24	12	15	5
The lack of a good prison reform	16	26	25	2	3
	17	22	19	6	9
	18	16	15	10	15
	19	19	17	11	9
	20	17	12	25	2

Table 4: Grouped data on the results of the applied survey. Source: own elaboration.

The results of the analysis showed an average value of 5. Although in general, these results are favorable, unfavorable responses were observed in those related to the budget to carry out the different activities, the increase in crime in the country, as well as as the non-existence of good prison reforms. [22]

In this sense, the lack of political and social will for the development of timely and efficient strategies for the deployment of activities and measures capable of promoting general changes in the country's prison policy was pointed out with greater force. Likewise, it was pointed out that effective actions are not carried out to minimize the factors of poverty, social marginalization, and violence, the main precursors of crime in the country. Finally, the poor planning of state budgets leads to the continuous decline of some of the rehabilitation centers to very disadvantaged conditions.

Conclusions

NeutroAlgebraic Structures and Antialgebraic Structures were introduced as an important application mechanism in everyday life, science, and engineering. The present study allowed the use of NeutroAlgebra theory to determine the factors with the greatest incidence in the poor state of the social rehabilitation system in Ecuador. Methods of generating ideas were carried out with the support of experts to obtain the elements to be evaluated focused on the canton of Babahoyos. Neutrosophic logic based on SVNS was applied to the DEMATEL method. The application of this method made it possible to determine the causal relationships between the initial elements and to focus the efforts of the interview to be carried out on the causal elements of the main problems.

References

[1] M. Grida, R. Mohamed, and A. H. Zaid, "A novel plithogenic MCDM framework for evaluating the performance of IoT based supply chain," *Neutrosophic Sets Syst.*, vol. 33, no. 1, pp. 323–341, 2020.

[2] A. S. S. L. F. Autran, M. Gomes, and K. R. Vijayalakshmi, "Assessment of MCDM problems by TODIM using aggregated weights," *Neutrosophic sets Syst.*, vol. 35, no. 1, pp. 78–99, 2020.

[3] F. Smarandache and M. Ali, "Neutrosophic Triplet Group (revisited)," *Neutrosophic sets Syst.*, vol. 26, no. 1, p. 2, 2019.

[4] M. Mullai and R. Surya, "Neutrosophic Inventory Backorder Problem Using Triangular Neutrosophic Numbers.," *Neutrosophic Sets Syst.*, vol. 31 SRC-, pp. 148–155, 2020.

[5] P. Biswas, S. Pramanik, and B. C. Giri, "Entropy based grey relational analysis method for multi-attribute decision making under single valued neutrosophic assessments," *Neutrosophic Sets Syst.*, vol. 2, no. 1, pp. 102–110, 2014.

[6] P. Biswas, S. Pramanik, and B. C. Giri, "TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment.," *Neural Comput. Appl.*, vol. 27, no. 3, 2016.

[7] F. Smarandache, "NeutroGeometry & AntiGeometry are alternatives and generalizations of the Non-Euclidean Geometries (revisited)," *Neutrosophic Sets Syst. Vol. 46, 2021*, p. 456, 2021.

[8] V. Kandasamy, I. Kandasamy, and F. Smarandache, "NeutroAlgebra of Neutrosophic Triplets using {[Z. sub. n], x}.,"

Neutrosophic Sets Syst., vol. 38, pp. 509–524, 2020.
[9] F. Smarandache, "Introduction to NeutroAlgebraic Structures and AntiAlgebraic Structures (revisited).," *Neutrosophic Sets Syst.*, vol. 31, pp. 1–17, 2020.
[10] S. A. Edalatpanah, "Systems of neutrosophic linear equations," *Neutrosophic sets Syst.*, vol. 33, no. 1, pp. 92–104, 2020.
[11] M. F. S. Salgado, J. P. C. Pardo, and T. H. C. Palacios, "Application of the Neutrosophic AHP Method for the Development of a Training Project on the Adoption Process in Ecuador," *Neutrosophic Sets Syst.*, vol. 37, no. 1, p. 48, 2020.
[12] B. De Baets and J. Fodor, "Van Melle's combining function in MYCIN is a representable uninorm: An alternative proof," *Fuzzy Sets Syst.*, vol. 104, no. 1, pp. 133–136, 1999.
[13] A. K. Tsadiras and K. G. Margaritis, "The MYCIN certainty factor handling function as uninorm operator and its use as a threshold function in artificial neurons," *Fuzzy Sets Syst.*, vol. 93, no. 3, pp. 263–274, 1998.
[14] G. Deschrijver and E. E. Kerre, "Uninorms in L∗-fuzzy set theory," *Fuzzy Sets Syst.*, vol. 148, no. 2, pp. 243–262, 2004.
[15] D. S. Jiménez, M. E. R. Ubilla, and N. B. Hernández, "NeutroAlgebra for the evaluation of barriers to migrants' access in Primary Health Care in Chile based on PROSPECTOR function," *Neutrosophic Sets Syst.*, vol. 39, pp. 1–9, 2021.
[16] P. M. M. Arvelo *et al.*, "Neutrosophic model for the analysis of criminal behaviour in Quevedo, Ecuador, from a spatial econometric analysis," *Neutrosophic Sets Syst.*, vol. 26, no. Special Issue, pp. 48–53, 2019.
[17] S. Pramanik, R. Mallick, and A. Dasgupta, "Contributions of selected indian researchers to multi attribute decision making in neutrosophic environment: an overview.," *Neutrosophic Sets Syst.*, vol. 20, pp. 109–130, 2018.
[18] N. Nabeeh, "A hybrid neutrosophic approach of DEMATEL with AR-DEA in technology selection," *Neutrosophic Sets Syst.*, vol. 31, pp. 17–30, 2020.
[19] L. H. Carrión Hurtado, F. G. Naranjo Armijo & D. X. Lahuasi Palma. "Competitividad en colocación de microcréditos de cooperativas de ahorro y crédito en Santo Domingo". Universidad y Sociedad, vol. 14 no. S2, pp 222-229, 2022.
[20] M. S. Cuarán Guerrero, B. G. Valle Fiallos & O. J. Torres Merlo. "Tendencias del emprendimiento joven: caso Emprende Joven Ecuador 2021". Universidad y Sociedad, vol. 14 no. S2, pp 215-221, 2022.
[21] A R. León Yacelga & M. A. Checa Cabrera. "Uso de tableros Kanban como apoyo para el desarrollo de las metodologías ágiles". Universidad y Sociedad, vol. 14 no. S2, pp 208-214, 2022.
[22] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021
[23] de Mora-Litardo, K., & Estupiñan-Ricardo, J. "La influencia de la programación neurolingüística en estudiantes universitarios en la República de Ecuador". Luz, vol. 16 no. 1, pp 104-112, 2017.
[24] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.
[25] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[26] Vega Falcón, V., Alarcón Quinapanta, M., Yancha Villacís, M., & Estupiñán Ricardo, J. Medición del capital intelectual: Caso hotelero. Dilemas Contemporáneos: Educación, Política y Valores, no. 96, pp 1-19, 2019.
[27] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.
[27] von Feigenblatt, O. F., Pardo, P., & Cooper, M. "Sufficiency Economy Philosophy (SEP): Thailand's Emic Approach to Governance and Development as Evidence of an Asian-value Oriented Inclusive Leadership Management Philosophy". Journal of Asia Pacific Studies, vol. 6. No. 2, pp 289-300, 2021.
[28] J. R. Santillán Andrade, A. A. Astudillo Aguilar, S. F. Fiallos Bonilla & A. A. Cadena Pozo. "Necesidad de un marco legal para regular la reproducción humana asistida en el Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 533-540, 2022.
[29] K. A. Cedeño Romero, W. A. Cacpata Calle, E. J. Naranjo Luzuriaga & L. F. Haro Terán. "La prisión preventiva como medida cautelar, aplicada en la ciudad de Santo Domingo, Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 522-532, 2022.
[30] M. J. Vinces Sandoval, C. F. Rey Siquilanda, G. F. Vinueza Arroyo & A. J. Peñafiel Palacios. "Derecho al bienestar: política pública ecuatoriana relativo a la vivienda". Universidad y Sociedad, vol. 14 no. S4, pp 513-521, 2022.

Received: August 13, 2022. **Accepted:** October 12, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Comparison of Neutrosophic Operators of Personality in Lawyers of the City of Santo Domingo

Germán Fabricio Acurio Hidalgo[1], Fernando José Caicedo Banderas[2], Ignacio Fernando Barcos Arias[3] and Sheila Belén Esparza Pijal[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.germanacurio@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.fernandocaicedo@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.ignaciobarcos@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: docentetp81@uniandes.edu.ec

Abstract. The objective of this study was focused on demonstrate the usefulness of using neutrosophic logic to determine and compare different personality traits in a sample of lawyers from the city of Santo Domingo. For this, a sample of 10 lawyers was taken, 5 of them specialized in the field of criminal defense, and 5 specialized in family defense. The neutrosophic correlation was used to select the most important personality traits to be analyzed during the study. The results obtained allowed focusing the analysis on 3 pairs of traits-anti-traits on which the sample was analyzed. The study made it possible to determine that the sampled criminal lawyers turned out to be more extroverted and less sensitive than the family lawyers. The latter presented a lower average level of insensitivity than the criminal lawyers and less rigidity. On the other hand, criminal lawyers showed indeterminacy between sensitivity and insensitivity.

Keywords: neutrosophic psychology, personality traits, jurists, lawyers, neutrosophic correlation coefficient.

1 Introduction

The need to consider solutions to the various scenarios that arise in daily life becomes increasingly vital in the face of the continuous presence of uncertainty in the data that is handled. In this way, analysts and decision-makers find it necessary to broaden their range of tools more and more in order to achieve results suitable for real life [1].

Neutrosophy is a branch of philosophy initiated by Smarandache, in 1995, as an extension of dialectics [2]. This theory studies the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra [3].

Neutrosophic set theory constitutes a powerful element that allows transcending the concept of an intuitionistic fuzzy set [4]. The origin of neutrosophy has conceived a dynamic triad: (<A>, <neutA>, <antiA>). <A> is an entity (concept, idea, theory, etc.) while <antiA> is its opposite. In this sense, the inclusion of the third element, <neutA>, is conceived as the neutral between the opposites <A> and <antiA>. Including the aspect of indeterminacy that does not opt for any of the poles of the concept or idea analyzed [5].

The use of neutrosophic logic in various aspects of life can solve certain problems that cannot be solved, effectively and adequately, by other means. This theory deals with imprecise and vague situations where exact analysis is difficult or impossible [6].

Neutrosophy has evidenced the expansion of neutrosophic logic toward the creation of neutrosophic sets, neutrosophic probability analysis, neutrosophic statistics, and many others. This evolution has allowed an increasing scope in various fields of science. Hundreds of applications have been seen in the fields of engineering and computing, decision support, image processing, facial recognition systems, medical diagnostics, administration, industry, and many other fields where indeterminacy is present [7], [8].

Likewise, the field of study of the human psyche, or psychology, has seen the birth of applications of great interest associated with neutrosophic logic. Human behavior is extremely complex and is the result of many simultaneous interactions between pluri-underegos, pluriegos, and pluri-superegos. No individual fits completely (100%) to a trait; this can happen only in an idealistic way [9].

Neutropsyche is a new psychological theory that studies the soul or spirit using the theories of neutrosophy and neutrosophic logic. This theory is based on neutrosophic psychological concepts, operations, ideas, and assumptions with the form (<A>, <neutA>, <antiA>) (positive, neutral, negative), (insufficient thinking, normal thinking, -thinking), etc. ., and its refinements [10].

Neutropsychic personality traits constitute a dynamic psychological system open to tendencies to feel, think

and act in a very specific way in each individual. In this way, it can be established that the neutrosophic psychological theory studies the concepts of traditional psychology, from a triad of possible states (<A> <neutA> <antiA>) [11].

Specialists in the field of legal sciences are probably some of the professionals who are greatly influenced by the situations they must face every day in the exercise of their work. From the constant process of making ethical decisions to coping with personal and social dogmas, they are elements that shape and in turn forge the character and personality of most of them.

The objective of this study focuses on demonstrating the usefulness of using neutrosophic logic to determine and compare different personality traits in lawyers in the city of Santo Domingo. For this, the study is carried out on a sample of 10 lawyers from different fields of specialization, through the use of experts, and a comparison and analysis of the results are carried out.

As a complementary method for decision-making, correlation coefficients are used, also using neutrosophic logic, in a way that is consistent with the objective of this study. These coefficients are a tool of great importance in judging the relationship between two objects, and as a method, it has been applied before, as an effective way for data analysis and classification, in the decision-making process, etc. [12].

In the present study, some basic concepts related to the Theory of Neutrosophic Psychology are firstly analyzed. Subsequently, the use of correlation coefficients using single-value neutrosophic numbers (SVNN) based on the extension of the correlation coefficient of intuitionistic fuzzy sets is analyzed. Consecutively, the bases on which the analysis is carried out are established, the results achieved are presented, and, the conclusions derived from the study are enunciated.

2 Prelims

2.1 Preliminary Neutrosophic Psychological Theory

The triplet $(< A >, < neut\,A >, < antiA >)$ is extended to discrete refined neutrosophic memory, where $(< A > 1, < A > 2, \dots, < A > l; < neutA > 1, < neutA > 2, \dots, < neutA > m; < antiA > 1, < antiA > 2, \dots, < antiA > n)$ are defined based on refined neutrosophy.

Given a universe of discourse, subsets A, B, and C, then the crisp neutrosophic set satisfies the axioms: $A \cap B = \emptyset, B \cap C = \emptyset, C \cap A = \emptyset,$ and $A \cup B \cup C = U$. Therefore, A, B, and C form a disjoint partition of the universe of discourse U.

The refined neutrosophic crisp set for type 2 (and similarly for types 1 and 3) is defined as: $A = A1 \cup A2 \cup \dots \cup Ap$, $B = B1 \cup B2 \cup \dots \cup Br$, $C = C1 \cup C2 \cup \dots \cup Cs$, with $A \cap B = B \cap C = C \cap A = \emptyset$, where p, r, s are integers ≥ 1, $p + r + s \geq 4$, and $Ai \cap Aj = \emptyset$ for $i, j \in \{1,2, \dots, p\}$, $i \neq j$; $Bk \cap Bl = \emptyset$ for $k, l \in \{1,2, \dots, r\}$, $k \neq l$; and $Cm \cap Cn = \emptyset$ for $m, n \in \{1,2, \dots, s\}, m \neq n$ [9].

Various experts and trait theorists have concluded that the position of the human being moves on the spectrum between two opposite traits, that is, he behaves dynamically. As an easy generalization of all trait models, any number n ≥ 1 of Traits (traits) and their corresponding antiTraits can be considered, for $1 \leq j \leq n$:

$< A\,1 > / < antiA1 >, < A\,2 > / < antiA2 >, \dots, < A\,n > / < antiAn >$.

If the degree of the Trait is greater than or equal to the Trait Threshold (ThT), then the individual is characterized by this Trait. Similarly, if the degree of antiTrait is less than or equal to the threshold of antiTrait (antiThr), then he is characterized by antiTrait. In a neighborhood of the midpoint [-ε, ε], it is the most confused (indeterminate) degree (almost half Trait and half antiTrait) or combination of Trait-antiTrait [13], [23], [25].

Personality traits are measurable by calculating the degree of <A> and the degree of <antiA>. Really, in the world, no individual fits completely (100%) to a personality trait since this is only possible idealistically. In this way, the constants: -antiThr, +Thr, and ε depend on each antiTrait/Trait pair, so they can be different from one antiTrait/Trait pair to another. These constants are generally determined by experts in psychology, depending on the research interests [14], [24], [26], [27], [28], [29].

In this sense, let any Trait/anti-Trait pair be, and let x be an individual belonging to a group of people S, then it is defined that:

$dTrait: S \rightarrow [0, 1]$,

dTrait(x) = the degree of the Trait that characterizes the individual x, and

$dantiTrait: S \rightarrow [-1, 0]$,

dantiTrait(x) = the degree of the antiTrait that characterizes the individual x. The Neutrosophic Trait Operator, combining the opposites, is the cumulative degree of individual x with respect to both the Trait and the anti-Trait, and is defined as:

$dRTrait\ and\ antiTrait: S \rightarrow [-1, 1]$,

$dTrait\ \&\ antiTrait(x) = dTrait\ (x) + dantiTrait(x)$.

For each Trait - antiTrait pair, the degree of the Trait dTrait(x) that characterizes the individual x, and the degree of the antiTrait dantiTrait(x) is calculated. Subsequently, the Neutrosophic Trait Operator dTrait & antiTrait(x) is used and compared with the two thresholds, Thr and antiThr:

- If $dTrait\ \&\ antiTrait(x) \geq +Thr$, then the individual is categorized as definitely belonging to the Trait,
- If $Trait\ \&\ antiTrait(x) \leq -antiThr$, then the individual is categorized as definitely belonging to the antiTrait.
- If $dTrait\ and\ anti\ Trait\ (x) \in (\varepsilon, Thr)$, then the individual is classified as being in a totally indeterminate state between Trait and antiTrait.
- If $dTrait\ and\ anti\ Trait\ (x) \in (\varepsilon, Thr)$, then the individual is classified as belonging mainly to the Trait.
- And finally, if $dTrait\ \&\ antiTrait(x) \in (-antiThr, -\varepsilon)$, then the individual is categorized as mostly belonging to the antiTrait.

2.2 Correlation Coefficient of SVNSs

Definition 1. [15] Let X be a space of points (objects), with a generic element in X denoted by x. A neutrosophic set A in X is characterized by a membership function of truth $T_A(x)$, a membership function of indeterminacy $I_A(x)$, and a membership function of falsehood $F_A(x)$. The functions $T_A(x)$, $I_A(x)$ and $F_A(x)$ are standard or nonstandard real subsets of $]0^-, 1^+[$, that is, $T_A\ (x)$: $X \rightarrow]0^-, 1^+[$, $I_A\ (x)$: $X \rightarrow]0^-, 1^+[\ and\ F_A\ (x)$: $X \rightarrow]0^-, 1^+[$. There is no restriction on the sum of $T_A\ (x)$, $I_A\ (x)$ and $F_A\ (x)$, so $0^- \leq supT_A(x) + supI_A(x) + supF_A(x) \leq 3^+$.

Obviously, it is difficult to apply the neutrosophic set to practical problems. The definition of SVNS is presented below.

Definition 2. [16] Let X be a space of points (objects) with generic elements in X denoted by x. An SVNS A in X is characterized by a truth membership function $T_A(x)$, an indeterminacy membership function $I_A(x)$, and a falsehood membership function $F_A(x)$ for each point x in X, $T_A(x), I_A(x), F_A(x) \in [0,1]$. Therefore, an SVNS A can be expressed as

$$A = \{x, T_A(x), I_A(x), F_A(x) \mid x \in X\}$$

Then, the sum of $T_A\ (x)$, $I_A\ (x), and\ F_A\ (x)$ satisfies the condition $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

Definition 3. [16] The complement of an SVNS A is denoted by and is defined as Ac

$$Ac = \{x, F_A(x), 1 - I_A(x), T_A(x) \mid x \in X\}$$

Definition 4. An SVNS A is contained within another SVNS $B, A \subseteq B$ if and only if $T_A(x) \leq T_B(x), I_A(x) \geq I_B(x)$, and $F_A(x) \geq F_B(x)$, and for every x in X.

Definition 5. Two SVNSs A and B are equal, written as A = B, if and only if $A \subseteq B$ and $B \subseteq A$

Definition 6. For any two SVNSs A and B in the universe of discourse $X = \{x_1, x_2, \ldots, x_n\}$, the correlation coefficient between two SVNSs A and B is defined as follows:

$$M(A,B) = \frac{1}{3n}\sum_{i=1}^{n}[\phi_i(1-\Delta T_i) + \varphi_i(1-\Delta I_i) + \psi_i(1-\Delta F_i)] \quad (1)$$

where

$$\phi_i = \frac{3 - \Delta T_i - \Delta T_{max}}{3 - \Delta T_{min} - \Delta T_{max}},$$

$$\varphi_i = \frac{3 - \Delta I_i - \Delta I_{max}}{3 - \Delta I_{min} - \Delta I_{max}},$$

$$\psi_i = \frac{3 - \Delta F_i - \Delta F_{max}}{3 - \Delta F_{min} - \Delta F_{max}},$$

$$\Delta T_i = |T_A(x_i) - T_B(x_i)|\ ,$$

$$\Delta I_i = |I_A(x_i) - I_B(x_i)|,$$

$$\Delta T_i = |T_A(x_i) - T_B(x_i)|\ ,$$

$$\Delta T_{min} = min_i|T_A(x_i) - T_B(x_i)|\ ,$$

$\Delta I_{min} = min_i|I_A(x_i) - I_B(x_i)|$,

$\Delta F_{min} = min_i|F_A(x_i) - F_B(x_i)|$,

$\Delta T_{max} = max_i|T_A(x_i) - T_B(x_i)|$,

$\Delta I_{max} = max_i|I_A(x_i) - I_B(x_i)|$,

$\Delta F_{max} = max_i|F_A(x_i) - F_B(x_i)|$,

For all and i = 1, 2, . . ., n$xi \in X$

However, the differences of importance are considered in the elements of the universe. Therefore, the weight $x_i(i = 1,2,\dots,n)$ of the element must be taken into account. A weighted correlation coefficient between the SVNS is presented below.

Definition 7. Let w_i be the weight of each element $x_i\ (i = 1,2,\dots,n), w_i \in [0,1]$, and $\sum_{i=1}^{n} w_i = 1$, then the following weighted correlation coefficient between SVNS A and B is expressed as:

$$M_w(A,B) = \frac{1}{3}\sum_{i=1}^{n} w_i[\phi_i(1-\Delta T_i) + \varphi_i(1-\Delta I_i) + \psi_i(1-\Delta F_i)] \quad (2)$$

Decision-making method using the correlation coefficient of SVNSs

In the multi-attribute decision problem with single-valued neutrosophic information, the characteristic of an alternative $A_i\ (i = 1,2,\dots,m)$ on an attribute $C_j\ (j = 1,2,\dots,n)$ is represented by the following SVNS:

$$A_i = \{C_j, T_{Ai}\ (C_j), I_{Ai}(C_j), F_{Ai}(C_j) | Cj \in C, j = 1,2,\dots,n\}$$

Where $T_{Ai}\ (C_j)$, $I_{Ai}(C_j), F_{Ai}(C_j)) \in [0,1]$ and $0 \le T_{Ai}\ (C_j)$, $I_{Ai}(C_j), F_{Ai}(C_j) \le 3$, for $Cj \in C, j = 1,2,\dots,n,$ and $i = 1,2,\dots,m.$

For convenience, the values of the three functions $T_{Ai}\ (C_j), I_{Ai}(C_j), F_{Ai}(C_j)$ are denoted by a single-valued neutrosophic value (SVNV) $d_{ij} =< t_{ij}, i_{ij}, f_{ij} >\ (i = 1,2,\dots,m;\ j = 1,2,\dots,n)$, which is usually derived from the evaluation of an alternative Ai against a criterion C_j by the expert or decision maker. Therefore, a single-valued neutrosophic decision matrix $D = (d_{ij})_{mxn}$. can be obtained.

In multi-attribute decision problems, the ideal point concept has been used to help identify the best alternative in the decision set. Although the ideal alternative does not exist in the real world, it does provide a useful theoretical construct against which to evaluate alternatives.

In the decision-making method, an ideal SVNV can be defined by $d_j^* =< t_j^*, i_j^*, f_j^* >=< 1,0,0 >\ (j = 1,2,\dots,n)$ in the ideal alternative A^*. Therefore, applying Equation (2), the weighted correlation coefficient between an alternative $A_i\ (i = 1,2,\dots,m)$ and the ideal alternative A^* is given by:

$$M_w(A_i, A^*) = \frac{1}{3}\sum_{j=1}^{n} w_j\left[\phi_{ij}\left(1-\Delta t_{ij}\right) + \varphi_{ij}\left(1-\Delta i_{ij}\right) + \psi_{ij}\left(1-\Delta f_{ij}\right)\right] \quad (3)$$

where

$$\phi_{ij} = \frac{3 - \Delta t_{ij} - \Delta t_{i\,max}}{3 - \Delta t_{i\,min} - \Delta t_{i\,max}},$$

$$\varphi_i = \frac{3 - \Delta i_{ij} - \Delta i_{i\,max}}{3 - \Delta i_{i\,min} - \Delta i_{i\,max}},$$

$$\psi_i = \frac{3 - \Delta f_{ij} - \Delta f_{i\,max}}{3 - \Delta f_{i\,min} - \Delta f_{i\,max}},$$

$\Delta t_{ij} = \left|t_{ij} - t_j^*)\right|$,

$\Delta i_{ij} = \left|i_{ij} - i_j^*)\right|$,

$\Delta f_{ij} = \left|f_{ij} - f_j^*)\right|$,

$$\Delta t_{i\,min} = min_j \left| t_{ij} - t_j^* \right| ,$$

$$\Delta i_{i\,min} = min_j \left| i_{ij} - i_j^* \right| ,$$

$$\Delta f_{i\,min} = min_j \left| f_{ij} - f_j^* \right| ,$$

$$\Delta t_{i\,max} = max_j \left| t_{ij} - t_j^* \right| ,$$

$$\Delta i_{i\,max} = max_j \left| i_{ij} - i_j^* \right| ,$$

$$\Delta f_{i\,max} = max_j \left| f_{ij} - f_j^* \right| ,$$

for $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$.. Using the correlation coefficient $M_w\ (A_i, A^*)$ $(i = 1, 2, \ldots, m)$, the ranking order of all the alternatives and the best one(s) can be obtained.

2.2 Materials and methods

The development of this study was carried out in the city of Santo Domingo, Ecuador. For this, a random sample of 10 lawyers was taken, of which 5 specialized in the field of criminal defense, and 5 specialized in family defense. To be as consistent as possible, it was determined that the 10 lawyers had the greatest number of points in common.

In this way, lawyers of the same sex (male), aged between 37 and 41 years, were selected. The selected subjects belong to the same geographical area (the city of Santo Domingo) and, as far as possible, it was tried that they all had a similar standard of living (medium to medium-high), with between 6 and 8 years of experience in the field of specialization.

Before carrying out the analysis of the personality traits, it was decided, for reasons of time and functionality, the need to make a selection of the specific and timely traits to be analyzed. In accordance with [17], [18], [21], the most used neutrosophic Trait-antiTrait personality pairs are:

- Extraversion – Introversion
- Conscientiousness – unconsciousness
- Perfectionism – Imperfectionism
- Sensitivism – Insensitivism
- Novator – Conservative
- Self-esteem – Low self-esteem
- Kindness – Dislike
- Openness to intellect and experience – Closeness to intellect and experience
- Inhibition – Disinhibition
- Flexibility – Stiffness
- Emotivism – No Emotivism
- Obsessiveness- No obsessiveness
- Caution – Impulsiveness
- Timidity – Audacity
- Honesty – Dishonesty
- Hostility – No hostility.

To select which of these elements to analyze, those that have a greater general impact on the development of the professional activities of both criminal and family lawyers were prioritized. In this sense, three fundamental elements are evaluated integrally: the importance of each feature for the analysis of the cases (C1), the impact on coherent decision-making (C2), and the resilience capacity before the effects of the exercise of the profession (C3).

For the analysis and selection of the exposed personality traits with respect to the evaluation criteria to be used, the experts are asked to complete a small form. An evaluation is obtained from this form specifying, for each of the analyzed personality traits, to what extent each expert considers that the personality trait or alternative Ai is good (Tx), bad (Fx), or not completely sure (Ix) with respect to the criterion Cj. For this case, it is considered that each of the criteria evaluated has the same weight wj=0.33. Likewise, the work carried out with the experts makes it possible to determine the weighting or degree of importance for each of the criteria with respect to the rest.

The most prominent personality traits are those that allow obtaining a comparative base between the groups of lawyers that were selected for the study. In this way, 3 sessions of interviews are carried out, using a neutrosophic questionnaire {based on neutrosophic responses of the type (degree of truth (t), degree of indeterminacy (uncertainty, lack of clarity) and degree of falsehood (f) for each question} in which the selected traits are evaluated in the sampled individuals. The analyzes are carried out with the support of 2 experts in the field of psychology and

their considerations are taken into account to obtain the final results. [19], [20], [22]

3 Results

To carry out the described analysis, the arithmetic mean of the evaluations made by the experts is considered. The results obtained from the evaluations allow the calculation of the operators φ, μ, and ψ to obtain the correlation coefficients. Tables 1 and 2 show the results of such operations.

Personality traits	ΔTmin	ΔImin	ΔFmin	ΔTmax	ΔImax	ΔFmax
Extraversion – Introversion	0.6	0.2	0.1	0.9	0.5	0.2
Conscientiousness – Unconsciousness	0.4	0.1	0.2	0.6	0.1	0.2
Perfectionism – Imperfectionism	0.4	0.2	0.1	0.6	0.3	0.3
Sensitivism – Insensitivism	0.4	0.1	0.2	0.5	0.2	0.4
Novator – Conservative	0.4	0.2	0.1	0.8	0.5	0.3
Self-esteem – Low self-esteem	0.5	0.3	0.1	0.6	0.4	0.2
Kindness – Dislike	0.6	0.2	0.2	0.9	0.5	0.3
Openness to intellect and experience – Closeness to intellect and experience	0.5	0.2	0.1	0.9	0.5	0.2
Inhibition – Disinhibition	0.4	0.2	0.1	0.6	0.3	0.3
Flexibility – Stiffness	0.3	0.1	0.2	0.6	0.2	0.3
Emotivism – Not Emotivism	0.4	0.2	0.1	0.8	0.5	0.3
Obsessiveness – No Obsessiveness	0.4	0.3	0.1	0.8	0.5	0.2
Caution – Impulsiveness	0.6	0.2	0.2	0.9	0.5	0.2
Timidity – Audacity	0.2	0.2	0.1	0.3	0.5	0.2
Honesty – Dishonesty	0.5	0.2	0.1	0.6	0.6	0.2
Hostility – No hostility.	0.6	0.1	0.1	0.9	0.5	0.2

Table 1: Minimum and maximum values of variation in the functions of belonging to truth, falsity, and indeterminacy. Source: own elaboration

This way, by using equation (3), the values of the correlation coefficients $M_w(A_i, A^*)$ are obtained. See Table 2.

Personality traits analyzed	φ			μ			ψ			coefficient M
	C1	C2	C3	C1	C2	C3	C1	C2	C3	
Conscientiousness – unconsciousness	0.93	1	0.8	1	0.96	0.87	1	0.96	1	0.57
Extraversion – Introversion	1	0.95	0.9	1	1	1	1	1	1	0.73
Perfectionism – Imperfectionism	0.9	0.95	1	1	0.96	1	0.92	0.96	1	0.67
Sensitivism – Insensitivism	1	0.95	1	1	0.96	0.96	0.92	1	1	0.70
Novator – Conservative	0.78	1	0.83	0.87	1	0.96	0.92	1	1	0.58
Self-esteem – Low self-esteem	0.95	1	0.95	1	1	0.96	1	0.96	1	0.64
Kindness – Dislike	1	1	0.8	1	0.96	0.87	0.96	1	1	0.56

Personality traits analyzed	φ			μ			ψ			coefficient M
	C1	C2	C3	C1	C2	C3	C1	C2	C3	
Openness to intellect and experience – Closeness to intellect and experience	0.75	1	0.94	0.87	1	0.96	0.96	1	1	0.59
Inhibition – Disinhibition	0.9	0.95	1	1	0.96	1	0.92	0.96	1	0.67
Flexibility – Stiffness	1	0.9	0.86	1	0.96	1	0.96	1	1	0.70
Emotivism – Not Emotivism	0.78	1	0.83	0.87	1	0.96	0.92	1	1	0.58
Obsessiveness - Obsessiveness	0.78	0.94	1	0.95	1	0.91	1	0.96	1	0.61
Caution – Impulsiveness	1	1	0.8	1	0.96	0.87	1	1	1	0.58
Timidity – Audacity	0.95	0.95	1	0.95	1	0.91	1	0.96	1	0.65
Honesty – Dishonesty	0.95	1	0.95	1	0.95	0.82	0.96	0.96	1	0.61
Extraversion – Introversion	0.87	0.8	1	1	0.83	0.96	1	0.96	1	0.58

Table 2: Values of φ, μ, ψ, and M for each selection alternative. Source: own elaboration

According to the analysis carried out, it can be observed that the experts' criteria show 3 personality traits with the highest incidence to be analyzed by psychologists. The traits selected as a result of this were the pairs related to Extraversion – Introversion, Sensitivity – Insensitivity, and Flexibility – Rigidity.

These results laid the foundation for the analysis of the two groups of lawyers selected for the study. The results of the data obtained after the analysis by the experts are shown in Table 3.

		$d_{(extrovert)}$	$d_{(introvert)}$	$d_{extroverted\&introverted}$	$d_{(sensitive)}$	$d_{(insensitive)}$	$d_{sensitive\&insensitive}$	$d_{(flexible)}$	$d_{(rigid)}$	$d_{flexible\&rigid}$
Family lawyers	A1	0.54	-0.25	0.29	0.87	-0.21	0.66	0.67	-0.13	0.54
	A2	0.65	-0.46	0.19	0.79	-0.16	0.63	0.59	-0.22	0.37
	A3	0.43	-0.33	0.1	0.59	-0.34	0.25	0.48	-0.28	0.2
	A4	0.87	-0.57	0.3	0.84	-0.34	0.5	0.71	-0.26	0.45
	A5	0.53	-0.26	0.27	0.59	-0.4	0.19	0.74	-0.16	0.58
Criminal lawyers	A6	0.66	-0.37	0.29	0.49	-0.43	0.06	0.7	-0.26	0.44
	A7	0.76	-0.22	0.54	0.64	-0.34	0.3	0.68	-0.25	0.43
	A8	0.74	-0.51	0.23	0.59	-0.48	0.11	0.59	-0.21	0.38
	A9	0.67	-0.3	0.37	0.54	-0.49	0.05	0.68	-0.3	0.38
	A10	0.57	-0.4	0.17	0.6	-0.31	0.29	0.59	-0.34	0.25

Table2: Determination of the ranges of personality traits analyzed. Source: own elaboration

These results allow the elaboration of an average graphic representation of each of the groups of lawyers that were analyzed. Figure 1 shows the average results found in each of the groups of lawyers analyzed. As can be seen, the sampled criminal lawyers turned out to be more extroverted and less sensitive than the family lawyers. The latter presented a lower average level of insensitivity than the criminal lawyers and less rigidity. No significant differences were observed regarding the level of flexibility of both groups of lawyers.

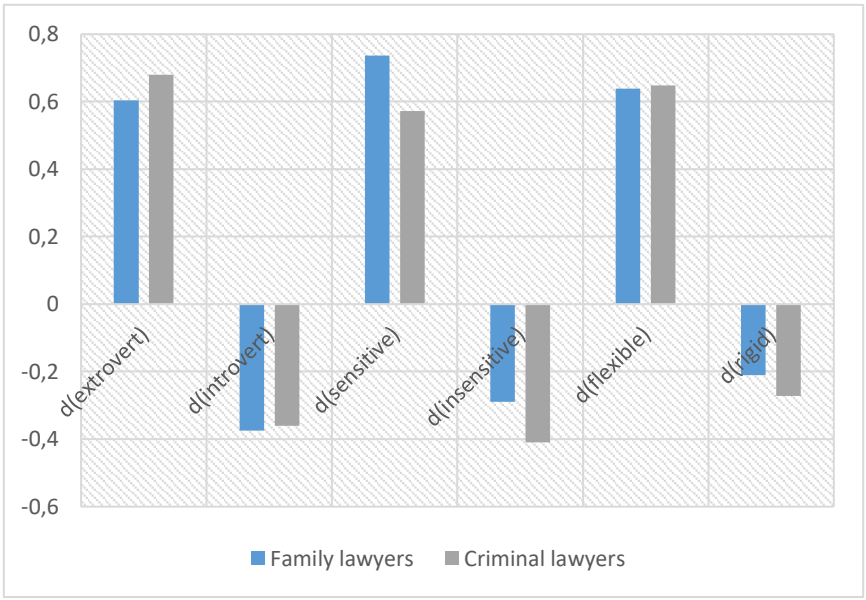


Figure 1: Average results of Personality Traits – Anti-Traits in each group of lawyers. Source: own elaboration

Finally, the levels obtained using the neutrosophic operator dTtrait&Antitrait (average) are compared with the values of ε and Thr set by the experts (see Figure 2).

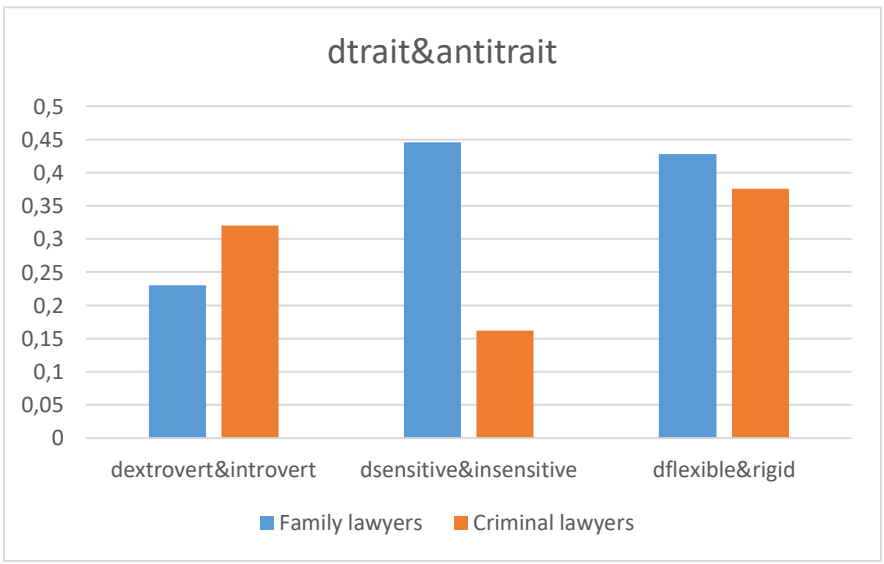


Figure 2: Average results of the d Personality Traits & Anti-Traits in each group of lawyers. Source: own elaboration

As can be seen, both family lawyers and criminal lawyers involved in the study have a greater tendency to be categorized as extroverted and flexible. In this sense, criminal lawyers were more extroverted and family lawyers more flexible and sensitive. On the other hand, criminal lawyers are in a state of indeterminacy between $\pm\varepsilon = 0.2$, which implies that they are close to the zero point, between sensitivity and insensitivity.

Conclusions

Neutrosophy applied to the field of psychology is a very useful tool that allows considering the indeterminacies and subjectivities that arise in this complex and dynamic field of life. This study allowed to determine and compare different personality traits in lawyers from the city of Santo Domingo. The neutrosophic correlation was used to select the most important personality traits to be analyzed during the study. The study made it possible to determine that criminal lawyers were more extroverted and family lawyers more flexible and sensitive. On the other hand, criminal lawyers showed indeterminacy between sensitivity and insensitivity.

References

[1] W. A. C. Calle, A. S. G. Betancourt, and N. J. Enríquez, "Validation of the proof reversal on the inexistence of untimely dismissal by using neutrosophic IADOV technique," *Neutrosophic Sets Syst.*, vol. 33, no. 1, pp. 33–36, 2019.

[2] M. Mullai and R. Surya, "Neutrosophic Inventory Backorder Problem Using Triangular Neutrosophic Numbers.," *Neutrosophic Sets Syst.*, vol. 31 SRC-, pp. 148–155, 2020.

[3] M. Saeed, M. Saqlain, A. Mehmood, and S. Yaqoob, "Multi-polar neutrosophic soft sets with application in medical diagnosis andDecision-making," *Neutrosophic Sets Syst.*, vol. 33, pp. 183–207, 2020.

[4] B. Said *et al.*, "An Intelligent Traffic Control System Using Neutrosophic Sets, Rough sets, Graph Theory, Fuzzy sets and its Extended Approach: A Literature Review," *Neutrosophic Sets Syst.*, vol. 50, no. 1, p. 2, 2022.

[5] F. Smarandache and M. Ali, "Neutrosophic Triplet Group (revisited)," *Neutrosophic sets Syst.*, vol. 26, no. 1, p. 2, 2019.

[6] P. Biswas, S. Pramanik, and B. C. Giri, "Distance Measure Based with Interval Trapezoidal Neutrosophic Numbers.," *Neutrosophic Sets Syst.*, vol. 19 SRC-, pp. 40–46, 2018.

[7] S. A. Edalatpanah, "Systems of neutrosophic linear equations," *Neutrosophic sets Syst.*, vol. 33, no. 1, pp. 92–104, 2020.

[8] N. A. Nabeeh, A. Abdel-Monem, and A. Abdelmouty, "A novel methodology for assessment of hospital service according to BWM, MABAC, PROMETHEE II," *Neutrosophic Sets Syst.*, vol. 31, no. 1, pp. 63–79, 2020.

[9] R. Aguilar Berrezueta, E. M. Sandoval, B. Villalta Jadán, and D. Palma Rivera, "An integrative neutrosophic model focused on personality (inmfp) for the adequate management of the level of work stress," *Neutrosophic Sets Syst.*, vol. 34, no. 1, p. 4, 2020.

[10] L. K. B. VIllanueva, M. A. Mendoza, R. Salcedo, and A. M. I. Morán, "The transformational leadership, sustainable key for the development of ecuadorian companies. A neutrosophic psychology approach," *Neutrosophic Sets Syst.*, vol. 34, pp. 143–152, 2020.

[11] K. Mondal and S. Pramanik, "Multi-criteria group decision making approach for teacher recruitment in higher education under simplified neutrosophic environment," *Neutrosophic sets Syst.*, vol. 6, pp. 28–34, 2014.

[12] J. Ye, "Another form of correlation coefficient between single valued neutrosophic sets and its multiple attribute decision-making method," *Neutrosophic Sets Syst.*, vol. 1, no. 1, pp. 8–12, 2013.

[13] C. V. V. Chicaiza, O. G. A. Paspuel, P. Yesenia, C. Cuesta, and S. D. R. Á. Hernández, "Neutrosophic Psychology for Emotional Intelligence Analysis in Students of the Autonomous University of Los Andes, Ecuador," *Neutrosophic Sets Syst.*, vol. 34, pp. 1–8, 2020.

[14] M. Amat Abreu and D. Cruz Velázquez, "Neutrosophic model based on the ideal distance to measure the strengthening of values in the students of Puyo university.," *Neutrosophic Sets Syst.*, vol. 26, 2019.

[15] F. Smarandache, *A unifying field in logics: neutrosophic logic. Neutrosophy, neutrosophic set, neutrosophic probability: neutrsophic logic. Neutrosophy, neutrosophic set, neutrosophic probability.* American Research Press, 2005.

[16] M. Saqlain, N. Jafar, S. Moin, M. Saeed, and S. Broumi, "Single and multi-valued neutrosophic hypersoft set and tangent similarity measure of single valued neutrosophic hypersoft sets," *Neutrosophic Sets Syst.*, vol. 32, no. 1, pp. 317–329, 2020.

[17] F. Smarandache, *Neutropsychic Personality. A mathematical approach to psychology*, 3rd ed. Brusels: Pons, 2018.

[18] S. B. Gallegos Gallegos. "La imputación objetiva en el delito de tránsito". Universidad y Sociedad, vol. 14 no. S2, pp 194-200, 2022.

[19] E. M. Arroyo Lalama & L. F. Pérez Solís. "Importancia de la magnificación en endodoncia". Universidad y Sociedad, vol. 14 no. S2, pp 165-171, 2022.

[20] Romero Fernández, A. J., Alvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[21] Estupiñán Ricardo, J., Domínguez Menéndez, J. J., Barcos Arias, I. F., Macías Bermúdez, J. M., & Moreno Lemus, N. "Neutrosophic K-means for the analysis of earthquake data in Ecuador". Neutrosophic Sets and Systems, vol. 44 no. 1, pp. 29, 2021

[22] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.

[23] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[24] Vega Falcón, V., Alarcón Quinapanta, M., Yancha Villacís, M., & Estupiñán Ricardo, J. Medición del capital intelectual: Caso hotelero. Dilemas Contemporáneos: Educación, Política y Valores, no. 96, pp 1-19, 2019.

[25] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[26] von Feigenblatt, O., Pardo, P., & Cooper, M. "The "Bad Students" Movement and Human Rights in Contemporary Thailand". Ciencias Sociales y Económicas, vol. 5 no. 1, pp 156-176, 2021.

[27] M. A. Salame Ortiz, U. F. Carrazana Martínez, C. P. Cisneros Zúñiga & C. A. Terán Vaca. "El tratamiento desde las leyes en el ejercicio de la patria potestad desde la inseminación artificial y sus implicaciones". Universidad y Sociedad, vol. 14 no. S4, pp 493-501, 2022.

[28] L. V. Rosillo Abarca, J. F. Navarrete Cuadrado, N. García Arias & L. F. Piñas Piñas. "El Procedimiento Abreviado en la legislación penal ecuatoriana". Universidad y Sociedad, vol. 14 no. S4, pp 486-492, 2022.

[29] M. R. Pesantes Salazar, Y. G. Calva Vega, Y. L. Valverde Torres & J. A. Urrutia Guevara. "Vulneración de las garantías al debido proceso en la aplicación del procedimiento directo en el Cantón Santo domingo en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 478-485, 2022.

Received: August 13, 2022. **Accepted:** October 12, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the Judging of Contraventions Committed in Indigenous Justice

Raúl Clemente Ilaquiche Licta[1], Felipe Alejandro Garcés Córdova[2], Luis Ramiro Ayala Ayala[3] and Kleber Eduardo Carrión León[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: pg.raulcil43@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador. E-mail: uq.felipegc09@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.luisayala@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.klebercarrion@uniandes.edu.ec

Abstract. The pronouncement of Ecuador as a plurinational state implies the recognition of the rights of indigenous peoples and other ethnic groups that live in the country. This fact represents a challenge for the legal sciences since mechanisms must be found to allow the harmonious functioning of ordinary and indigenous justice, in which there are associated difficulties. Like any phenomenon of practical life, it contains a part of uncertainty in the processed information, which can be taken into account with the application of Neutrosophy. The objective of the investigation is the neutrosophic analysis of the judgment of the contraventions committed in indigenous justice. To meet the objective, theoretical and empirical methods were used. Surveys were applied to 110 students of the law career, and the main difficulties associated with the judgment of indigenous justice were identified. Four professors were selected for the application of the neutrosophic soft set model, obtaining as a result the hierarchy of the difficulties encountered and the level of relevance of each one. The most relevant is the lack of an adequate legal framework that allows the organic application of ordinary and indigenous justice without duplication of sanctions.

Keywords: indigenous justice, neutrosophic soft set, neutrosophy.

1 Introduction

Ecuador is a plurinational country, where several nationalities and indigenous peoples coexist, as well as Afro-Ecuadorian and white mestizo peoples, each of them with very particular socio-cultural characteristics. However, for decades the Ecuadorian State has undervalued and ignored the cultural power of the towns [1]. The administration of indigenous justice is neither superior nor inferior to the form of ordinary justice. It is rather different, but it can coexist and develop within the framework of mutual respect, recognition, and appreciation [2].

The subject of indigenous justice is not new, but studies can still be carried out to delve deeper into it. Indigenous justice is not a group of written normative statements that allow or prohibit some conduct, but are oral ancestral practices, based on their own philosophies of life; for example, respect for nature and maintaining order in the environment where they live [3]. Certain constitutions, including that of Ecuador, recognized collective rights and special rights of indigenous peoples, for which it became a State with a plurality of legal systems.

Within the current Constitution of the State, Indigenous Justice is recognized, this is the power of the indigenous communities, to apply their norms of justice, as long as they do not violate human rights or affect the validity of other legal provisions. Given this fact, there are challenges for legal sciences, and solutions must be sought to new legal problems of this nature. Among them, the interpretation of principles that are enshrined in the Constitution and its link with the indigenous justice system, achieving a balance between maintaining compliance with fundamental human rights and autonomy in the application of its laws [4].

The current situation of indigenous justice is highly debated since some members of society consider that this justice is a violent practice to try to stop crime, but the root of the conflict lies in the lack of a procedure for the Judgment of the contraventions in the administration of indigenous justice, which causes a conflict with ordinary justice since, in the penal system, the sanction imposed on the sentenced person is prison, confinement and a fine according to the crime. In the case of indigenous people, they are sanctioned with physical punishment, community work, and fines, among others, since they do not think that being deprived of liberty is a way to regenerate the criminal and reintegrate him into society [5].

Indigenous justice is recognized as a multicultural, multiethnic manifestation, to promote intercultural coexistence of the country's peoples and communities, multilingual, where there must be clear rules on how to carry out the trial and the corresponding sanctions and every type of uncertainty must be avoided within this type of justice [6].

In the current context, it is necessary to recognize the rights of minorities, to avoid that multiple cultures are not visible and that the worldview they possess is violated. For this reason, it is useful to confirm, through the

analysis of the existing theory, if these concepts have effectively transcended their legal fulfillment. Or if they have simply been limited to a doctrine, which is an aspiration, but lacks effective applicability in legal development, carried out by countries that recognize multiculturalism and legal pluralism.

In the Ecuadorian Constitution, Article 10, it is stated that: persons, communities, peoples, nationalities, and groups are holders and will enjoy the rights guaranteed in the Constitution and international instruments. In this context, a group of collective rights is recognized, among which are the right of the authorities of indigenous peoples to exercise jurisdictional functions, based on their own or customary law.

Article 171 states that: the authorities of the indigenous communities, peoples, and nationalities shall exercise jurisdictional functions, based on their ancestral traditions and their own law, within their territorial scope, with the guarantee of women's participation and decision. The authorities will apply their own rules and procedures for the resolution of internal conflicts, and that is not contrary to the Constitution and human rights recognized in international instruments [7].

For indigenous communities, the conceptualization of Law is understood as a set of regulatory norms of life in society, it becomes an ancestral way since the Quichua language knows the law as kamachik. There are 3 basic principles of Quichua culture and justice: not to be idle (ama quilla), not to lie (ama llulla), and not to steal (ama shua). Among the rights that must be preserved in indigenous processes are the right to defend oneself either personally or through third parties, compliance with the principles, norms, and rules with fairness and impartiality, that torture is not carried out, that there is no slavery, no cruel treatment, and no physical or psychological aggression.

Multiculturalism, like legal pluralism, are recently developed doctrines that tend to protect minority cultures, it is for this reason that we must study and analyze them, and it is necessary for those interested in law to understand the impact of the existence of these in the legal field. As with almost all the phenomena that occur in practical life, its analysis and interpretation cannot be rigid, but must also consider the uncertainty in each fact.

In practice, many more situations are observed, which for various reasons include a portion of indeterminacy and uncertainty in the information, making it uncertain and not unique, but hesitant or alternative [8]. To include qualitative research, this quantitative character of uncertainty, the discipline known as Neutrosophy arises. Neutrosophy, and specifically the Soft Set, has numerous applications to real life, among which are the legal and social sciences.

Neutrosophy arises to deal with decision-making problems that involve human knowledge, which frequently have uncertainty, indeterminacy, and inconsistency in information. This is a tool to represent those inconsistencies and contradictions that undoubtedly exist in the processing of evidence within the social sciences and everyday life [9]. The Classic Soft Set is based on a certain function (whose values are certain and unique), they were made known with the investigations carried out by Professor Molodtsov in 1999 [10], then the studies were extended, giving way to talk of the Neutrosophic Soft Set in 2013.

The Neutrosophic set was initially approached by Professor Florentin Smarandache, this is a novel tool to characterize uncertain information in a more sufficient and precise way while allowing to represent the information in a more complete and real way, which admits and encompasses not only truth or falsehood but also ambiguity, ignorance, contradiction, neutrality, and saturation [11].

Neutrosophic sets are characterized by a truth membership function (t), an indeterminacy membership function (i), and a falsehood membership function (f) independently, which lie within the standard real unit interval $[-0, 1+]$ standard or not standard [12, 24]. There is not always total certainty in the information that is worked on, since there may be several points of view that sometimes may even be contrary, lack of information, or that it is incomplete due to various causes, the lack of witnesses, the hesitant opinion of one of the factors involved in the process, among other reasons [13].

When triads of truth values are assigned to the possible values of the obtained sets, meaning membership, non-membership, and indeterminacy, soft set theory is combined with that of neutrosophic sets to obtain greater precision in the results [14], [20], [22], [26], [27], [28]. This situation can be modeled by operators that have some degree of indeterminacy due to the imprecision that exists in the world. Taking into account what has been analyzed up to here, the neutrosophic analysis of the judging of contraventions committed in indigenous justice is proposed as the objective of the investigation, for which the following specific objectives are defined:

1.1 Identify the main existing problems in the topic addressed.
1.2 Carry out a neutrosophic analysis of the problems defined through a Soft Set model.

2 Materials and methods

2.1 Theoretical methods

2.1.1. Synthetic analytical method: the analytical method allowed the decomposition of the whole into specific aspects to understand the structure; which makes it easier to observe and better understand

the components. In this context, this method implies synthesis, that is, the union of dispersed elements to form a total component.

2.1.2. Deductive inductive method: this research method allows for logical reasoning. While the inductive method starts from specific premises to reach general aspects, the deductive method is the opposite, since it starts from the generic until reaching the particular aspects. However, both methods are essential in the construction of knowledge.

2.1.3 Logical historical method: these methods allow the construction of the investigation from the historical elements that are part of the investigation to understand its essential elements and its historical evolution.

2.2 Empirical methods

2.2.1. Interviews: will be applied to the sample made up of selected experts. Structured interviews were prepared in order to obtain information on the real problem and issue possible solutions, to reach valid conclusions, and support the results.

Sample's size calculation:

$$n = \frac{Z2*P*Q*N}{(N-1)E2+Z2*P*Q} \quad (1)$$

N = sample.
N = population universe
E = maximum admissible error.
Z: Critical value corresponding to a confidence coefficient with which the investigation is to be carried out.
P: Population proportion of occurrence of an event
E: Sample error (difference between statistical and parametric)

2.2.2. Observation: to check how the phenomenon under investigation behaves.

2.2.3. Surveys: a survey was developed and applied to people from the interest group.

2.2.4. Information processing methods: General Problem Solving Method (GPSM)

The depth of the application of this method lies in [15], however, in summary, it is stated that the first step in solving a problem consists in understanding it. Surely it is a truism to say that it is impossible to solve a task without prior understanding of it, but understanding a problem does not only mean understanding the words, language, or symbols in which it is raised but also assuming the situation as such a problem and acquire a readiness to search for that solution. [16, 17, 25]

Generally, for a situation to be considered a problem, one must be aware that a new situation exists or that there has been a change with respect to some previous situation, or that it is a task for which there is only one insufficient explanation. Understanding a problem implies realizing the difficulties and pitfalls that a task presents and the willingness to try to overcome them. For this understanding to occur, it is, of course, necessary that in addition to the novelty elements, the problem contains already-known aspects that guide the search for a solution. [21].

Once the problem has been understood, a plan must be devised to help solve it. It should be considered what is the distance between the situation from which one starts and the goal to which one intends to reach and what procedures are the most useful to reduce this distance. The success of a strategy will depend both on the way it fits into the structure of the task, and on the presence of specific rules, algorithms, and operators; in a word, of techniques that contribute to the subject effectively developing his plans. For its application, the following stages must be executed:

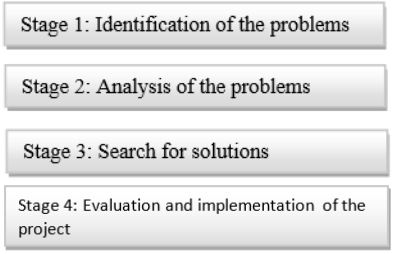


Figure 1. Representation of the stages of the GPSM. Source: own elaboration.

2.3 Neutrosophic Soft Set

Let U, be a universe of situations, H a non-empty subset of U, and $P(H)$ the power function of H. Let a be an attribute and A a set of these attribute values.

A function $F: A \to P(H)$ is called an indeterminate or soft function if:

i. the set A has some indeterminacy;

ii. or $P(H)$ has some indeterminacy;

iii. or there is at least one attribute value $v \in A$, such that F(v) = *indeterminate* (unclear, uncertain, or not unique);

iv. or two or the three previous situations.

The Neutrosophic Soft Set is defined as the Soft Set where F (perhaps) or F (indeterminate), etc, is roughly equivalent to F (yes), F (no), F (true), or F (false), associated with a triad of values (α, β, γ), where $(\alpha, \beta, \gamma) \in [0, 1]^3$ mean the degrees of truth, indeterminacy, and falsehood, respectively [18], [19], [23].

From the previously discussed, the following neutrosophic triplet can be formed [16]:

i. (Classical) function, which is a well-defined (inner-defined) function for all elements in its domain of definition, or (T, I, F) = (1, 0, 0).

ii. Neutrofunction (or neutrosophic function), is a function that is partially well defined (degree of truth T), partially indeterminate (degree of indeterminacy I), and partially externally defined (degree of falsehood F) in its domain of definition, where (T, I, F)$\in$\{(1,0,0), (0,0,1)\}.

Definition 1[16]: let U be a universe of situations, H is a non-empty subset of U, with $P(H)$ the power set of H, and an attribute, with its set of attribute values, is denoted by A. Then the pair (F, H), where f $F: A \to P(H)$, is called classic soft set on H.
Definition 2 [16]: If the function $F: A \to P(H)$, where for each $x \in A, f(x) \in P(H)$ and $f(x)$ is true and unique, it is called a determinate (classical) function.

2.4 Model based on Neutrosophic Soft Sets

Starting from a group of statements or sentences that will be denoted by $A = \{a_1, a_2, \cdots, a_k\}$, which must be classified or evaluated by the specialists that belong to the group of experts chosen for the study $E = \{e_1, e, \cdots, e_l\}$. The set of parameters to be measured is given by C={Yes, No}, where "yes" means that for the expert, the statement is positive, while "no" means the opposite.
The algorithm to follow is:

1. A group of statements is compiled whose veracity and relevance in the legal context are to be determined. These will be denoted by $A = \{a_1, a_2, \cdots, a_k\}$.

A group of experts or specialists are convened to issue a criterion regarding the veracity or relevance of the statements described. This is understood as a set $E = \{e_1, e, \cdots, e_l\}$.

2. The expert (e_j) is asked to give his opinion on the statement a_i about truthfulness and relevance Expert (e_j) is asked to rate the truth of the statement and its relevance on a scale of 0 to 100. This value is called α_{ij}.

   2.2. Expert (e_j) is asked to give an evaluation of the falsehood and irrelevance of the statement on a scale of 0 to 100. This value is called γ_{ij}

   2.3. Expert (e_j) is asked to assess the uncertainty and relevance of the situation on a scale of 0 to 100. This value is called β_{ij}

As a result, the following triad is obtained:

$$R\_ij = \langle \alpha\_ij/100, \beta\_ij/100, \gamma\_ij/100 \rangle \quad (2)$$

This is the triad of truth values between 0 and 1, to evaluate the degrees of truth, indeterminacy, and falsehood, respectively, of the relevance of the i-th test according to the j-th expert.

3. The Soft Set is formed by $F: A \to P(H)$, where $A = \{si, no\}$, being as follows:

$$F(yes) = \{(a_i, e_j, R_{ij}), where\ R_{ij} \neq \langle 0, \tau, 1 \rangle, \tau \geq 0\}, \quad (3)$$

while:

$$F(no) = \{(a_i, e_j, R_{ij}), where\ R_{ij} \neq \langle 1,0,0 \rangle\} \quad (4)$$

4. The results for tests or evidence are obtained from:

$$G(yes) = \{(a_i, \wedge_j R_{ij}) : j \in \{1,2,\cdots,l\}\ such\ that\ (a_i, e_j, R_{ij}) \in F(si)\} \quad (5)$$

Where, (6) $[\![\wedge\_j\ R]\!]\ \_ij = \langle \min\_j \{\alpha\_ij/100\}, \max\_j \{\beta\_ij/100\}, \max\_j \{\gamma\_ij/100\} \rangle$

$$G(no) = \{(a_i, \wedge_j NOT(R_{ij})) : j \in \{1,2,\cdots,l\}\ such\ that\ (a_i, e_j, R_{ij}) \in F(no)\} \quad (7)$$

Where, $[\![NOT(R)]\!]\ \_ij) = \langle \gamma\_ij/100, \beta\_ij/100, \alpha\_ij/100 \rangle$

5. For each proof or evidence s_i, select between $G(yes)$ y $G(no)$ the triad that meets the following requirements.

   5.1 If a_i is in $G(yes)$ and is not in $G(no)$, then this statement is determined to be true or relevant, with a truth value determined by $\bar{R}_i = \wedge_j R_{ij}$.

   5.2 If a_i is in $G(no)$ and is not in $G(yes)$, then this statement is determined to be true or relevant, with a truth value determined by $\tilde{R}_i = \wedge_j NOT(R_{ij})$.

   5.3 If a_i is in both sets, the following criteria are followed:

A single value $\bar{V}\_i = (2 + \bar{R}\_i1 - \bar{R}\_i2 - \bar{R}\_i3)/3$ is calculated, where $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3} \rangle$, while $\bar{F}\_i = (2 + \bar{R}\_i1 - \bar{R}\_i2 - \bar{R}\_i3)/3$, where $\tilde{R}_i = \langle \tilde{R}_{i1}, \tilde{R}_{i2}, \tilde{R}_{i3} \rangle$.

   5.3.1 If $\bar{V}_i > \bar{F}_i$ then the i-th statement is relevant with a truth value of $\bar{R}_i$.

   5.3.2 If $\bar{V}_i < \bar{F}_i$ then the ith test is not relevant with a value of truth $\tilde{R}_i$.

   5.3.4 If $\bar{V}_i = \bar{F}_i$ then it is determined that the ith test is not relevant enough with a truth value of $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3} \rangle$.

6. The statements that were classified as relevant are issued, sorted from highest to lowest, where $e_m \succ e_n$ if and only if $\bar{V}_m > \bar{V}_n$.

3 Application

3.1 Application of the General Problems Solving Method (GPSM)

Stage 1: Identification of problems

In order to identify the difficulties associated with judging contraventions committed in indigenous justice, a survey of a universe of 153 law students from the Universidad Autónoma de Los Andes is proposed.
Calculation of the sample that constitutes a significant part of the universe, was carried out using formula 1

Where
N = population universe (153)
E: 5% = 0.05 Z: 1.96 (value that corresponds to a coefficient of 95%).
P: 50% = 0.50 (since the value is not known, maximum variability is assumed)

Q: 1 -P = 0.50
n= 110

Survey applied:

The purpose of this instrument is to collect information on knowledge about the judgment of contraventions committed in indigenous justice, this survey is completely anonymous, and the data obtained from it will be processed for investigative purposes. We appreciate your contribution to the development of this study.

1- Have you heard how indigenous justice is applied?
2- Do you know what is understood in legal terms as indigenous justice?
3- Do you consider that the information on indigenous justice issues is well organized?
4- Do you observe contradictions or limitations associated with the application of indigenous justice? Mention them.

Source: own elaboration.

The resulting responses were processed and tabulated, as shown in Table 1:

Question	Yes	No	Partially
1- Have you heard how indigenous justice is applied?	65%	28%	7%
2- Do you know what is understood in legal terms as indigenous justice?	82%	3%	15%
3- Do you consider that the information on indigenous justice issues is well organized?	53%	29%	18%
4- Do you observe contradictions or limitations associated with the application of indigenous justice? Mention them.	67%	33%	0%

Table 1. Survey questionnaire. Source: own elaboration

Once the information was processed, the following limitations or difficulties were identified:

1- Lack of effective communication actions that make known the essence and form of application of indigenous justice.
2- Ambiguity and lack of clarity in relation to the modes of action of indigenous justice to guarantee compliance with human and constitutional rights without limiting their application.
3- Inexistence of an adequate legal framework that allows the organic application of ordinary and indigenous justice without duplication of sanctions.

To carry out the neutrosophic analysis of the difficulties encountered, 4 law professors were chosen, those who had a greater command of the subject and at least 5 years of experience teaching it. The 4 professors consulted (p_1, p_2, p_3, p_4) issue their criteria regarding the difficulties identified (d_1, d_2, d_3), in triads of values from 0 to 100, in order to standardize truthfulness, negative and indeterminate answers, where the first score represents the certainty or relevance of the assertion raised, the second value indicates doubt or indeterminacy regarding the assertion described and the third value indicates the falsehood of that assertion.

2.2.1. Stage 2. Analysis of the causes. Application of the Neutrosophic Model.

Professor/Difficulty	d_1	d_2	d_3
p_1	⟨62,15,20⟩	⟨79,14,8⟩	⟨89,6,14⟩
p_2	⟨69,12,17⟩	⟨86,10,6⟩	⟨83,0,9⟩
p_3	⟨78,8,12⟩	⟨73,18,13⟩	⟨92,9,13⟩
p_4	⟨82,11,8⟩	⟨76,16,7⟩	⟨81,10,21⟩

Table 2: Result of the evaluation of the difficulties according to the teachers.

The above results are divided by 100 to bring them to a [0, 1] scale which is more common in neutrosophic theories.

Professor/Difficulty	d_1	d_2	d_3
p_1	⟨0.62,0.15,0.20⟩	⟨0.79,0.14,0.8⟩	⟨0.89,0.6,0.14⟩
p_2	⟨0.69,0.12,0.17⟩	⟨0.86,0.10,0.6⟩	⟨0.83,0,0.9⟩
p_3	⟨0.78,0.8,0.12⟩	⟨0.73,0.18,0.13⟩	⟨0.92,0.9,0.13⟩
p_4	⟨0.82,0.11,0.8⟩	⟨0.76,0.16,0.7⟩	⟨0.81,0.10,0.21⟩

Table 2: Result of the evaluation of the difficulties according to the teachers, expressed in the form of neutrosophic numbers.

Soft sets are defined as:

$$F(yes) = \left\{ \begin{array}{c} (p_1, d_1, \langle 0.62,0.15,0.20\rangle), (\mathrm{p}_1, \mathrm{d}_2, \langle 0.79,0.14,0.8\rangle), (p_1, d_3, \langle 0.89,0.6,0.14\rangle), \\ (p_2, d_1, \langle 0.69,0.12,0.17\rangle), (p_2, d_2, \langle 0.86,0.10,0.6\rangle), , \\ (p_2, d_3, \langle 0.83,0,0.9\rangle), (\mathrm{p}_3, d_1, \langle 0.78,0.8,0.12\rangle), (p_3, d_2, \langle 0.73,0.18,0.13\rangle), \\ (p_3, d_3, \langle 0.92,0.9,0.13\rangle), (p_4, d_1, \langle 0.82,0.11,0.8\rangle), \\ (p_4, d_2, \langle 0.76,0.16,0.7\rangle), (p_4, d_3, \langle 0.81,0.10,0.21\rangle) \end{array} \right\}$$

$$F(no) = \left\{ \begin{array}{c} (p_1, d_1, \langle 0.62,0.15,0.20\rangle), (\mathrm{p}_1, \mathrm{d}_2, \langle 0.79,0.14,0.8\rangle), (p_1, d_3, \langle 0.89,0.6,0.14\rangle), \\ (p_2, d_1, \langle 0.69,0.12,0.17\rangle), (p_2, d_2, \langle 0.86,0.10,0.6\rangle), , \\ (p_2, d_3, \langle 0.83,0,0.9\rangle), (\mathrm{p}_3, d_1, \langle 0.78,0.8,0.12\rangle), (p_3, d_2, \langle 0.73,0.18,0.13\rangle), \\ (p_3, d_3, \langle 0.92,0.9,0.13\rangle), (p_4, d_1, \langle 0.82,0.11,0.8\rangle), \\ (p_4, d_2, \langle 0.76,0.16,0.7\rangle), (p_4, d_3, \langle 0.81,0.10,0.21\rangle) \end{array} \right\}$$

$G(yes) = \{(d_1, \langle 0.62,0.15,0.20\rangle), (d_2, \langle 0.73,0.18,0.13\rangle), (d_3, \langle 0.81,0.10,0.21\rangle)\}$

$G(no) = \{(d_1, \langle 0.20,0.15,0.62\rangle), (d_2, \langle 0.13,0.18,0.73\rangle), (\mathrm{d}_3, \langle 0.21,0.10,0.81\rangle)\}$

From $G(yes)$ and $G(no)$ it is concluded that is relevant with a truth value of $\langle 0.62,0.15,0.20\rangle$, d_2 is relevant with a truth value of $\langle 0.73,0.18,0.13\rangle$, and finally, $\mathrm{d}_3$is also relevant with a truth value of $\langle 0.81,0.10,0.21\rangle$.

This decision is made since, $\bar{V}_1 = 0.80 > \bar{F}_1 = 0.45$; $\bar{V}_2 = 0.9 > \bar{F}_2 = 0.37$; $\bar{V}_3 = 0.91 > \bar{F}_3 = 0.42$.

The difficulties identified are ranked as follows: $d_3 \succ d_2 \succ d_1$, where all are relevant or important according to the results obtained.

Finally, the order of relevance of the identified difficulties is as follows:

1- d_3: Inexistence of an adequate legal framework that allows the organic application of ordinary and indigenous justice without duplication of sanctions.
2- d_2: Ambiguity and lack of clarity in relation to the modes of action of indigenous justice that guarantee compliance with human and constitutional rights without limiting their application.
3- d_1: Lack of effective communication actions that make known the essence and form of application of indigenous justice.

Conclusions

The application of indigenous justice is a right for the peoples of this origin, but it also represents a challenge for the state and legal sciences. In order to identify the difficulties associated with judging contraventions committed in indigenous justice, a survey was applied to 110 law students from the Universidad Autónoma de Los Andes. The analysis of these difficulties must be from a multidisciplinary and open perspective, considering the uncertainty in the information. This possibility is opened with the application of neutrosophy and the chosen soft set model also allowed the hierarchization of the difficulties encountered. The level of relevance according to the method applied is: the most relevant is the lack of an adequate legal framework that allows the organic application of ordinary and indigenous justice without duplication of sanctions. Followed by the ambiguity and lack of clarity in relation to the modes of action of indigenous justice to guarantee compliance with human and constitutional rights without limiting their application. Finally, the lack of effective communication actions that make known the essence and form of application of indigenous justice.

References

[1] U. D. Berg and L. P. Martínez, "The Legality of (Im) mobility: Migration, Coyoterismo, and Indigenous Justice in Southern Ecuador," in *Migration in South America*: Springer, Cham, 2022, pp. 145-166.

[2] L. Viaene and G. Fernández-Maldonado, "Legislating coordination and cooperation mechanisms between indigenous and ordinary jurisdictions: reflections on progress and setbacks in Ecuador," in *Critical Indigenous Rights Studies*: Routledge, 2018, pp. 201-226.

[3] V. Santafe-Troncoso and P. A. Loring, "Indigenous food sovereignty and tourism: The Chakra Route in the Amazon region of Ecuador," *Journal of Sustainable Tourism,* vol. 29, no. 2-3, pp. 392-411, 2021.

[4] J. J. Guzmán, "Decolonizing Law and expanding human rights: Indigenous conceptions and the rights of nature in Ecuador," *Journal of Human Rights,* no. 4, pp. 59-86, 2019.

[5] H. E. Laguna Delgado, C. M. Méndez Cabrita, J. M. Puetate Paucar, and M. E. Álvarez Tapia, "Origen y evolución del pluralismo jurídico en América Latina, como una visión crítica desde la perspectiva del derecho comparado," *Revista Universidad y Sociedad,* vol. 12, no. 5, pp. 381-388, 2020.

[6] C. A. Hand, J. Hankes, and T. House, "Restorative justice: The indigenous justice system," *Contemporary Justice Review,* vol. 15, no. 4, pp. 449-467, 2012.

[7] P. Lupien, "The incorporation of indigenous concepts of plurinationality into the new constitutions of Ecuador and Bolivia," *Democratization,* vol. 18, no. 3, pp. 774-796, 2011.

[8] M. Khan, L. H. Son, M. Ali, H. T. M. Chau, N. T. N. Na, and F. Smarandache, "Systematic review of decision making algorithms in extended neutrosophic sets," *Symmetry,* vol. 10, no. 8, p. 314, 2018.

[9] N. El-Hefenawy, M. A. Metwally, Z. M. Ahmed, and I. M. El-Henawy, "A review on the applications of neutrosophic sets," *Journal of Computational and Theoretical Nanoscience,* vol. 13, no. 1, pp. 936-944, 2016.

[10] D. Molodtsov, "Soft set theory—first results," *Computers & mathematics with applications,* vol. 37, no. 4-5, pp. 19-31, 1999.

[11] M. L. Vázquez, J. Estupiñan, and F. Smarandache, "Neutrosofía en Latinoamérica, avances y perspectivas," *Revista Asociación Latinoamericana de Ciencias Neutrosóficas. ISSN 2574-1101,* vol. 14, pp. 01-08, 2020.

[12] I. Deli, "Interval-valued neutrosophic soft sets and its decision making," *International Journal of Machine Learning and Cybernetics,* vol. 8, no. 2, pp. 665-676, 2017.

[13] M. Abu Qamar and N. Hassan, "An approach toward a Q-neutrosophic soft set and its application in decision making," *Symmetry,* vol. 11, no. 2, p. 139, 2019.

[14] M. I. Ali, F. Feng, X. Liu, W. K. Min, and M. Shabir, "On some new operations in soft set theory," *Computers & Mathematics with Applications,* vol. 57, no. 9, pp. 1547-1553, 2009.

[15] J. I. Pozo, M. d. Pérez, J. Domínguez, M. Gómez, and Y. Postigo, "La solución de problemas," *Madrid: Santillana,* 1994.

[16] F. Smarandache, "Introduction to the IndetermSoft Set and IndetermHyperSoft Set," *Neutrosophic Sets and Systems,* vol. 50, no. 1, p. 38, 2022.

[17] M. E Gaspar Santos, M. A. Zambrano Olvera & K. C. Triviño Vera. "Obligaciones contractuales de los empleadores para regular relaciones laborales con sus trabajadores en empresas privadas". Universidad y Sociedad, vol. 14 no. S2, pp 55-64, 2022.

[18] J. C. D. J. Arrias Añez, I. J. Diaz Basurto & C. E. Paucar Paucar. "Análisis socio-jurídico sobre la figura de la suspensión condicional del proceso en materia penal". Universidad y Sociedad, vol. 14 no. S2, pp 17-22, 2022.

[19] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[20] Álvarez Gómez, S. D., Romero Fernández, A. J., Estupiñán Ricardo, J., & Ponce Ruiz, D. V. "Selección del docente tutor basado en la calidad de la docencia en metodología de la investigación". Conrado, vol. 17 no. 80, pp 88-94, 2021.

[21] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.

[22] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[23] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[24] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[25] Von Feigenblatt, O. F. "Honor, Loyalty, and Merit: The Cultura Contemporary of the Spanish Nobility". Ediciones Octaedro, 2022.

[26] A. L. Santillán Molina, M. F. Medina Lascano, E. J. Escobar Gonzales & D. F. Coka Flores. "Análisis crítico–jurídico sobre las nuevas normas de comportamiento ético gubernamental en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 398-414, 2022.

[27] H. E. Lozano Rojas, M. C. Moran Giler & M. R. Dávila Castillo. "Causal relations in the deficiencies of the administrative and judicial process of national adoption in Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 415-424, 2022.

[28] J. D, Bósquez Remache, J. P Zambrano Zambrano, G. C. Robles Santana & R. A. Falconi Herrera. "El principio de presunción de inocencia como condición para la suspensión condicional de la pena en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 387-397, 2022.

Received: August 14, 2022. **Accepted:** October 12, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Application of a Neutrosophic Soft Set Model to Animal Abandonment and its Consideration as Mistreatment

Esperanza Del Pilar Araujo Escobar[1], Juan Carlos Arandia Zambrano[2], Carlos Fernando Soria Mesías[3] and Jorge Alfredo Eras Díaz[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. E-mail: up.esperanzadae48@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador. E-mail: uq.juanarandia@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.carlossoria@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.jorgeeras@uniandes.edu.ec

Abstract. The recognition of animal rights is an issue that has boomed in recent years and more and more states are taking them into account in their legal framework. Even though it seeks the recognition of animals as subjects of law, in social life actions of cruelty towards them continue to be appreciated and practices such as abandonment are normalized, without often being interpreted as mistreatment. The present investigation seeks to know the perception of jurists around this problem, using a model to evaluate the relevance of some situations of abandonment, based on the Neutrosophic Soft Set theory. This is a tool where the indeterminacy studied by Neutrosophy is mixed with the classic soft sets. In this way, greater precision is achieved to study the evidence, at the cost of greater uncertainty. As a result, it was obtained that all the situations analyzed were ranked and deemed relevant for consideration as abuse.

Keywords: Neutrosophic Soft Set, animal abuse, animal abandonment

1 Introduction

Neutrosophy arose as a solution to address many decision-making problems that involve human knowledge, which is often impregnated with uncertainty, indeterminacy, and inconsistency in information. It is a tool to represent those inconsistencies and contradictions that undoubtedly exist in the processing of evidence within administrative law and everyday life [1].

The classical soft set is based on a certain function (whose values are true and unique), but in our world, there are many sources that, due to lack of information or ignorance, provide indeterminate information (uncertain and not unique, but hesitant or alternative). Areas such as artificial intelligence, applied physics, image processing, social sciences, and topology also suffer from the same problems [2].

Classic soft sets [3], [15] started from the studies developed by Professor Molodtsov in 1999 and the neutrosophic soft sets in 2013. The former are deterministic since the set of parameters on which the evaluations are based are deterministic, although they generalize the definition of fuzzy sets. When triads of truth values are assigned to the possible values of the obtained sets, meaning membership, non-membership, and indeterminacy, soft set theory is combined with that of neutrosophic sets to obtain greater precision in the results [4].

These tools are used because there cannot always be one hundred percent clarity in the evidence that is handled, some of them can be interpreted in different and perhaps conflicting ways, and there is some incomplete evidence due to destruction, lack of witnesses, hesitant opinion of one of the factors involved in the process, among other reasons.

This situation can be modeled by operators that have some degree of indeterminacy due to the imprecision that exists in the world. Neutrosophic sets are characterized by a truth membership function (t), an indeterminacy membership function (i), and a falsehood membership function (f) independently, which lie within the standard real unit interval $[-0, 1+]$ standard or not standard. The Neutrosophic Sets (NS) proposed by Smarandache are a powerful mathematical tool to handle incomplete, indeterminate, and inconsistent information in the real world [5]. They are a generalization of fuzzy set theory, intuitionistic fuzzy sets, and interval-valued intuitionistic fuzzy sets.

Multiple are the applications of Neutrosophy in real life and within it, the so-called soft sets, among which are the legal and social sciences. In recent years, a social phenomenon has been observed that has been marked by an increase in sensitivity regarding respect for the rights of animals, and, consequently, more mechanisms have been sought for their protection, despite this, manifesting acts of cruelty that threaten the life and integrity

of animals [6].

As a result, measures have been adopted to control human behavior that can cruelly harm or cause unjustified death to an animal. Animal welfare is multifaceted and involves important scientific, ethical, economic, and political dimensions. An agglutinative approach brings together researchers from different disciplines, such as physiology, veterinary science, ethology, and comparative psychology [7].

At the global level, actions have been carried out that include some significant achievements of the World Organization for Animal Health (OIE): in 2003, twelve global standards on animal welfare were published, dealing with issues such as transport, slaughter, control of stray dog populations and the welfare of farm animals, including fish; three OIE world conferences on animal welfare were organized, in Paris, 2004, Cairo, 2008 and Kuala Lumpur, 2012; three special issues on animal wellbeing were published, volumes 24, number 2, in 2005 and 33, number 1, in 2014 of the OIE Scientific and Technical Review, and volume 10 of the OIE Technical Series, in 2008 on Evaluation and scientific management of animal pain [8].

The state of the art is limited, especially in relation to interpretation, since there are no clear and established parameters that define the actions of the judges, since the cases in which animal abuse is reported and sanctioned, the punishments do not correspond to the actions committed and the damage caused. Similarly, there is no consensus regarding the actions that are classified as abuse, since, for example, in the case of abandonment, a specific response has not been reached. Although this statistic is included in reports on the treatment of animals [9]. Image 1 shows some of the actions that are taken at the state level and that have an impact on animal welfare.

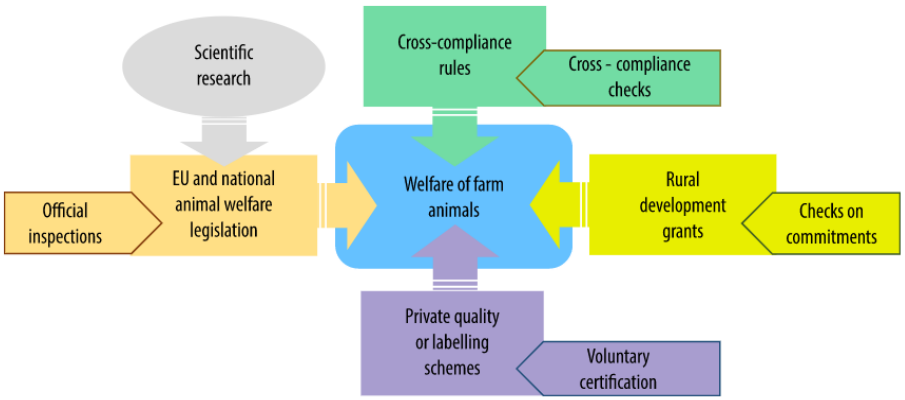


Figure 1. Actions with an impact on animal welfare. Source: https://op.europa.eu

Criminal legislation must be an effective tool against the most serious cases of abuse and abandonment of animals. In the first place, an expansion of the animals criminally protected against abuse must be carried out, including wild animals. One of the most advanced regions in the protection of animal welfare is Europe, where large sums are invested for this purpose.

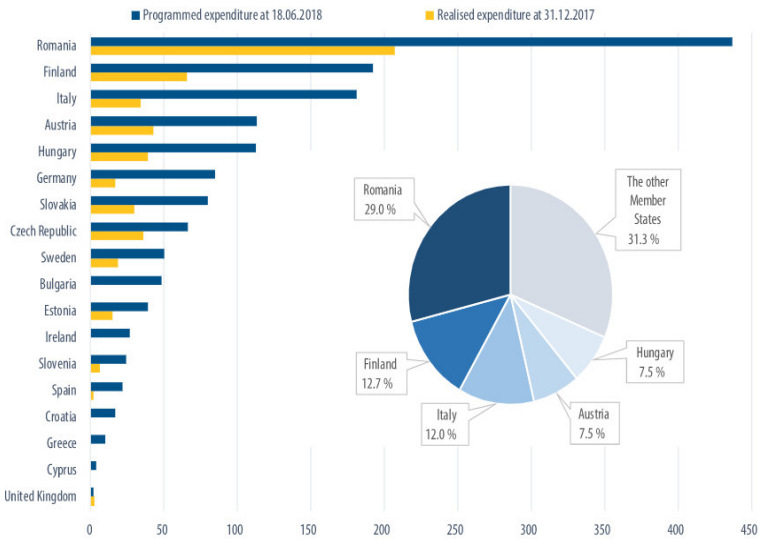


Figure 2: EU rural development spending on measure 14 "animal welfare" in the 2014-2020 programming period (million euros). Source: European Court of Auditors, based on information from DG Agriculture and Rural Development.

In the case of Latin America, the situation is different, since being poorer economies, the number of resources destined to guarantee animal welfare is much lower. However, in many of the nations that make up the region, there are protection laws for animals. As shown in Figure 3.

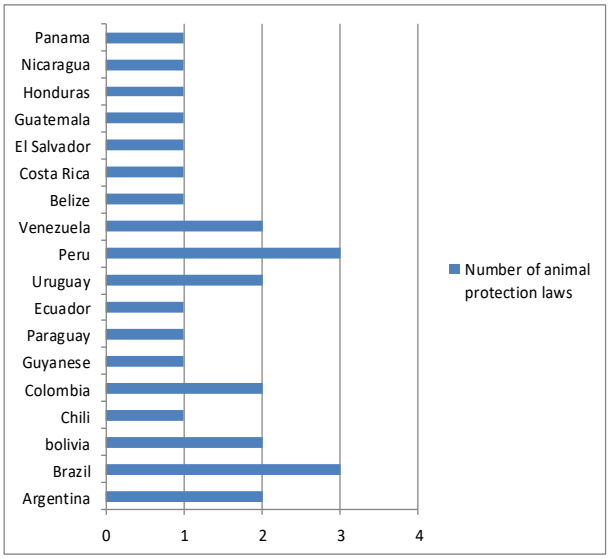


Figure 3. Actions with an impact on animal welfare. Source: [8].

Despite the laws and measures adopted in the region to reduce animal abuse, cases of abuse towards them persist, especially in homes where there is domestic violence. Data suggest that pet abuse is a coercive tactic used to control the victim of domestic violence through intimidation and threats. In other words, this is one of the forms of abuse that animals may suffer in the domestic environment, but it is not the only one. There is talk of physical and sexual abuse, but also neglect of their basic needs such as water, food, medical care, and abandonment [10], [16]. Among the main causes of abandonment are problems related to the behavior of the animal, with changes in the conditions in the environment or by decisions of the owners.

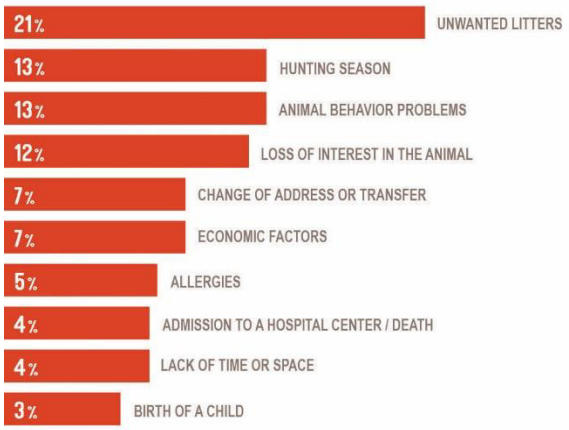


Figure 4. Causes of animal abandonment. Source: https://www.affinity-foundation.org.

Due to the aforementioned, the objective of this research is to carry out an analysis, using the Neutrosophic Soft Sets theory, of the act of animal abandonment as mistreatment and therefore as a crime.

2 Materials and methods

The neutrosophic soft set is defined as the soft set where F (maybe) or F (indeterminate), etc., is roughly equivalent to F (yes), F (no), F (true), or F (false), associated with a triad of values (α, β, γ), where $(\alpha, \beta, \gamma) \in [0, 1]^3$ are the degrees of truth, indeterminacy, and falsehood, respectively [11], [17], [19], [21], [22], [23].
Let U, be a universe of situations, H a non-empty subset of U, and $P(H)$ the power function of H. Let a be an attribute and A a set of these attribute values.

A function $F: A \to P(H)$ is called an indeterminate or smooth function if:

i. The set A has some indeterminacy;

ii. or $P(H)$ has some indeterminacy;

iii. or there exists at least one attribute value $v \in A$, such that F(v) = *indeterminate* (unclear, uncertain, or not unique);

iv. or two or the three previous situations.

Definition 1 [11]: let U be a universe of situations, H is a non-empty subset of U, with P(H) the power set of H, and an attribute, with its set of attribute values, is denoted by A. Then the pair $F, H)$, where f $F: A \to P(H)$, is called classic soft set on H.

Definition 2 [11]: If the function $F: A \to P(H)$, where for each $x \in A, f(x) \in P(H)$ and $f(x)$ is true and unique, it is called a determinate (classical) function.

From the previously discussed, the following neutrosophic triplet can be formed [11, 12, 13, 20]:

v. (Classical) function, which is a well-defined (inner-defined) function for all elements in its domain of definition, or (T, I, F) = (1, 0, 0).

vi. Neutrofunction (or neutrosophic function), is a function that is partially well defined (degree of truth T), partially indeterminate (degree of indeterminacy I), and partially externally defined (degree of falsehood F) in its domain of definition, where (T, I, F)ϵ{(1,0,0), (0,0,1)}.

2.1 Model based on Neutrosophic Soft Sets

This section presents the design of the proposed model for this case.

Starting from a group of situations or assumptions that will be denoted by $S = \{s_1, s_2, \cdots, s_k\}$, which must be classified or evaluated by the specialists that belong to the group $J = \{j_1, j_2, \cdots, j_l\}$. The set of parameters to be measured is given by D={Yes, No}, where "yes" means that the expert's opinion on the situation is affirmative, while "no" means the opposite.

The algorithm to follow is:

1. A group of situations or assumptions is compiled whose relevance is to be determined, to classify it and process it as a crime or not. It will be denoted by $S = \{s_1, s_2, \cdots, s_k\}$.

It is necessary to gather a group of experts or specialists, lawyers in this case, who must issue an opinion on the constitution as a crime of each of the situations expressed. This is understood as a set $J = \{j_1, j_2, \cdots, j_l\}$.

2. The jurist (j_j) is asked to give an opinion on the situation s_i regarding whether it is considered a crime or notJurist (J_j) is asked to rate the truth of the situation and its relevance on a scale of 0 to 100. This value is called.α_{ij}

   2.2. Jurist (J_j) is asked to give an evaluation of the falsehood and irrelevance of the situation on a scale of 0 to 100. This value is called γ_{ij}

   2.3. Jurist (J_j) is asked to give an assessment of the uncertainty and irrelevance of the situation on a scale of 0 to 100. This value is called β_{ij}

As a result, the following triad is obtained:

$$R\_ij = \langle \alpha\_ij/100, \beta\_ij/100, \gamma\_ij/100 \rangle \quad (1)$$

This is the triad of truth values between 0 and 1, to evaluate the degrees of truth, indeterminacy, and falsehood, respectively, of the relevance of the i-th test according to the j-th expert.

3. The Soft Set is formed by $F: D \to P(H)$, where $D = \{yes, no\}$, being as follows:

$$F(si) = \{(e_i, s_j, R_{ij}), where\ R_{ij} \neq \langle 0, \tau, 1\rangle, \tau \geq 0\}, \quad (2)$$

while:

$$F(no) = \{(e_i, s_j, R_{ij}), where\ R_{ij} \neq \langle 1,0,0\rangle\} \quad (3)$$

4. The final results for tests or evidence are obtained from:

$$G(si) = \{(e_i, \wedge_j R_{ij}): j \in \{1,2,\cdots,l\}\ such\ that\ (e_i, s_j, R_{ij}) \in F(yes)\} \quad (4)$$

Where, (5) $[\![\wedge\_j\ R]\!]\_ij = \langle \min\_j\ \{\alpha\_ij/100\}, \max\_j\ \{\beta\_ij/100\}, \max\_j\ \{\gamma\_ij/100\}\rangle$

$$G(no) = \{(e_i, \wedge_j NOT(R_{ij})): j \in \{1,2,\cdots,l\}\ such\ that\ (e_i, s_j, R_{ij}) \in F(no)\} \quad (6)$$

Where, $[\![NOT(R)]\!]\_ij) = \langle \gamma\_ij/100, \beta\_ij/100, \alpha\_ij/100\rangle$

5. For each proof or evidence $D = \{yes, no\}$, select between $G(yes)$ and $G(no)$ the triad that meets the following requirements.

   5.1 If s_i is in $G(yes)$ and it is not in $G(no)$, it is determined that this situation is relevant or that it should be considered a crime, with a truth value determined by $\bar{R}_i = \wedge_j R_{ij}$.

   5.2 If s_i is in $G(no)$ and is not in $G(yes)$, this evidence is determined to be relevant to the case with a truth value of $\tilde{R}_i = \wedge_j NOT(R_{ij})$.

   5.3 If s_i is in both sets, the following criteria are followed:

A single value $V\_i = (2 + R\_i1 - R\_i2 - R\_i3)/3$ is calculated, where $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3}\rangle$, while $F\_i = (2 + R\_i1 - R\_i2 - R\_i3)/3$, where $\tilde{R}_i = \langle \tilde{R}_{i1}, \tilde{R}_{i2}, \tilde{R}_{i3}\rangle$.

   5.3.1 If $\bar{V}_i > \bar{F}_i$ then the i-th test is relevant with a truth value of $\bar{R}_i$.

   5.3.2 If $\bar{V}_i < \bar{F}_i$ then the i-th test is not relevant with a value of truth $\tilde{R}_i$.

   5.3.4 If $\bar{V}_i = \bar{F}_i$ then it is determined that the ith test is not relevant enough with a truth value of $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3}\rangle$.

6. The tests or evidence that were classified as relevant are issued, sorted from highest to lowest, where $e_m \succ e_n$ if and only if $\bar{V}_m > \bar{V}_n$.

2.2 Application

Approaches that can be used for the analysis and interpretation of the case of abandonment as animal abuse or a crime, in the field of so-called soft sets:

2.2.1 Classic Soft Set:

The analysis of animal abandonment as mistreatment is based on the consideration of the action as such, and its definition as a crime in 3 situations (s_1: due to the animal's illness, s_2: due to not wanting to keep it and s_3: because the animal has caused damage to the physical integrity of an individual or an affectation of the material order) and the criteria of several jurists on the application of the current legality regarding the subject. [14], [18]

The set of alternatives can be represented as S= $\{s_1, s_2, s_3\} \cup \{\phi\}$, where $\{\phi\}$ is empty or null, the attribute D= crime, this has 2 possible values for the attribute D={Yes, No}

i. It is established as a function $F_1: C \to P(S)$, where $P(S)$ is determined by S, which represents the information offered by jurist 1, J_1

In this case:

$J_1(Yes) = s_2$, this means that according to the criteria of jurist 1, situation 2 is classified as abuse and therefore

should be considered a crime, that is, its value is unique.

2.2.2 Indeterminate Operator as an extension of the Soft Set

ii. Then, the function $F_2: C \to P(S)$, where the value of S is the criterion of jurist 2, J_2. In this case, the jurist does not have a single opinion, but rather provides some indeterminacy in his response.

$J_2(Yes) = NO\ (s_3)$ and $J_2(No) = s_1$ or s_2. This means that jurist 2 provides information that is not clear or unique, which means that for him the situation s_3 is not considered abuse, consequently: the situations s_1 and s_2 can be considered as such, or $\{\phi\}$ would mean that neither is considered abuse, consequently:

$C_2^1 + C_2^2 + 1 = 2^2 = 4$ possibilities (alternatives or outputs), resulting from 1 single input to choose from, where C_n^m, which means the combination of n elements taken from the groups of m elements, for intervals $0 \leq m \leq n$.

The following indeterminate information is given by s_1 or s_2, this can mean that: $\{s_1\ Yes\ and\ s_2\ No\}$, or that $\{s_1\ No\ and\ s_2\ Yes\}$, or that $\{s_1\ Yes\ and\ s_2 Yes\}$, then there are 3 alternatives or outputs to choose from.

Consequently

$F_2: C \to P(S)$is an indeterminate soft function

2.2.3 Indeterminate values

In the case of jurist 3, he has a less tacit criterion, that is, he thinks that in the case of situation s_1, "perhaps" can be considered as mistreatment, this can be translated using Neutrosophy, through the theory of opposites: $< A > = yes, < antiA > = no$ and the indeterminate or neutral function. Therefore $F_3: C \to P(S)$, would be given by $J_3(perhaps) = s_1$, this can be translated as follows:

$J_3(perhaps) = s_1$that is $J_3(yes) = s_1$ (to a certain degree); $J_3(No) = s_1$ (to a certain degree), which is the same as, $J_3(yes) = s_1(0{,}6)$ which is interpreted as a 60% probability that it will be considered abuse and therefore a crime.

$J_3(perhaps) = s_1$ that is $J_3(yes) = s_1(0{,}6; 0{,}3)$ which means that there is a 60% probability that it will be considered abuse and therefore a crime and a 30% that it will not be.

$J_3(perhaps) = s_1$ that is $J_3(yes) = s_1(0{,}6; 0{,}3; 0{,}2)$ which means that there is a 60% probability that it will be considered an abuse and therefore a crime, a 30% probability that it will not be, and a 20% probability that it will not be considered as either of the two.

2.3 Application of the Model based on Neutrosophic Soft Sets

The 3 jurists consulted (j_1, j_2, j_3) issue their criteria regarding the situations (s_1, s_2, s_3), in triads of values from 0 to 100, to standardize the veracity, the negative and indeterminate responses, where the first score represents the seriousness or relevance of the situation raised to be considered as a crime of abuse, the second value indicates the doubt or indeterminacy regarding the relevance of the situation described in its consideration as a crime of abuse and the third value indicates the irrelevance of that situation to be considered as a crime of mistreatment of animals.

Results are shown in Table 1.

Situation/Jurist	j_1	j_2	j_3
s_1	⟨76,0,20⟩	⟨80,0,10⟩	⟨75,10,22⟩
s_2	⟨95,0,15⟩	⟨85,0,30⟩	⟨70,20,40⟩
s_3	⟨50,30,18⟩	⟨45,50,20⟩	⟨65,25,15⟩

Table 1: Result of the evaluation of the relevance of the situation according to the jurists.

The above results are divided by 100 to bring them to a [0, 1] scale which is more common in Neutrosophic theories.

Situation/Jurist	j_1	j_2	j_3
s_1	⟨0.76,0,0.20⟩	⟨0.80,0,0.10⟩	⟨0.75,0.10,0.22⟩
s_2	⟨0.95,0,0.15⟩	⟨0.85,0,0.30⟩	⟨0.70,0.20,0.40⟩
s_3	⟨0.50,0.30,0.18⟩	⟨0.45,0.50,0.20⟩	⟨0.65,0.25,0.15⟩

Table 2: Result of the evaluation of the relevance of the situation according to the jurists expressed in the form of neutrosophic numbers.

Soft sets are defined as

$$F(Yes) = \left\{ \begin{array}{c} (j_1, s_1, \langle 0.76,0,0.20\rangle), (j_1, s_2, \langle 0.95,0,0.15\rangle), (j_1, s_3, \langle 0.50,0.30,0.18\rangle), (j_2, s_1, \langle 0.80,0,0.10\rangle), \\ (j_2, s_2, \langle 0.85,0,0.30\rangle), (j_2, s_3, \langle 0.45,0.50,0.20\rangle), (j_3, s_1, \langle 0.75,0.10,0.20\rangle), (j_3, s_2, \langle 0.70,0.20,0.40\rangle), \\ (j_3, s_3, \langle 0.65,0.25,0.15\rangle) \end{array} \right\}$$

$F(no)$ is exactly the same as above.

$G(yes) = \{(j_1, \langle 0.75,0.10,0.22\rangle), (j_2, \langle 0.70,0.20,0.40\rangle), (j_3, \langle 0.45,0.50,0.20\rangle)\}$

$G(no) = \{(j_1, \langle 0.22,0.10,0.75\rangle), (j_2, \langle 0.40,0.20,0.70\rangle), (j_3, \langle 0.20,0.50,0.45\rangle)\}$

From $G(yes)$ and $G(no)$ it is concluded that s_1 is relevant with a truth value of $\langle 0.75,0.10,0.22\rangle$, j_2 relevant with a truth value of $\langle 0.70,0.20,0.40\rangle$, and finally j_3 is also relevant with a truth value of $\langle 0.45,0.50,0.20\rangle$.

This decision is made since, $\bar{V}_1 = 0.9122 > \bar{F}_1 = 0.4589$; $\bar{V}_2 = 0.922 > \bar{F}_2 = 0.4611$; $\bar{V}_3 = 0.727 > \bar{F}_3 = 0.4333$. Following step 5.3 of the chosen algorithm.

The order of severity or relevance of abandonment situations to be considered a crime is as follows: $e_2 \succ e_1 \succ e_3$, where all are relevant or important according to the results obtained.

Finally, the order of severity of the situations is as follows:

1- s_2: for not wanting to keep it

2- s_1: due to animal disease

3- s_3: because the animal has caused damage to the physical integrity of an individual or an affectation of the material order

Conclusions

With the completion of this investigation, the following conclusions were reached: the different approaches that can be given in the processing of responses to real-life situations and in particular the legal framework were analyzed. The application of the chosen neutrosophic model allows us to focus more clearly on the relevant tests or situations, eliminating those that do not contribute to what is being analyzed. The consideration of indeterminacy in the answers is introduced, which makes the result closer to reality. The hierarchization of the answers provides a useful edge for decision-making in relation to the situations raised, in this case, it was found as the most serious or relevant for the consideration of abandonment as abuse, according to the jurists consulted that it should be to the decision or personal desire not to keep the animal, in a second moment that is due to illness of the animal and finally that it has caused damage to the physical integrity of an individual or a material affectation. It should be noted that according to the results obtained, although the situations are ranked, all are relevant for the consideration of abandonment as animal abuse.

References

[1] N. El-Hefenawy, M. A. Metwally, Z. M. Ahmed, and I. M. El-Henawy, "A review on the applications of neutrosophic sets," *Journal of Computational and Theoretical Nanoscience,* vol. 13, no. 1, pp. 936-944, 2016.

[2] M. Khan, L. H. Son, M. Ali, H. T. M. Chau, N. T. N. Na, and F. Smarandache, "Systematic review of decision-making algorithms in extended neutrosophic sets," *Symmetry,* vol. 10, no. 8, p. 314, 2018.

[3] D. Molodtsov, "Soft set theory—first results," *Computers & mathematics with applications,* vol. 37, no. 4-5, pp. 19-31, 1999.

[4] M. I. Ali, F. Feng, X. Liu, W. K. Min, and M. Shabir, "On some new operations in soft set theory," *Computers & Mathematics with Applications,* vol. 57, no. 9, pp. 1547-1553, 2009.

[5] I. Deli, "Interval-valued neutrosophic soft sets and its decision making," *International Journal of Machine Learning and Cybernetics,* vol. 8, no. 2, pp. 665-676, 2017.

[6] M. Cleary, D. K. Thapa, S. West, M. Westman, and R. Kornhaber, "Animal abuse in the context of adult intimate partner violence: A systematic review," *Aggression and violent behavior,* vol. 61, p. 101676, 2021.

[7] E. Alleyne and C. Parfitt, "Adult-perpetrated animal abuse: A systematic literature review," *Trauma, Violence, & Abuse,* vol. 20, no. 3, pp. 344-357, 2019.

[8] R. Ellefsen and J. Busher, "The dynamics of restraint in the Stop Huntingdon Animal cruelty campaign," *Perspectives on Terrorism,* vol. 14, no. 6, pp. 165-179, 2020.

[9] D. R. Goyes and R. Sollund, "Animal abuse, biotechnology and species justice," *Theoretical Criminology,* vol. 22, no. 3, pp. 363-383, 2018.

[10] A. H. Garrido, "Maltrato animal: las victimas ocultas de la violencia doméstica," in *Derecho Animal. Forum of Animal Law Studies*, 2020, vol. 11, no. 1, pp. 14-17.

[11] F. Smarandache, "Introduction to the IndetermSoft Set and IndetermHyperSoft Set," *Neutrosophic Sets and Systems,* vol. 50, no. 1, p. 38, 2022.

[12] J. L. Acosta Espinoza. "Sistema de gestión documental para la coordinación de vinculación con la sociedad de Uniandes sede Ibarra". Universidad y Sociedad, vol. 14 no.3, pp 523-532, 2022.

[13] C. J. Lizcano Chapeta, D. J. Chamorro Valencia, E. P. Vega, & R. G. Cachimuel Colta. "Disposiciones legales de la gestión comunitaria del agua y los pueblos indígenas en el Ecuador". Universidad y Sociedad, vol. 14 no.3, pp 514-522, 2022.

[14] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[15] Álvarez Gómez, S. D., Romero Fernández, A. J., Estupiñán Ricardo, J., & Ponce Ruiz, D. V. "Selección del docente tutor basado en la calidad de la docencia en metodología de la investigación". Conrado, vol. 17 no. 80, pp 88-94, 2021.

[16] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018

[17] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[18] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[19] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[20] von Feigenblatt, O. F., & Linstroth, J. P. "Applied history and the teaching of leadership: a case for the use of historical case studies in leadership programs". Universidad y Sociedad, vol. 14 no. S3, pp 433-438, 2022.

[21] B. E. Cuenca Mina, I. X. León Rodríguez, J.A. Eras Diaz & P. O. Piray Rodríguez. "El maltrato a los animales de compañía inadvertido ante las autoridades de Santo Domingo". Universidad y Sociedad, vol. 14 no. S4, pp 377-386, 2022.

[22] L. C. Campaña Muñoz, A. C. Diaz Paredes, J. G. Del Pozo Carrasco & M. R. Hidalgo Ruiz. "Propuesta de un mecanismo de control sobre el cumplimiento de las penas no privativas de libertad para Santo Domingo en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 369-376, 2022.

[23] N. Garcia Arias, J. L. Gutiérrez Medranda, C. F. Soria Mesías & D. V. Garcés Mayorga. "Análisis crítico al principio de objetividad en el procedimiento directo". Universidad y Sociedad, vol. 14 no. S4, pp 359-367, 2022.

Received: August 15, 2022. **Accepted:** October 13, 2022

NSS
Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Effectiveness of the Legal Rules that Protect Disabled People through Neutrosophic Techniques

Santiago Fernando Fiallos Bonilla[1], Diego Xavier Chamorro Valencia[2], Diego Vladimir Garcés Mayorga[3] and Eduardo Luciano Hernández Ramos[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.santiagofiallos@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.diegochamorro@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Puyo. Ecuador. E-mail: up.diegogarces@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.eduardohernandez@uniandes.edu.ec

Abstract. Multi-criteria decision problems are present in all branches of life and present a high degree of complexity to determine a feasible solution. When it comes to individual rights, decisions are even more delicate, especially when it comes to people with disabilities. The Ecuadorian State has created insertion policies for these people within society. However, this vulnerable group is constantly the victim of discrimination, even though they are within the priority attention group. This study presents the application of multi-criteria evaluation techniques as a method for assessing the effectiveness of legal regulations regarding people with disabilities, according to certain pre-established parameters of interest. For this, the combination of the TODIM and PROMETHEE methods was used to obtain the results. In addition, single-valued neutrosophic sets based on neutrosophic logic are used. In such a way that the indeterminate and inconsistent information typical of the real world can be adequately handled. The use of the employed method demonstrates the efficiency of these methods in solving complex problems in real life and different fields of society.

Keywords: multi-criteria decisions, neutrosophic logic, neutrosophic sets, legal norms, rights.

1 Introduction

The Ecuadorian State has created Labor Insertion Policies for people within society, including disabled people. However, this vulnerable group is the victim of constant discrimination even though they are within the priority attention group. According to the National Council for Equality of Disabilities (Conadis) in Ecuador, there are 471,205 people with accredited disabilities. That is, they have an evaluation by the Ministry of Public Health. It is the most up-to-date figure and is cut to January 2022. Of these people, 215,205 have a physical disability; 108,957 intellectual; 66,538 auditory; 54,397 visual; and 26,157 psychosocial.

The place achieved by Ecuador in terms of disabilities is due in large part to the policies and legal regulations created to serve this sector of society. For years, care for people with disabilities has been relegated, and several governments only treated it as social assistance. Today it is a State policy to give priority attention to people with disabilities. Backed by the requirements of international standards and the execution of national standards, it is shown in the large projects of direct assistance to the disabled. This new regime has made Ecuador a model of assistance work and clear policies around disability, becoming a model in Latin America and achieving international recognition at the UN.

To respond to international standards, the actions of the Ecuadorian State in this regard must be considered. So much so, that the International Convention on the Rights of Persons with Disabilities was signed by Ecuador and published in Official Gazette 329 on May 5, 2008. It is a supranational norm, which means that its provisions prevail even on domestic law. The international standard that makes direct reference to the issue of labor inclusion of people with disabilities is reflected in the following statement:

> The States Parties shall adopt effective and pertinent measures, including through the support of persons in the same circumstances so that persons with disabilities can achieve and maintain maximum independence, physical, mental, social, and vocational capacity, and inclusion… full participation in all aspects of life. To this end, the States Parties shall organize, intensify and expand general rehabilitation and rehabilitation services and programs, in particular in the fields of health, employment, education, and social services. (Article 26)

The State adopts actions to ensure a better quality of life for the disabled. Social inclusion, obtaining credits, and scholarships, and the development of programs and policies to promote recreation and rest. Political participation, the promotion of their autonomy, and the reduction of dependency, among others.

With the measures adopted by the State in favor of people with disabilities, it is ensured that there is social inclusion, with state and private investment, so that they can participate in the political, social, cultural, educational, and economic spheres. In each of these social spheres, serious policies must be established so that people with disabilities are taken into account, not as a means of propaganda or social assistance, but rather that their condition is respected.

Currently, there is no active participation of people with disabilities in politics. In other areas, the margin of social assistance is kept and has been left in the hands of NGOs or foundations to take over the responsibility that the State must assume. Despite establishing a policy of entrepreneurship and support for local production, this policy is not very decisive when granting loans or providing facilities to people with disabilities. At least, what is personal loans is not better known and many banking entities do not accept a person with a disability as the main debtor.

Regarding the achievement of scholarships at all levels, it is fulfilled as people are aware of this measure and it can be generated. In this sense, clear conditions are established that favor people with disabilities and may in the future generate an acceptable social space for their realization. The development of programs that include specialized adaptation is the responsibility of the state. These must attend and lead to personal fulfillment in their emotional growth and determination to instill their independence from the people who care for them. They must correspond to the disability they have, be they severe or profound, which is why it has been demanded that full compliance be given to the provisions.

The current Constitution mentions the labor insertion of which the person with a disability must be a part. In it, requirements are determined so that services, help, and facilities are implemented in the activity that the person favored with a job must carry out. At the same time, it is determined that the remuneration cannot be reduced, much worse if the person's disability is conditioned. Therefore, it must be understood that as it is a constitutional right it is applicable in the public and private sectors.

For this reason, the objective of this study is to determine, through neutrosophic methods, the effectiveness of Ecuadorian national standards regarding people with disabilities. So that, according to the results obtained, they can be given a better opportunity to be active subjects of society, under the principle of constitutional equality.

2 Methodology

This study presents the application of multi-criteria evaluation techniques as a method for the best evaluation of Ecuadorian laws for the protection of disabled people. In this sense, certain pre-established parameters of interest were taken into account. To develop the proposed objective, the study is based on the use of multi-criteria decision methods (MCDM). The MCDMs allow taking very complex real-life situations and developing actions to achieve decision-making under certain conditions. In this way, the problems initially raised reach a decisive state [1], [2].

Many are the MCDM developed for the resolution of problems in various areas of life and society [3]–[9], however, in traditional methods, the alternatives are usually evaluated with neat values in general. Due to the complexity of the environment and the subjectivity of the human being, MCDM problems are often accompanied by uncertainty, so the decision information provided is often confusing or linguistic.

This article introduces the TODIM and PROMETHEE methods [10], through the use of single-valued neutrosophic sets (SVNS). Neutrosophy, as part of philosophy, analyzes the nature of neutralities and everything related to it. Regarding neutrosophic logic and neutrosophic sets, indeterminacy membership functions are included for the first time. Indeterminacy is caused by a lack of information, by contradictory, inconsistent, and paradoxical information, among others. For this study, neutrosophic sets are used in order to eliminate the impossibility of traditional methods to handle the indeterminate and inconsistent information of the real world [11], [25].

For greater clarity of the information used, the preliminary aspects of the neutrosophic theory are first introduced, as well as the methodology. Subsequently, the methodology is applied, and finally, the results achieved and the conclusions derived from the study are presented.

Definition 1. Let X be a space of points (objects) with generic elements in X denoted by x. A single-valued neutrosophic set (SVNS) A in X is characterized by the truth-membership function TA (x), indeterminacy-membership function IA (x), and falsehood membership function FA (x). Then, an SVNS A can be denoted by A = {x, TA(x), IA(x), FA(x) x ∈ X}, where TA (x), IA (x), FA (x) ∈ [0, 1] for each point x in X. Therefore, the sum of TA (x), IA (x) and FA (x) satisfies the condition $0 \leq TA(x) + IA(x) + FA(x) \leq 3$ [12], [23].

Decision-making normally involves human language or linguistic variables. A linguistic variable simply represents words or terms used in human language. Therefore, this linguistic variable approach is a convenient way for decision-makers to express their assessments. Ratings of criteria can be expressed by using linguistic variables. Linguistic variables can be transformed into SVNSs as shown in Table 1.

Definition	SVNS
Extremely Preferred (EXP)	(1,0,0)
Very Very Preferred (VVP)	(0.9, 0.1, 0.1)
Very Preferred (VP)	(0.8,0,15,0.20)
Preferred (P)	(0.70,0.25,0.30)
Equally Preferred (EP)	(0.50,0.50,0.50)
Not Preferred (NP)	(0.35,0.75,0.80)
Very Not Preferred (VNP)	(0.20,0.85,0.80)
Very Very Not Preferred (VVNP)	(0.10,0.90,0.90)
Extremely Not Preferred (ENP)	(0,1,1)

Table1: Linguistic variable and Single Valued Neutrosophic Numbers (SVNNs). Source: [13].

Definition 2. Let $E_k = (T_k , I_k , F_k)$ be a neutrosophic number defined for the rating of k-th decision maker. Then, the weight of the k-th decision maker can be written as [7]:

$$\psi_k = \frac{1-\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(\mathrm{F}(x))^2]/3}}{\sum_{k=1}^{p}\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(\mathrm{F}(x))^2]/3}} \quad (1)$$

Further, in achieving a favorable solution, group decision-making is important in any decision-making process. In the group decision-making process, all the individual decision-maker assessments need to be aggregated into one aggregated neutrosophic decision matrix. This can be done by employing a single valued neutrosophic weighted averaging (SVNWA) aggregation operator proposed by Ye [14], [26].

Definition 3. ([14]) Let $D^{(k)}=(d_{ij}^{(k)})_{mxn}$ be the single-valued neutrosophic decision matrix of the k-th decision-maker and $\psi = (\psi_1\psi_2, \dots, \psi_p)^T$ be the weight vector of decision-maker such that each $\psi_k \in [0,1], D = (d_{ij})_{mxn}$ where

$$d_{ij} = \langle 1 - \prod_{k=1}^{p}\left(1 - T_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(I_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(F_{ij}^{(p)}\right)^{\psi_k}\rangle \quad (2)$$

Definition 4. Let A and B be two single-valued neutrosophic numbers (SVNNs), then the normalized Hamming distance between them is:

$$d(A,B)\frac{|TA-TB|+|IA-IB|+|FA-FB|}{3} \quad (3)$$

Definition 5. Let A= (TA, IA, FA) be a SVNN, the complement of SVNN A is:

$$AC= (FA, 1-IA, TA). \quad (4)$$

2.1 Method

Let $A = (A_1,\dots,A_m)$ be the alternatives, and $G = (G_1, G_2,\dots,G_n)$ the attributes. Let the weights of the attributes be $W = (w_1, w_2,\dots,w_n)$, where $0 \le wj \le 1$, $\sum_{j=1}^{n} w_j = 1$. Let a_{ij}, $i = 1, 2\dots m$, j = 1, 2,.., n, be the attribute value of the alternative A_i with attribute G_j, the $A = (a_{ij})$ $m \times n = \langle (T_{ij}, I_{ij}, F_{ij})\rangle_{mxn}$ is a SVNNs matrix, where T_{ij}, I_{ij} and F_{ij} are membership degree, indeterminacy-membership degree and non-membership degree, the procedure followed to perform the analysis is as shown bellow [15], [27].

Step 1: Identify the decision alternatives to be evaluated.

Step 2: Determine the weights of the decision-makers. Due to the logic of the method, each decision-maker can have a unique and different evaluation from the rest of the decision-makers, since each evaluation is granted according to the level of knowledge of each expert regarding the decision issue addressed. The relative weight of each decision maker is considered as linguistic variables and is transmitted in SVNN to later be identified using equation (1).

Step 3: Convert the linguistic evaluations given by the experts into SVNN. From the individual neat integer matrices obtained from the experts' evaluations, the individual neutrosophic matrices of the decision-makers are constructed, as indicated in Table 1.

Step 4: Obtain the initial relationship matrix of alternatives $A = (A_1,\dots,A_m)$ and attributes $G = (G_1, G_2,\dots,G_n)$, where each a_{ij}, $i = 1, 2\dots m$, j = 1, 2,.., n, is the value of the attribute of the alternative A_i with the attribute G. The

$A = (a_{ij})\ m\times n = \langle (T_{ij}, I_{ij}, F_{ij}) \rangle_{mxn}$ is an SVNNs matrix, where T_{ij}, I_{ij} and F_{ij} are the degree of membership, degree of indeterminacy- membership, and degree of non-membership, using equation (2) [16], [17], [28].

Step 5: Standardize decision information. That is, normalize $A = (a_{ij})\ m\times n$ into $B = (b_{ij})\ m\times n$. If the decision is a cost factor, the decision information should be changed to its complementary set using equation (3), while if it is an efficiency factor, it should not be changed.

Step 6: Construct a preference function $P_j(B_i, B_r)$ of the alternative B_i relative to B_r under the attribute G_j using (5).

$$P_j(B_i, B_r) = \begin{cases} 0, d \le p \\ \frac{d-p}{q-p}\ , p < d < q \\ 1, d \ge q \end{cases} \quad (5)$$

Step 7: Calculate the relative weight of the attributes w_{jr}, which is the relative weight of Gj to Gr, where

$$w_{jr} = \frac{w_j}{w_r} = (j, r = 1,2, \dots, n) \quad (6)$$

Step 8: Define the priority index $\pi(B_i, B_r)$ of scheme B_i relative to B_r by

$$[1] \quad \pi(B_i, B_r) = \frac{\sum_{j=1}^{n} w_{jr} P_j(B_i, B_r)}{\sum_{j=1}^{n} w_{jr}} \quad (7)$$

Step 9: Calculate input flow $\Phi^+(B_i)$, the outflow $\Phi^-(B_i)$ and the net flow $\Phi(B_i)$ as follows

$$\Phi^+(B_i) = \frac{\sum_{r=1}^{m} \pi(B_i, B_r) - \min_{1\le i\le m} \{\sum_{r=1}^{m} \pi(B_i, B_r)\}}{\max_{1\le i\le m} \{\sum_{r=1}^{m} \pi(B_i, B_r)\} - \min_{1\le i\le m} \{\sum_{r=1}^{m} \pi(B_i, B_r)\}} \quad (8)$$

$$\Phi^-(B_i) = \frac{\sum_{r=1}^{m} \pi(B_r, B_i) - \min_{1\le i\le m} \{\sum_{r=1}^{m} \pi(B_r, B_i)\}}{\max_{1\le i\le m} \{\sum_{r=1}^{m} \pi(B_r, B_i)\} - \min_{1\le i\le m} \{\sum_{r=1}^{m} \pi(B_r, B_i)\}} \quad (9)$$

$$\Phi(B_i) = \Phi^+(B_i) - \Phi^-(B_i) \quad (10)$$

Step 10: Rank all alternatives according to the value of $\Phi(B_i)$. The higher the value of $\Phi(B_i)$, the better the alternative.

Methodological process

The place achieved by Ecuador in terms of disabilities is due in large part to the policies and legal regulations created to serve a sector of society that has been relegated for years and by several governments that only served as social assistance, today it is a State policy to give priority attention to people with disabilities, in accordance with the requirements of international standards and the implementation of national standards reflected in the large projects of direct assistance to the disabled; this new regime has made Ecuador a model of work in assistance and clear policies around disability, becoming a model in Latin America and international recognition at the UN [18], [19], [20].

For the definition of the alternatives to be evaluated, the regulations in force in the country were studied, in order to identify and know the main legislations that include the protection of disabled people:

- Constitution of the Republic of Ecuador (CRE)
- Ecuadorian Labor Code (ELC)
- Organic Law on Disabilities (OLD)
- Social Security Law (SSL)
- Comprehensive Criminal Organic Code (CCOC)

The criteria for the evaluation of the alternatives represent the guidelines to be used in the decision-making process, using them as a source of principles for the evaluation of the regulations. In this way, the alternatives to the problem can be analyzed from the same perspectives. This study was structured with 4 evaluation criteria, which were presented to the decision-makers for validation. For the analysis carried out, the analysts agreed to give the same weight of importance to each criterion (value of each weight, w= 0.25).

For this research, the following criteria will be used:

- **Accessibility:** the general principle and right that the pertinent measures be adopted to ensure that persons with disabilities can move, orient themselves or communicate naturally in any setting or activity. [21], [24]

- **Employment stability:** Despite the existing legislation, the pressure to which people with disabilities are subjected often forces them to end their working lives. In many cases, the disability also implies underlying diseases. With them, the absences and interruption of working hours, finally ends up bothering the bosses or other personnel, thus motivating dismissals. Even when the laws provide benefits in this regard.

- **Equal opportunities:** it is a legal principle, based on the idea that a fair society can only be achieved if any person has the same possibilities of access to minimum levels of social welfare, and their rights are not inferior to those of other groups. To this end, regulatory mechanisms are established that prohibit discrimination for reasons of various kinds.

- **Reasonable adjustments:** Necessary modifications and adaptations in infrastructure and services. These are applied according to particular cases, to guarantee that people with disabilities enjoy or exercise their rights on equal terms with others. [22], [23], [29], [30], [31], [32]

3 Results

Table 2 shows the evaluations given to decision-makers according to their relative importance in terms of the topic discussed.

Decision-makers	Linguistic evaluation	SVNN	Numerical value
Decision-maker 1	Very Important	(0.9;0.1;0.1)	0.21
Decision-maker 2	Moderately Important	(0.5;0.5;0.5)	0.17
Decision-maker 3	Very Important	(0.9;0.1;0.1)	0.21
Decision-maker 4	Very Important	(0.9;0.1;0.1)	0.21
Decision-maker 5	Important	(0.75;0.25;0.20)	0.2

Table 2: Evaluations given to decision-makers according to their importance. Source: own elaboration.

Once the decision-makers individually evaluate the alternatives indicated based on each of the criteria or attributes chosen for the evaluation, using equation (2) they are transformed to obtain the normal decision matrix of alternatives, which is shown in table 3.

	Accessibility	Employment stability	Equal opportunity	Reasonable adjustments
CCOC	(0.61424;0.38576;0.35486)	(0.67429;0.32571;0.28374)	(0.7626;0.2374;0.2081)	(0.7257;0.2743;0.2519)
OLD	(0.55653;0.44347;0.42667)	(0.5;0.5;0.5)	(0.56731;0.43269;0.41301)	(0.5;0.5;0.5)
CRE	(0.68696;0.31304;0.2988)	(0.54297;0.47088;0.45555)	(0.47187;0.54413;0.5515)	(0.6024;0.4096;0.3789)
SSL	(0.69071;0.30929;0.29523)	(0.61623;0.38377;0.35244)	(0.47187;0.54413;0.5515)	(0.5673;0.4327;0.413)
ELC	(0.5;0.5;0.5)	(0.55653;0.44347;0.42667)	(0.5;0.5;0.5)	(0.7445;0.2555;0.2555)

Table 3: Decision normal matrix of alternatives Note. Source: own elaboration.

All the selected criteria are considered as benefit criteria, that is, they should be maximized, except for criterion 4, so the normalized matrix obtained coincides with the normal matrix shown in Table 3. From it, the degrees of preference P_j (B_i,B_r) with respect to G_j. This calculation can be carried out using the linear function proposed in (4). For this case, it is assumed that q = 1, p = 0, obtaining the matrices from P_1 a P_4.

$$P_1 = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.0000 & 0.0000 & 0.0187 & 0.0199 & 0.0000 \\ B_2 & 0.0239 & 0.0000 & 0.0426 & 0.0438 & 0.0000 \\ B_3 & 0.0000 & 0.0000 & 0.0000 & 0.0012 & 0.0000 \\ B_4 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_5 & 0.0484 & 0.0245 & 0.0671 & 0.0683 & 0.0000 \end{vmatrix}$$

$$P_2 = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.0000 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_2 & 0.0721 & 0.0000 & 0.0102 & 0.0492 & 0.0244 \\ B_3 & 0.0619 & 0.0000 & 0.0000 & 0.0390 & 0.0142 \\ B_4 & 0.0229 & 0.0000 & 0.0000 & 0.0000 & 0.0000 \\ B_5 & 0.0476 & 0.0000 & 0.0000 & 0.0247 & 0.0000 \end{vmatrix}$$

$$\boldsymbol{P_3} = \begin{vmatrix} & \boldsymbol{B_1} & \boldsymbol{B_2} & \boldsymbol{B_3} & \boldsymbol{B_4} & \boldsymbol{B_5} \\ \boldsymbol{B_1} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \\ \boldsymbol{B_2} & \mathbf{0.0683} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \\ \boldsymbol{B_3} & \mathbf{0.1198} & \mathbf{0.0515} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0225} \\ \boldsymbol{B_4} & \mathbf{0.1198} & \mathbf{0.0515} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0225} \\ \boldsymbol{B_5} & \mathbf{0.0973} & \mathbf{0.0290} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \end{vmatrix}$$

$$\boldsymbol{P_4} = \begin{vmatrix} & \boldsymbol{B_1} & \boldsymbol{B_2} & \boldsymbol{B_3} & \boldsymbol{B_4} & \boldsymbol{B_5} \\ \boldsymbol{B_1} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \\ \boldsymbol{B_2} & \mathbf{0.0827} & \mathbf{0.0000} & \mathbf{0.0364} & \mathbf{0.0290} & \mathbf{0.0815} \\ \boldsymbol{B_3} & \mathbf{0.0463} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0451} \\ \boldsymbol{B_4} & \mathbf{0.0537} & \mathbf{0.0000} & \mathbf{0.0074} & \mathbf{0.0000} & \mathbf{0.0525} \\ \boldsymbol{B_5} & \mathbf{0.0012} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} & \mathbf{0.0000} \end{vmatrix}$$

By using equation (6), the integral priority index is obtained, as shown in the matrix Π, from which the input, output, and net flow of each alternative are obtained, as shown in table 4.

$$\Pi = \begin{vmatrix} & B_1 & B_2 & B_3 & B_4 & B_5 \\ B_1 & 0.000 & 0.000 & 0.005 & 0.005 & 0.000 \\ B_2 & 0.062 & 0.000 & 0.022 & 0.030 & 0.026 \\ B_3 & 0.057 & 0.013 & 0.000 & 0.010 & 0.020 \\ B_4 & 0.049 & 0.013 & 0.002 & 0.000 & 0.019 \\ B_5 & 0.049 & 0.013 & 0.017 & 0.023 & 0.000 \end{vmatrix}$$

	Φ+	**Φ−**	**Φ**
CCOC	0	1,000	-1,000
OLD	1	0.000	1,000
CRE	0.691	0.036	0.654
SSL	0.555	0.167	0.388
ELC	0.703	0.150	0.553

Table 4: Input, output, and net flow of the alternatives. Note: Source: Own elaboration

The positive and negative flows in this type of analysis indicate the degrees of preference and non-preference against other alternatives. In this sense, from the results achieved by the analysis carried out, the Organic Law on Disabilities has a higher level of preference with respect to the other regulations. Closely followed by the Constitution and the Labor Code, being the one that has the least preference over the rest, the Comprehensive Criminal Organic Code. On the other hand, when analyzing the negative flows obtained, it can be seen that the CCOC is the one with the highest degree of non-preference with respect to the other laws. In this case, all regulations present similar levels of non-preference, except for the Organic Law on Disabilities, which in this case is the lowest of the values.

Conclusions

The use of the employed neutrosophic method demonstrates the efficiency of these methods in solving complex problems in real life, and different fields of society; in this particular case, the Law. Through the use of single value neutrosophic sets, it was possible to solve the proposed problem, eliminating the indeterminacies and vagueness of reality.

When analyzing the entire legal and regulatory framework, both in national and international regulations, it can be concluded that there is more than enough legislation to specify the rights of people with disabilities. The study shows that the most important are the rights to health, education, and employment. Gradually, an effective social and economic integration of people with disabilities is being achieved in the face of social issues, but there is still work to be done to guarantee compliance with all the rights that assist them.

The net flows confirm the data given by the negative and positive flows and show that the preferred regulation by the analysts in charge of decision-making was the Organic Law on Disabilities, placing the Constitution and the Labor Code in second and third place. It is pointed out that, in this case, the Comprehensive Criminal Organic Code was the least preferred by the analysts.

References

[1] D. Gillyane, G. Camilo, R. P. De Souza, T. Dias, and C. Frazão, "Multi-criteria analysis in the health area : selection of the most appropriate triage system for the emergency care units in," pp. 1–16, 2020.

[2] J. Aznar and F. Guijarro, *Nuevos métodos de valoración: modelos multicriterio*. Universitat Politècnica de València, 2012.

[3] S. Bernal and D. Niño, "MODELO MULTICRITERIO APLICADO A LA TOMA DE DECISIONES REPRESENTABLES EN DIAGRAMAS DE ISHIKAWA," 2018. [Online]. Available: file:///C:/Users/Maricar/AppData/Local/Mendeley Ltd./Mendeley Desktop/Downloaded/Bernal, Niño - 2018 - MODELO MULTICRITERIO APLICADO A LA TOMA DE DECISIONES REPRESENTABLES EN DIAGRAMAS DE ISHIKAWA.pdf

[4] M. Nassereddine, A. Azar, A. Rajabzadeh, and A. Afsar, "Aplicación de la toma de decisiones en la respuesta colaborativa a emergencias: una nueva función de preferencia PROMETHEE.," *Rev. Int. reducción del riesgo Desastr.*, vol. 38, p. 101221, 2019.

[5] S. Singh, S. K. Verma, and A. (2020) Tiwari, "A novel approach for finding crucial node using ELECTRE method.," *Int. J. Mod. Phys. B*, vol. 34, no. 09, 2020.

[6] T. Arar, S. Karaoğlan, and C. Dirik, "Selección de la ubicación de la oficina por fuzzy AHP y VIKOR.," *Rev. Int. Ciencias la Inf. y la Decisión*, vol. 11, no. 1, pp. 36–54, 2019.

[7] P. Biswas, S. Pramanik, and B. C. Giri, "TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment.," *Neural Comput. Appl.*, vol. 27, no. 3, 2016.

[8] D. K. Sen, S. Datta, and S. S. Mahapatra, "Ampliación de TODIM para la toma de decisiones en entorno difuso: un caso de investigación empírica sobre selección de robot industrial," *Rev. Int. Gestión Operaciones y Serv.*, vol. 26, no. 2, pp. 238–276, 2017.

[9] F. Smarandache, J. E. Ricardo, E. G. Caballero, and V. Leyva, "Delphi method for evaluating scientific research proposals in a neutrosophic environment.," *Neutrosophic Sets Syst. 34*, 2020.

[10] D. Xu, X. Wei, H. Ding, and H. Bin, "A new method based on PROMETHEE and TODIM for multi-attribute decision-making with single-valued neutrosophic sets.," *Mathematics*, vol. 8, no. 10, p. 1816, 2020.

[11] F. Smarandache, *A unifying field in logics. neutrosophy: Neutrosophic probability, set and logic.* 1999.

[12] J. L. Salmeron and F. Smarandache, "Redesigning Decision Matrix Method with an indeterminacy-based inference process. Multispace and Multistructure," *Neutrosophic Transdiscipl. (100 Collect. Pap. Sci.*, vol. 4, p. 151, 2010.

[13] M. Abdel-Basset, M. Mohamed, F. Smarandache, and A. H. P. Neutrosophic, "An Extension of for Strategic Planning and Decision-Making.," *Symmetry 116*, vol. 10, no. 4 SRC-BaiduScholar FG-0, 2018.

[14] J. Zou, Y. Deng, Y. Hu, and G. Lin, *Measure distance between neutrosophic sets: An evidential approach.* Infinite Study, 2018.

[15] R. E. Chuga Quemac, M. E. Gaspar Santos, L. A. Colcha Ramos, and C. P. Cisneros Zúñiga, "Neutrosophic Analytic Hierarchy Process for the Analysis of Innovation in Latin America," *Neutrosophic Sets Syst.*, vol. 44, no. 1, p. 45, 2021.

[16] J. Ye, "A multicriteria decision-making method using aggregation operators for simplified neutrosophic sets.," *J. Intell. Fuzzy Syst.*, vol. 26, no. 5, pp. 2459–2466, 2014.

[17] S. I. Abdel-Aal, M. M. A. Abd-Ellatif, and M. M. Hassan, "Two Ranking Methods of Single Valued Triangular Neutrosophic Numbers to Rank and Evaluate Information Systems Quality.," *Neutrosophic Sets Syst.*, vol. 19 SRC-, pp. 132–141, 2018.

[18] S. J. L. Baque, "Limites en la Atención a Discapacitados Intelectuales y Psicosociales en la actividad notarial en Ecuador," *USFQ Law Rev.*, vol. 8, no. 2, pp. 15–41, 2021.

[19] R. E. Meléndez Rojas, "Las políticas públicas en materia de discapacidad en América Latina y su garantía de acceso a una educación inclusiva de calidad," *Actual. Investig. en Educ.*, vol. 19, no. 2, pp. 291–319, 2019.

[20] A. L. Santillán Molina, N. V. Vinueza Ochoa, C. F. Benavides Salazar, & S. J. Santillán Ojeda. "Drogas, tráfico y crimen organizado como detonante de actos violentos en las cárceles del Ecuador". Universidad y Sociedad, vol. 14 no.3, pp 478-486, 2022.

[21] S. X. Guerrón Enríquez, J. C. Sigcha Báez, & G. Y Mora Tana. "La vaginitis aguda en mujeres de 18 a 40 años y la incidencia de sus factores de riesgo". Universidad y Sociedad, vol. 14 no. S3, pp 659-665, 2022.

[22] J. E. Jami Carrera, A. A. Monsalve Guamán & C. E. Sánchez Palacios. "Reacciones cutáneas desarrolladas al administrar la vacuna contra el COVID-19". Universidad y Sociedad, vol. 14 no. S3, pp 649-658, 2022.

[23] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[24] González, I. A., Fernández, A. J. R., & Ricardo, J. E. "Violación del derecho a la salud: caso Albán Cornejo Vs Ecuador". Universidad Y Sociedad, vol. 13 no. S2, pp 60-65, 2021.

[25] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.

[26] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[27] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[28] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[29] von Feigenblatt, O. F., Peña-Acuña, B., & Cardoso-Pulido, M. J. "Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones". Ediciones Octaedro, 2022.

[30] G. A. Alcívar Soledispa, S. M. Gavilánez Villamarin, J. A. Urrutia Guevara & M. R. Hidalgo Ruiz. "Manual de procedimiento para el pesaje adecuado de sustancias sujetas a fiscalización en estado líquido: Actualización". Universidad y Sociedad, vol. 14 no. S4, pp 323-332, 2022.

[31] O. D. Ruiz Suarez, J. R. Santillán Andrade, P. A. Centeno Maldonado & R. E. Chuga Quemac. "La sustanciación de los sumarios administrativos a docentes del sistema educativo fiscal y sus consecuencias en las resoluciones emitidas". Universidad y Sociedad, vol. 14 no. S4, pp 316-322, 2022.

[32] F. I. Salazar Barrera, M. A. Salame Ortiz, D. R. Andrade Santamaría & J. E. Nuñez Sanabria (2022). "El derecho del estado ante sucesiones intestadas, incidencia en el patrimonio de herederos. Caso de estudio Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 306-315, 2022.

Received: August 16, 2022. **Accepted:** October 14, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the Nursing Care Process in the Teaching of Nursing

Roberto Enrique Alvarado Chacón[1], Adisnay Rodríguez Plasencia[2] and Olga Mireya Alonzo Pico[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.robertoac58@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.adisnayrodriguez@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Tulcán. Ecuador. E-mail: ut.olgaalonzo@uniandes.edu.ec

Abstract. The health system in any country becomes a Strength based on the level of preparation that its professionals possess and with it their performance in the work. One of the important professionals in this sector is the nursing staff. In the teaching of nursing professionals in universities, the Nursing Care Process is the method of main application and link of all the components required for good professional behavior. The correct fulfillment of its stages, phases, and components achieves the required attention to each patient, the accurate diagnosis of the medical team, and the subsequent proper procedure. In this investigation, the potentialities that Neutrosophic Science possesses are exploited, which with its significant advances, facilitates the determination to a greater degree of the existing problems. A study of the Nursing Care Process in the teaching of Nursing in Ecuador is carried out, in which the criteria of experts in the university training and specialty are taken, as well as students of five selected groups from different regions of the country.

Keywords: Neutrosophy, process, Nursing Care Process, teaching, nursing.

1. Introduction

Medical care is an element of great importance in human well-being in any country, regardless of its economic and social development. Within this, primary care is of greater value, since subsequent follow-up of the patient depends on it. Increasing the capacity of the Health System to respond to the needs of the population is, without a doubt, a task that requires hard work. Primary Health Care, since it is the gateway to the system, should be the instance where the greatest number of health problems are resolved. Thus the importance of making it more resolute [1].

The development of medical care processes from the patient's arrival has to a large extent an important role in the work carried out by the nursing staff. Since its inception, this staff must carry out the tasks of data collection and nursing diagnosis, based on observation, interview, and exploration. They must be used in this same order, this will allow a logical development in the collection and integration of information about the patient by the nursing professional, thereby facilitating the contrast, verification, and in-depth analysis of the data that lead to making diagnoses more effectively.

The objectives of the health system are aimed at equity, the satisfaction of the population with respect to the services received, efficiency, and effectiveness in terms of health and quality of life. In the achievement of these objectives, the medical and nursing staff constitute a fundamental part [2]. In this sense, the training of nursing staff in Ecuador constitutes the basis of the procedure that is carried out. Within the training process, this staff acquires the fundamental knowledge of the Nursing Care Process, an essential process in the initial care of the patient that must be carried out in compliance with all its stages.

The strategy for primary care in the Basque Country, published in February 2019, includes the organization of the corporate model of Care Demand Management (CDM) in Primary Care (PC). This model was born and implanted in Catalonia in 2009, later spreading to other communities such as Andalusia. The objective of the CDM is for PC administrative, nursing, and medical professionals to work as a team, to provide an efficient and proactive response to the health needs presented by the citizen.

From the Patient or User Care Area (PUCA) an administrative triage is carried out to direct each patient to the place where their need can be solved. The implementation of the model requires these professionals to develop new skills and competencies. In the new strategy, the one that deals with the care skills of the PC is the nurse, to make her a benchmark in the care field in collaboration with the doctor. In the current context, the nurse acquires the competence to assess five self-limited mild processes, upper respiratory tract flu, fever, sore throat, nausea and/or vomiting, and diarrhea [3].

The transformation of primary care in Ecuador is shown in non-verbal communication, values and feelings, protection measures, direct attention to citizens, and the identification of vulnerable groups [4]. For this, the Nursing Care Process requires the nurse to have extensive knowledge of various disciplines. The nurse is expected to master basic concepts of Anatomy, Physiology, Chemistry, Microbiology, Nutrition, and Psychology. Such knowledge constitutes the scientific basis for assessing the physiological and psychological state of the individual, family, or community; identifying nursing diagnoses (human responses or functional patterns) in the face of problems related to the health-disease process; detecting factors that contribute to its frequency; selecting the individualized nursing actions that are most likely to be effective, and evaluating the effectiveness of the nursing actions.

The teaching process in the nursing course should include actions aimed at palliative care, which continues to be deficient, especially in its practical application, with training being necessary to have repercussions on the care of people with palliative needs and their families [5]. In this training process, technical skills or abilities involve specific procedures and techniques that allow the nurse to collect data, develop, execute and assess the care plan.

Interpersonal skills or abilities are important during the entire stage of the Nursing Care Process. Since it is a communicative-interactive process, the nurse must have highly developed verbal and non-verbal communication skills. This ability will facilitate the development of positive relationships between the nurse, the patient, and the family. These positive relationships will allow to:

1. Determine what the priorities of the patient or family are.
2. Identify added nursing problems.
3. Create a therapeutic environment in which joint results can be achieved.

The Nursing Care Process has its maximum manifestation during the training of nursing staff, in professional practice, where the nurse makes intentional decisions aimed at their objective. To this end, it relies heavily on critical reasoning, which involves questioning assumptions; determining conclusions, and identification of justifications that support them. You need to have critical thinking skills as an individual and as a professional and be able to make informed personal decisions, as well as all those necessary to provide safe, competent, and qualified nursing care.

This critical reasoning approach is based on the scientific method and reduces the limitations imposed when opinions, values, or feelings influence the reasoning process. Consistent use of well-developed critical thinking skills increases the chances of success in nursing practice and positive patient outcomes. The nursing professional uses the concepts outlined above while applying the Nursing Care Process. This is especially important as health care becomes more complex, its knowledge base expands, and nurses seek to practice more autonomously.

In the training process during teaching, the nurse must learn to make an exact and complete assessment to facilitate the diagnosis and treatment of human responses. The characteristics of the stages, phases, and components of the Nursing Care Process, in its learning and correct application, contribute to the acquisition of this knowledge. In this process, teamwork is required for the efficient development of skills, habits, and knowledge [6].

In the training of nursing staff, the teaching of the Nursing Care Process must allow students to develop skills for caring for people with complex chronic diseases who are vulnerable, which deteriorate as the diseases progress, requiring individualized and coordinated professional care that takes into account disease progression, transitions, and individual preferences [7], [20].

Based on these concepts, the study aims to carry out a neutrosophic analysis of the Nursing Care Process in the teaching of nursing in Ecuador, for which the following specific objectives are defined:

1. To determine the methods for the development of the neutrosophic study of the Nursing Care Process in the teaching of the nursing
2. To assess learning behavior in students of the Nursing Care Process
3. To analyze the learning outcomes of the Nursing Care Process during the course

The indeterminacy in the responses and considerations of the experts and respondents makes it necessary to develop research on the neutrosophic subject. For its realization, an epigraph dedicated to the exposition of materials and methods and another referring to the analysis of its application and discussion were structured. Later, the content of the work is summarized in the form of conclusions.

2. Materials and methods

2.1 Preliminaries

Definition 1: Let X be a space of points (objects) with generic elements in X denoted by x. A neutrosophic single-valued set (SVNS) A in X is characterized by the truth membership function TA(x), the indeterminacy membership function TA(x), and the falsehood membership function FA(x). Then, an SVNS A can be denoted by A=(x, TA(x), IA(x), FA(x) x ∈ X), where TA(x), IA(x), FA(x) ∈ [0.1] for each point x in X. Therefore, the sum

of TA(x), IA(x), and FA(x) satisfies the condition $0 \leq TA(x), +(x)+FA(x) \leq 3$. For convenience, an SVN number is denoted by A = (a b c), where a, b, c ∈ [0,1] and a + b + c ≤ 3 [8].

Definition 2: Let $A_1 = (a_1,b_1,c_1)$ and $A_2 = (a_2,b_2,c_2)$ be two SVN numbers, then the sum between A1 and A2 is defined as follows:

$$A_1 + A_2 = (a_1 + a_2 - a_1a_2, b_1b_2, c_1c_2) \quad (1)$$

Definition 3: Let A1= (a1,b1,c1) and A2= (a2,b2,c2) be two SVN numbers, then the multiplication between A1 and A2 is defined as follows:

$$A_1 * A_2 = (a_1a_2, b_1 + b_2 - b_1b_2, c_1 + c_2 - c_1c_2) \quad (2)$$

Definition 4: Let A = (a,b,c) be an SVN number and $\lambda \in \mathbb{R}$ an arbitrary positive real number, then:

$$\lambda A = \left(1 - (1-a)^{\lambda}, b^{\lambda}, c^{\lambda}\right), \lambda > 0 \quad (3)$$

Definition 5: Let A={A1,A2,…,An } be a set of n SVN numbers, where Aj= (aj,bj,cj) (j= 1,2,…,n). The single-valued neutrosophic weighted average operator is defined by:

$$\sum_{j=1}^{n} \lambda_j A_j = \left(1 - \prod_{j=1}^{n} (1-a_j)^{\lambda_j}, \prod_{j=1}^{n} b_j^{\lambda_j}, \prod_{j=1}^{n} c_j^{\lambda_j}\right) \quad (4)$$

Where λ is the weight of Aj (j= 1,2,…,n), $\lambda_j \in [0,1]$ and $\sum_{j=1}^{n} \lambda_j = 1$

Definition 6: Let $A^* = \{A_1^*, A_2^*, \ldots, A_n^*\}$ be a vector of n SVN numbers, such that Aj* = (a*,b*,c) (j= 1,2,…,n), and Bi={Bi1,Bi2,…,Bim } (i= 1,2,…,m), (j= 1,2,…, north). Then the measure of separation between Bi and A* based on the Euclidean distance is defined as follows:

Next, a scoring function is proposed to classify SVN numbers as follows:

$$s_i = \left(\frac{1}{3}\sum_{j=1}^{n} \left(|a_{ij} - a_j^*|\right)^2 + \left(|b_{ij} - b_j^*|\right)^2 + \left(|c_{ij} - c_j^*|\right)^2\right)^{\frac{1}{2}} \ (i = 1,2,\ldots,m) \quad (5)$$

Then, a scoring function is proposed to classify SVN numbers as follows:

Definition 7: Let $A = (a,b,c)$ be a single-valued neutrosophic number, a score function of a single-valued neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree and falsehood membership degree is defined by:

$$S(A) = \frac{1+a-2b-c}{2} \quad (6)$$

Where: $S(A) \in [-1,1]$

The scoring function S reduces to the scoring function proposed by [8] if b = 0 and a + b ≤ 1.

A linguistic variable is a variable whose values are characterized by words or phrases rather than numbers in a natural or artificial language. The value of a linguistic variable is expressed as an element of its term set. The concept of linguistic variables is very useful for solving decision-making problems with complex content. For example, we can express the performance ratings of alternatives on qualitative attributes using linguistic variables such as very important, important, medium, somewhat important, very slightly important, and so on. Such linguistic values can be represented using single-valued neutrosophic numbers [9, 21]. In the case of the investigation, the linguistic variables to be used are shown below:

Linguistic term	SVNSs
Very No Influence / (VNI)	(0.9;0.1;0.1)
No influence /(NI)	(0.75;0.25;0.20)
Medium influence /(M)	(0.50;0.5;0.50)
Influence /(I)	(0.35;0.75;0.80)
Very High Influence /(VHI)	(0.10;0.90;0.90)

Table 1: Neutrosophic values of linguistic terms. Adapted from: Kilic and Yalsin [9].

2.2 TOPSIS

In the method, there are k-decision makers, m-alternatives, and n-criteria. Decision makers *k* assess the importance of the m-alternatives under n-criteria and rank the performance of the n-criteria with respect to linguistic statements converted to single-valued neutrosophic numbers [10, 24, 25, 26, 27]. Here, decision makers often use a set of weights such that W = (very important, important, medium, unimportant, and very unimportant), and the importance weights based on single-valued neutrosophic values of the linguistic terms are given in Table 1.

On the other hand, the TOPSIS method for SVNS used consists of the following: Assuming that A={ρ1,ρ2,…,ρm } is a set of alternatives and G={β1,β2,…,βn } is a set of criteria, the following steps will be carried out:

Step 1: Determine the relative importance of the experts: For this, the specialists evaluate according to the linguistic scale shown in Table 1, and the calculations are made with their associated SVNN. Le $A_t = (a_t, b_t, c_t)$ be the SVNS corresponding to the t-th decision maker $(t = 1, 2, \dots, k)$. The weight is calculated by the following formula:

$$\delta_t = \frac{a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)}{\sum_{t=1}^{k} a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)} \quad where: \delta_t \geq 0 \; and \sum_{t=1}^{k} \delta_t = 1 \tag{7}$$

Step 2: Construction of the aggregate single value neutrosophic decision matrix: This matrix is defined by $D = \sum_{t=1}^{k} \lambda_t D^t$, where $d_{ij} = (u_{ij}, r_{ij}, v_{ij})$and is used to aggregate all the individual evaluations. It is calculated as the aggregation of the evaluations given by each expert, using the weights of each one with the help of equation 7. In this way, a matrix D = $(d_{ij})_{ij}$ is obtained, where each d_{ij} is a SVNN $(i = 1,2,..,m;\ j = 1,2,\dots,n)$..

Step 3: Determination of the Weight of the Criteria: Suppose that the weight of each criterion is given by $W = (w_1, w_2, \dots, w_n)$, where w_j denotes the relative importance of the criterion $\lambda_t w_j^t = (a_j^t, b_j^t, c_j^t)$. *Si* is the evaluation of the criterion λ_t by the t-th expert. Equation 7 is then used to aggregate the w_j^t with the weights λ_t [11], [22].

Step 4: Construction of the weighted average of single values neutrosophic decision matrix regarding the criteria.

$$D^* = D * W, where\ d_{ij} = (a_{ij}, b_{ij}, c_{ij}) \tag{8}$$

Step 5: Calculation of the positive and negative SVNN ideal solutions: The criteria can be classified as cost-type or benefit-type. Let G_1 be the set of benefit-type criteria and G_2 the cost-type criteria. The ideal alternatives will be defined as follows [12]:

The positive ideal solution that corresponds to G_1.

$$\rho^+ = a_{\rho+w}(\beta_i), b_{\rho+w}(\beta_i), ac_{\rho+w}(\beta_i) \tag{9}$$

The negative ideal solution that corresponds to G_2.

$$\rho^- = (a_{\rho-w}(\beta_i), b_{\rho-w}(\beta_i), ac_{\rho-w}(\beta_i)) \tag{10}$$

Where:

$$a_{\rho+w}(\beta_j) = \begin{cases} max_i a_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ min_i a_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases} \qquad a_{\rho-w}(\beta_j) = \begin{cases} min_i a_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ max_i a_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases}$$

$$b_{\rho+w}(\beta_j) = \begin{cases} max_i b_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ min_i b_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases} \qquad b_{\rho-w}(\beta_j) = \begin{cases} min_i b_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ max_i b_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases}$$

$$c_{\rho+w}(\beta_j) = \begin{cases} max_i c_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ min_i c_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases} \qquad c_{\rho-w}(\beta_j) = \begin{cases} min_i c_{\rho iw}(\beta_j), si\ j \epsilon G_1 \\ max_i c_{\rho iw}(\beta_j), si\ j \epsilon G_2, \end{cases}$$

Step 6: Calculation of the distances to the positive and negative SVNN ideal solutions: With the help of equations 9 and 10 the following equations are calculated:

$$d_i^+ = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^+\right)^2 + \left(b_{ij} - b_j^+\right)^2 + \left(c_{ij} - c_j^+\right)^2\right\}\right)^{\frac{1}{2}} \tag{11}$$

$$d_i^- = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^-\right)^2 + \left(b_{ij} - b_j^-\right)^2 + \left(c_{ij} - c_j^-\right)^2\right\}\right)^{\frac{1}{2}} \tag{12}$$

Step 7: Calculation of the Coefficient of Proximity (CP): The CP of each alternative is calculated with respect to the positive and negative ideal solutions [13].

$$\widetilde{\rho_J} = \frac{s^-}{s^+ + s^-} \tag{13}$$

Where: $.0 \leq \widetilde{\rho_J} \leq 1$

Step 8: Determining the order of the alternatives: They are sorted according to what was achieved by $\widetilde{\rho_J}$. The alternatives are ordered from greatest to least, with the condition that $\widetilde{\rho_J} \rightarrow 1$ is the optimal solution [14, 15, 19], based on the results obtained in the surveys applied to five nursing groups selected from different regions of Ecuador that have approximately the same characteristics.

3 Results and discussion

The training of nursing staff in Ecuador requires good preparation for the Nursing Care Process that favors their comprehensive training in the patient care process[16, 17, 18, 23]. To assess the main components within this process, 8 experts were selected, with a close relationship in the training of nursing staff and high experience in it, who also have links with medical institutions and are updated in the care process. The criteria and components that were taken into account in the development of the research are shown in Fig. 1.

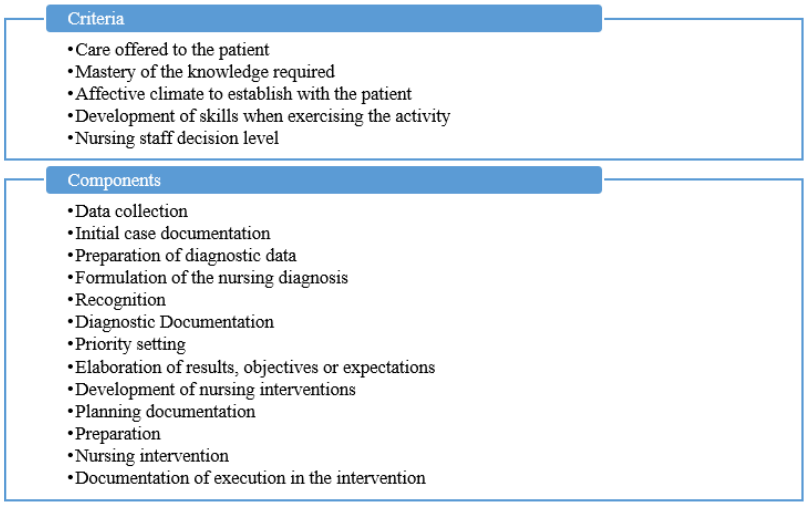


Figure 1: Relevant elements for the investigation. Source: own elaboration.

For the determination of the components most influenced by the previously exposed criteria, the application of the TOPSIS method was necessary. Initially, the weight of the groups of decision-makers established in figure 1 was determined. Due to the relevance determined within the Nursing Care Process and the actions of the nursing staff, the five with the greatest weight were selected. Table 2 shows the results:

	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
Importance Vector $\boldsymbol{\lambda_t}$	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	(0.35;0.75;0.80)
Numerical Importance	0.1646	0.2236	0.2236	0.1646	0.2236

Table 2: Determination of the weight of the main components. Source: own elaboration.

Subsequently, it was necessary to take into account the consideration of these groups, which were asked to fill out a questionnaire to evaluate components against criteria according to the neutrosophic linguistic scale determined in section 2.1 (see Table 3), which gave way to the elaboration of the single-valued criteria matrix (see Table 4). Below is the result of the mode of the rankings of the respondents.

	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
			Data collection		
P1	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.35;0.75;0.80)
P2	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.10;0.90;0.90)	(0.50;0.5;0.50)	(0.50;0.5;0.50)
P3	(0.75;0.25;0.2)	(0.35;0.75;0.80)	(0.75;0.25;0.2)	(0.75;0.25;0.2)	(0.75;0.25;0.2)
P4	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.35;0.75;0.80)	(0.50;0.5;0.50)	(0.50;0.5;0.50)
P5	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.10;0.90;0.90)	(0.50;0.5;0.50)	(0.10;0.90;0.90)
			Formulation of the diagnosis		
P1	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.35;0.75;0.80)
P2	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.10;0.90;0.90)
P3	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)
P4	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	(0.35;0.75;0.80)
P5	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	(0.10;0.90;0.90)
			Priority setting		
P1	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	(0.35;0.75;0.80)
P2	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.35;0.75;0.80)
P3	(0.10;0.90;0.90)	(0.50;0.5;0.50)	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.10;0.90;0.90)
P4	(0.35;0.75;0.80)	(0.50;0.5;0.50)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.10;0.90;0.90)

P5	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.50;0.5;0.50)
			Development of nursing interventions		
P1	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.10;0.90;0.90)
P2	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.50;0.5;0.50)	(0.35;0.75;0.80)	(0.35;0.75;0.80)
P3	(0.10;0.90;0.90)	(0.50;0.5;0.50)	(0.10;0.90;0.90)	(0.50;0.5;0.50)	(0.10;0.90;0.90)
P4	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.10;0.90;0.90)
P5	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.50;0.5;0.50)
			Documentation of execution in the intervention		
P1	(0.50;0.5;0.50)	(0.35;0.75;0.80	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.50;0.5;0.50)
P2	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.50;0.5;0.50)
P3	(0.50;0.5;0.50)	(0.35;0.75;0.80)	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.35;0.75;0.80)
P4	(0.75;0.25;0.20)	(0.50;0.5;0.50)	(0.75;0.25;0.20)	(0.50;0.5;0.50)	(0.75;0.25;0.20)
P5	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.50;0.5;0.50)	(0.50;0.5;0.50)	(0.35;0.75;0.80)

Table 3: Evaluation of the components according to criteria. Source: own elaboration.

	C1	C2	C3	C4	C5
P1	(0.5061;0.5221;0.5161)	(0.5061;0.5221;0.5161)	(0.5061;0.5221;0.5161)	(0.5061;0.5221;0.5161)	(0.5061;0.5221;0.5161)
P2	(0.2482;0.8137;0.8433)	(0.2482;0.8137;0.8433)	(0.2482;0.8137;0.8433)	(0.2482;0.8137;0.8433)	(0.2482;0.8137;0.8433)
P3	(0.1632;0.864;0.8766)	(0.1632;0.864;0.8766)	(0.1632;0.864;0.8766)	(0.1632;0.864;0.8766)	(0.1632;0.864;0.8766)
P4	(0.2625;0.805;0.8374)	(0.2625;0.805;0.8374)	(0.2625;0.805;0.8374)	(0.2625;0.805;0.8374)	(0.2625;0.805;0.8374)
P5	(0.5718;0.4282;0.4074)	(0.5718;0.4282;0.4074)	(0.5718;0.4282;0.4074)	(0.5718;0.4282;0.4074)	(0.5718;0.4282;0.4074)

Table 4: Criteria array of single values. Source: own elaboration.

Continuously and logically, the weights of the problems determined by the group of experts were defined (see Table 5). In addition, the weighted aggregate decision matrix was calculated (see Table 6).

	Criterion weight
C1	(0.6431;0.36581;0.3699)
C2	(0.68262;0.31738;0.30487)
C3	(0.56289;0.45317;0.44142)
C4	(0.38126;0.65378;0.67023)
C5	(0.55363;0.45751;0.46262)

Table 5: Vector of criteria weights. Source: own elaboration.

	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
P1	(0.28017;0.74074;0.73996)	(0.34547;0.67378;0.66363)	(0.28488;0.73867;0.7297)	(0.19296;0.83454;0.84042)	(0.32547;0.69692;0.69509)
P2	(0.09035;0.92622;0.93369)	(0.1114;0.90716;0.91422)	(0.09186;0.92563;0.93107)	(0.06222;0.95291;0.95931)	(0.10495;0.91375;0.92225)
P3	(0.13741;0.89893;0.911579)	(0.16943;0.87283;0.89107)	(0.13971;0.89813;0.91247)	(0.09463;0.9355;0.94833)	(0.15962;0.88185;0.90126)
P4	(0.14533;0.89421;0.91262)	(0.17919;0.86689;0.88697)	(0.14776;0.89337;0.90917)	(0.10008;0.93249;0.94638)	(0.16881;0.87633;0.89755)
P5	(0.31657;0.6898;0.68155)	(0.39032;0.60968;0.58807)	(0.32186;0.68732;0.66899)	(0.218;0.80203;0.80458)	(0.36772;0.63767;0.6266)

Table 6: SVNS Weighted Aggregate Decision Matrix. Source: own elaboration.

The results corresponding to the values of the Coefficient of Proximity are shown in Table 7, which served as the basis for determining the ranking of the effects in terms of the difficulties of preparation in the Nursing Care Process in the nursing education of the population range under study.

	Ideal value +	Ideal value -
P1	(0.10495;0.91375;0.92225)	(0.10495;0.6374;0.6678)
P2	(0.1114;0.90716;0.91422)	(0.1114;0.6097;0.5881)
P3	(0.09186;0.92563;0.93107)	(0.0918;0.6873;0.669)

P4	(0.06222;0.95291;0.95931)	(0.06222;0.802;0.8046)
P5	(0.09035;0.92622;0.93369)	(0.31657;0.6898;0.6816)

Table 7: Positive and negative ideal values and distances. Source: own elaboration.

Alternatives	d+	d-	CP	Order
C1	0.35506471	0.381339	0.51784	4
C2	0.15460157	0.602875	0.7959	1
C3	0.15049808	0.565311	0.78975	2
C4	0.15340259	0.559522	0.78483	3
C5	0.45245592	0.367267	0.44804	5

Table 8: Ranking of components according to Coefficient of Proximity (CP). Source: own elaboration.

Analyzing the results, the formulation of the diagnosis is the main problem within the Nursing Care Process in the teaching of Ecuadorian nursing. In this sense, actions must be reinforced to ensure that nurses, in any of the specialties in which they are trained or specialized, achieve to make a *nursing diagnosis* as accurate as possible. Based on this, what comes next is the *setting of the priorities* and *development of nursing interventions* that this professional is capable of performing. Although preparation actions are carried out, the main direction in the process must be in this path, which will allow, coupled with the comprehensive knowledge, that this staff achieves in each case, to make precise decisions from the nursing diagnosis and its intervention.

Conclusions

The teaching in the nursing course in Ecuador, includes in its formation the Nursing Care Process, an important aspect, The studies of Neutrosophic Science and its significant advances, allowed to make an assessment of this process and determine the existing situation in care to each of its main components and the difficulties in them.

Neutrosophy allowed us to verify more accurately that nursing students in Ecuador, despite the actions developed, require greater attention within the Nursing Care Process, to the main components of the process. It allows this professional to perform an adequate and accurate follow-up of the patient from the moment they enter the medical center, which in turn, serves as a basis and strength for the doctor for the definitive diagnosis and application of the treatment or procedure.

The analysis of the results obtained by the benefits of the application of Neutrosophic Science, allowed to determine that in nursing education, the component with the greatest affectation in training is the *formulation of the diagnosis*, which leads the professional to the correct establishment of priorities and development of nursing interventions, in compliance with each of the stages, phases, and components that make up the Nursing Care Process.

References

[1] F. Aguirre-Bozafa, "El rol de la enfermería de práctica avanzada en atención primaria en Chile," *Revista Médica Clínica Las Condes,* vol. 29, no. 3, pp. 343-346, 2018. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0716864018300646.

[2] I. Pérez-Ciordia, I. Pérez-Fernández, P. A. Herce, and B. I. Beroiz, "Las razones que motivan a estudiar Medicina o Enfermería y el grado de satisfacción con la profesión," *Educación Médica,* vol. 23, no. 3, p. 100743, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1575181322000353.

[3] J. Román-Baquero and D. Redondo-Collado, "Resolución enfermera de los procesos leves autolimitados en atención primaria: estudio descriptivo," *Atención Primaria,* vol. 54, no. 4, p. 102219, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0212656721002535.

[4] S. Berlanga-Fernández, R. Rifà-Ros, R. Villafáfila-Ferrero, and M. Rodríguez-Monforte, "Perspectiva de los estudiantes de enfermería sobre la transformación de la atención primaria durante la pandemia de la enfermedad coronavirus-19: estudio cualitativo mediante fotoelicitación," *Educación Médica,* vol. 22, no. 4, pp. 237-240, 2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1575181321000462.

[5] I. García-Salvador *et al.*, "Valoración de necesidades formativas de nivel básico en cuidados paliativos en enfermeras de atención primaria en España," *Atencion Primaria,* vol. 54, no. 5, p. 102344, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0212656722000646.

[6] J. Dickerson and A. Latina, "Enfermería de equipo: el enfoque colaborativo mejora la atención al paciente," *Nursing (Ed. española),* vol. 35, no. 3, pp. 15-16, 2018. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/S0212538218300694.

[7] A. Miguélez-Chamorro, M. I. Casado-Mora, M. C. Company-Sancho, E. Balboa-Blanco, M. A. Font-Oliver, and I. R.-M. Isabel, "Enfermería de Práctica Avanzada y gestión de casos: elementos imprescindibles en el nuevo modelo de atención a la cronicidad compleja en España," *Enfermería Clínica,* vol. 29, no. 2, pp. 99-106, 2019. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/S1130862118302134.

[8] A. A. Supciller and F. Toprak, "Selection of wind turbines with multi-criteria decision making techniques involving neutrosophic numbers: A case from Turkey," *Energy,* vol. 207, no. 1, p. 118237, 2020. [Online]. Available: https://doi.org/10.1016/j.energy.2020.118237.

[9] H. S. Kilic and A. S. Yalcin, "Comparison of municipalities considering environmental sustainability via neutrosophic DEMATEL based TOPSIS," *Socio-Economic Planning Sciences,* vol. 75, no. 1, p. 100827, 2021. [Online]. Available: https://doi.org/10.1016/j.seps.2020.100827.

[10] P. Gulum, E. Ayyildiz, and A. T. Gumus, "A two level interval valued neutrosophic AHP integrated TOPSIS methodology for post-earthquake fire risk assessment: An application for Istanbul," *International Journal of Disaster Risk Reduction,* vol. 61, no. 1, p. 102330, 2021. [Online]. Available: https://doi.org/10.1016/j.ijdrr.2021.102330.

[11] R. Kumar Tiwari and R. Kumar, "A framework for prioritizing cloud services in neutrosophic environment," *Journal of King Saud University - Computer and Information Sciences,* vol. 34, no. 6, Part B, pp. 3151-3166, 2022/06/01/ 2022, doi: https://doi.org/10.1016/j.jksuci.2020.05.009.

[12] P. Gulum, E. Ayyildiz, and A. Taskin Gumus, "A two level interval valued neutrosophic AHP integrated TOPSIS methodology for post-earthquake fire risk assessment: An application for Istanbul," *International Journal of Disaster Risk Reduction,* vol. 61, p. 102330, 2021/07/01/ 2021, doi: https://doi.org/10.1016/j.ijdrr.2021.102330.

[13] M. Abdel-Basset, A. Atef, and F. Smarandache, "A hybrid neutrosophic multiple criteria group decision making approach for project selection," *Cognitive Systems Research,* vol. 57, pp. 216-227, 2019/10/01/ 2019, doi: https://doi.org/10.1016/j.cogsys.2018.10.023.

[14] A. A. Supciller and F. Toprak, "Selection of wind turbines with multi-criteria decision making techniques involving neutrosophic numbers: A case from Turkey," *Energy,* vol. 207, p. 118237, 2020/09/15/ 2020, doi: https://doi.org/10.1016/j.energy.2020.118237.

[15] A R. Soria Acosta., A. Rodriguez Plasencia & B. Sánchez Martínez. "Guía para el manejo de pacientes pediátricos diagnosticados con epilepsia refractaria al tratamiento". Universidad y Sociedad, vol. 14 no. S3, pp 638-648, 2022

[16] R. F. Donoso Noroña., N. Gómez Martínez & A. Rodríguez Plascencia. "Incidencia en las personas adultas del síndrome metabólico: prevalencia, diagnóstico y tratamiento". Universidad y Sociedad, vol. 14 no. S3, pp 630-637, 2022.

[17] J. S. Villareal Lima, C. G. Rosero Martínez & k. D. Villareal Enríquez. "El aborto y su argumento jurídico en caso de enfermedades catastróficas en el Ecuador". Universidad y Sociedad, vol. 14 no. S3, pp 566-575, 2022.

[18] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[19] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.

[20] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.

[21] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[22] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[23] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[24] Acuña, B. P., & Von Feigenblatt, O. F. "La lengua y la literatura en el aula del futuro enmarcado en el aprendizaje personalizado. In Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones" (pp. 13-24). Ediciones Octaedro, 2022.

[25] C. F. Benavides Salazar, A. P. Vera Coloma, M. C. Moran Giler & E. J. Escobar Gonzales. "Conflicto entre la teoría del delito y la sentencia condenatoria en el procedimiento abreviado en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 298-305, 2022.

[26] G. V. Jordán Naranjo, J. H. Sánchez Espinosa, C. F. Soria Mesías & J. E. Nuñez Sanabria. "Principio de proporcionalidad de las penas en el delito de peculado. Caso de estudio Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 287-297, 2022.

[27] J. O. Jacome Cordones, M. A. Yamasque Paredes, F. D. Villamarin Barragán & M. R. Mena Peralta. "La citación por medios de comunicación en procesos no penales en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 278-286, 2022.

Received: August 17, 2022. **Accepted:** October 14, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Application of Neutrosophy to the Analysis of Open Government, its Implementation and Contribution to the Ecuadorian Judicial System

Gustavo Adolfo Álvarez Gómez[1], Maikel Yelandi Leyva Vázquez[2], and Jesús Estupiñán Ricardo[3]

[1] Rector, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: rectorado@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Babahoyo. Ecuador. E-mail: ub.c.investigacion@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.jesusestupinan@uniandes.edu.ec

Abstract. The implementation of open governments is a trend in recent years in democratic countries, of which Ecuador is a part. Reaching its correct development and operation represents a challenge and an opportunity for the sectors that make up society, including the judicial system. The present investigation is based on the analysis of open government and how it can be brought to reality in the Ecuadorian judicial system, taking into account that like any phenomenon of practical life, it presents a certain degree of indeterminacy in the information analyzed. Methods such as PESTEL analysis, cognitive maps, and neutrosophic soft sets were used. The conditions that must be guaranteed for the application of an open government in Ecuador and the interrelationships between them were determined which were plotted through a neutrosophic cognitive map. Then, the neutrosophic soft sets were applied for the hierarchy of these conditions, determining that in the first place the judicial system should be strengthened through an increase in the mechanisms of citizen participation.

Keywords: open government, neutrosophy, neutrosophic soft set, neutrosophic cognitive maps.

1 Introduction

Having effective spaces for participation is a necessity for countries and democratic systems to maintain citizen trust. The assumed model of public governance must take into account the great persistent inequalities in terms of access and use of information, which is accentuated in the Latin American region. If not managed properly, these inequalities make the implementation of the government much more complex [1].

Open Government is born as a new prototype and way of interacting between the government, society, and administrations. This is a transparent, collaborative, and multidirectional approach to citizen participation, both in monitoring and in public decision-making, from whose stage or space of action it is possible to create public value beyond the borders of state procedures. It is a new way of communicating, organizing, and managing innovation inside and outside the public service. Actively interact with everyone, mainly with citizens; decentralize resources that were constrained, and benefit from massive collaboration. It is characterized by transparency in its operations and does not behave as an isolated department or jurisdiction [2].

Multiple studies have been carried out in this area of knowledge, which is largely subject to the forms of action and perception of people, which makes it difficult to carry out and interpret since a portion of indeterminacy and uncertainty is introduced in information, as happens in most cases of practical life, making it uncertain and not unique, but hesitant or alternative [3]. To include qualitative research, this quantitative character of uncertainty, the discipline known as Neutrosophy arises. There are numerous applications of neutrosophy to real life and specifically, the soft set, among which are the legal and social sciences.

Neutrosophy deals with decision-making problems that involve human knowledge, which frequently presents uncertainty, indeterminacy, and inconsistency in information, this is a tool to represent those inconsistencies and contradictions that undoubtedly exist in the processing of evidence within the social sciences and everyday life [4].

The Neutrosophic set is a novel tool to characterize uncertain information in a more sufficient and precise way, as well as allowing the information to be represented in a more complete and real way, which allows covering not only truth or falsehood but also ambiguity. ignorance, contradiction, neutrality, and saturation [5].

Neutrosophic sets are characterized by a truth membership function (t), an indeterminacy membership function (i), and a falsehood membership function (f) independently, which lie within the standard real unit interval $[-0, 1+]$ standard or not standard [6]. There is not always total certainty in the information that is worked on, since there may be several points of view that sometimes may even be contrary, lack of information, or that it is

incomplete due to various causes, the lack of witnesses, the hesitant opinion of one of the factors involved in the process, among other reasons [7].

When triads of truth values are assigned to the possible values of the obtained sets, meaning membership, non-membership, and indeterminacy, soft set theory is combined with that of neutrosophic sets to obtain greater precision in the results [8]. This situation can be modeled by operators that have some degree of indeterminacy due to the imprecision that exists in the world.

2 Materials and methods

2.1 Strategic Analysis PESTEL

It is a strategic analysis technique to determine the external environment that affects the following factors, namely political, economic, sociocultural, technological, ecological, and legal. It consists of determining the forces that affect the specific environment: sector, employment market, target groups, and competition, among others. It is a technique to analyze businesses that allows and determines the context in which it operates, in turn, allows the design of strategies to defend themselves, take advantage of or adapt to anything that affects the sector. The categories contemplated are the following: internal policies, economics, human resources, technology, social, and legal [9, 10].

2.2 Neutrosophic Cognitive Maps

Starting from the previous elements, in this particular work, the use of Neutrosophic Cognitive Maps (NCMs) is proposed considering the advantages that this technique offers compared to other soft-computing techniques, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy relationships. NCMs are an integration of the Fuzzy Cognitive Maps (FCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NSs) introduced by Smarandache in 1995.

This technique overcomes the inability of traditional FCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty. NCMs constitute a technique that has received increasing attention due to their possibilities for representing causality. The following is a set of definitions necessary for working with NCMs.

Definition 1. Let $N = \{(T, I, F): T, I, F \in [0,1]\}$be a neutrosophic set of evaluation v: is a mapping of a group of propositional formulas into N, i.e., each sentence p is associated with a value in N, as it is exposed in Equation 1, meaning that P is T% true, I% indeterminate, and F% false.

$$v(p) = (T, I, F) \tag{1}$$

Hence, neutrosophic logic is a generalization of fuzzy logic, based on the concept of neutrosophy according to [11].

Definition 2. (See [12]) Let K be the ring of real numbers. The ring generated by $K \cup I$ is called a neutrosophic ring if it involves the indeterminacy factor in it, where I satisfies $I2 = I, I + I = 2I$ and in general, $I + I + \ldots + I = nI$, if $k \in$, then $k.I = kI, 0I = 0$. The neutrosophic ring is denoted by $K(I)$, which is generated by $K \cup I, i.e., K(I) = < K \cup I >$, where $< K \cup I >$ denotes the ring generated by K and I.

Definition 3. A neutrosophic matrix is a matrix $A = [c]_{ij} = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n;\ m, n \geq 1$, such that each$a_{ij} \in K(I)$, where $K(I)$ is a neutrosophic ring.

An element of the matrix can have the form $a + bI$, where "a" and "b" are real numbers, whereas I is the indeterminacy factor. The usual operations of neutrosophic matrices can be extended from the classical matrix operations.

For example, $\begin{pmatrix} -1 & I & 5I \\ I & 4 & 7 \end{pmatrix} \begin{pmatrix} I & 9I & 6 \\ 0 & I & 0 \\ -4 & 7 & 5 \end{pmatrix} = \begin{pmatrix} -21I & 27I & -6 + 25I \\ -28 + I & 49 + 13I & 35 + 6I \end{pmatrix}$

Additionally, a neutrosophic graph is a graph that has at least one indeterminate edge or one indeterminate node. The neutrosophic adjacency matrix is an extension of the adjacency matrix in classical graph theory. $a_{ij} = 0$ means nodes i and j are not connected, $a_{ij} = 1$ means that these nodes are connected and $a_{ij} = I$, which means the connection is indeterminate (unknown if it is or if not). Fuzzy set theory does not use such notions. On the other hand, if the indetermination is introduced in a cognitive map, as it is referred to, then this cognitive map is called a neutrosophic cognitive map, which is especially useful in the representation of causal knowledge. It is formally described in Definition 4.

Definition 4. A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts like policies, and events, among others, as nodes and causalities or indeterminates as edges. It represents the causal relationship between concepts. The measures described below are used in the proposed model, they are based on the absolute values of the adjacency matrix [13]:

Outdegree(v_i) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of outgoing relationships (c_{ij}) of the variable:

$$od(v_i) = \sum_{}^{n} c_{ij} \tag{2}$$

Indegree(v_i) is the sum of the column elements. It reflects the strength of outgoing relationships (c_{ij}) from the variable:

$$id(v_i) = \sum_{}^{n} c_{ji} \tag{3}$$

Total centrality (total degree (v_i)), is the sum of the indegree and the outdegree of the variable:

$$td(v_i) = od(v_i) + id(v_i) \tag{4}$$

The variables are classified according to the following criteria:

- Transmitting variables are those with $od(v_j) > 0\ e\ id(v_i) = 0$
- The receiving variables are those with $od(v_j) = 0\ e\ id(v_i) > 0$
- Ordinary variables satisfy both $od(v_j) \neq 0\ e\ id(v_i) \neq 0$

The static analysis is applied using the adjacency matrix, taking into consideration the absolute value of the weights. Static analysis in Neutrosophic Cognitive Maps (NCM), initially contains the neutrosophic number of the form $(a\ +\ bI)$, where I = indetermination. It requires a process of de-neutrosophication as proposed in [12], where $I\ \in\ [0, 1]$ and it is replaced by their values maximum and minimum. Finally, the average of the extreme values are processed, which is useful to obtain a single value. This value contributes to the identification of the characteristics to be attended, according to the factors obtained, for our case study.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{5}$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \tag{6}$$

2.3 Neutrosophic Soft Set

Let U, be a universe of situations, H a non-empty subset of U, and $P(H)$ the power function of H. Let a be an attribute and A a set of these attribute values.
A function F: $A \rightarrow P(H)$ is called an indeterminate or soft function if:

i. The set A has some indeterminacy;

ii. or $P(H)$ has some indeterminacy;

iii. or there exists at least one attribute value $v \in A$, such that F(v) = *indeterminate* (unclear, uncertain, or not unique);

iv. or two or the three previous situations.

The neutrosophic soft set is defined as the soft set where F (perhaps) or F (indeterminate), etc, is roughly equivalent to F (yes), F (no), F (true), or F (false), associated with a triad of values (α, β, γ), where $(\alpha, \beta, \gamma) \in [0, 1]^3$ mean the degrees of truth, indeterminacy, and falsehood, respectively [14].

From the previously discussed, the following neutrosophic triplet can be formed [14]:

i. (Classical) function, which is a well-defined (inner-defined) function for all elements in its domain of definition, or (T, I, F) = (1,0,0).

ii. Neutrofunction (or neutrosophic function), is a function that is partially well defined (degree of truth T), partially indeterminate (degree of indeterminacy I), and partially externally defined (degree of falsehood F) in its domain of definition, where (T, I, F)ϵ{(1,0,0), (0,0,1)}.

Definition 5. [14]: let U be a universe of situations, H is a non-empty subset of U, with $P(H)$ the power set of H, and an attribute, with its set of attribute values, is denoted by A. Then the pair (F, H), where $F: A \to P(H)$, is called classic soft set on H.

Definition 6. [14]: If the function $F: A \to P(H)$, where for each $x \in A, f(x) \in P(H)$ and $f(x)$ is true and unique, it is called a determinate (classical) function.

2.4 Model based on neutrosophic soft sets

Starting from a group of statements or sentences that will be denoted by $A = \{a_1, a_2, \cdots, a_k\}$, which must be classified or evaluated by the specialists that belong to the group of experts $E = \{e_1, e, \cdots, e_l\}$ chosen for the study. The set of parameters to be measured is given by C={Yes, No}, where "yes" means that for the expert, the statement is positive, while "no" means the opposite.
The algorithm to follow is:

1. A group of statements is compiled whose veracity and relevance in the legal context are to be determined. These will be denoted by $A = \{a_1, a_2, \cdots, a_k\}$.

A group of experts or specialists is convened to issue a criterion regarding the veracity or relevance of the statements described. This is understood as a set.

2. The expert (e_j) is asked to give its opinion on the statement a_i about truthfulness and relevance Expert (e_j) is asked to rate the truth of the statement and its relevance on a scale of 0 to 100. This value is called α_{ij}.

   2.2. Expert (e_j) is asked to give an on-scale evaluation of the falsehood and irrelevance of the statement on a scale of 0 to 100. This value is called γ_{ij}.

   2.3. Expert (e_j) is asked to give an on-scale assessment of the uncertainty relevance of the situation on a scale of 0 to 100. This value is called β_{ij}.

As a result, the following triad is obtained:

$$R\_ij = \langle \alpha\_ij/100, \beta\_ij/100, \gamma\_ij/100 \rangle \quad (7)$$

This is the triad of truth values between 0 and 1, to evaluate the degrees of truth, indeterminacy, and falsehood, respectively, of the relevance of the i-th test according to the j-th expert.

3. The Soft Set is formed by $F: A \to P(H)$, where $A = \{yes, no\}$, being as follows:

$$F(yes) = \{(a_i, e_j, R_{ij}), where\ R_{ij} \neq \langle 0, \tau, 1 \rangle, \tau \geq 0\}, \quad (8)$$

while:

$$F(no) = \{(a_i, e_j, R_{ij}), where\ R_{ij} \neq \langle 1,0,0 \rangle\} \quad (9)$$

4. The final results for tests or evidence are obtained from:

$$G(yes) = \{(a_i, \wedge_j R_{ij}) : j \in \{1,2, \cdots, l\}\ such\ that\ (a_i, e_j, R_{ij}) \in F(si)\} \quad (10)$$

Where, (11) $[\![\wedge\_j\ R]\!]\_ij = \langle \min\_j \{\alpha\_ij/100\}, \max\_j \{\beta\_ij/100\}, \max\_j \{\gamma\_ij/100\} \rangle$

$$G(no) = \{(a_i, \wedge_j NOT(R_{ij})) : j \in \{1,2, \cdots, l\}\ such\ that\ (a_i, e_j, R_{ij}) \in F(no)\} \quad (12)$$

Where, $[\![NOT(R)]\!]\_ij) = \langle \gamma\_ij/100, \beta\_ij/100, \alpha\_ij/100 \rangle$

5. For each proof or evidence s_i, select between $G(yes)$ and $G(no)$ the triad that meets the following requirements.

   5.1 If a_i is in $G(yes)$ and is not in $G(no)$, then this statement is determined to be true or relevant, with a truth value determined by $\overline{R}_i = \wedge_j R_{ij}$.

5.2 If a_i is in $G(no)$ and is not in $G(yes)$, then this statement is determined to be true or relevant, with a truth value determined by $\tilde{R}_i = \wedge_j NOT(R_{ij})$.

5.3 If a_i is in both sets, the following criteria are followed:

A single value $V\_i = (2 + R\_i1 - R\_i2 - R\_i3)/3$ is calculated, where $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3} \rangle$, while $F\_i = (2 + R\_i1 - R\_i2 - R\_i3)/3$, where $\tilde{R}_i = \langle \tilde{R}_{i1}, \tilde{R}_{i2}, \tilde{R}_{i3} \rangle$.

5.3.1 If $\bar{V}_i > \bar{F}_i$ then the i-th statement is relevant with a truth value of $\bar{R}_i$.

5.3.2 If $\bar{V}_i < \bar{F}_i$ then the i-th test is not relevant with a value of truth $\tilde{R}_i$.

5.3.4 If $\bar{V}_i = \bar{F}_i$ then it is determined that the i-th test is not relevant enough with a truth value of $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3} \rangle$.

6. The statements that were classified as relevant are issued, in order from highest to lowest, where $e_m \succ e_n$ if and only if $\bar{V}_m > \bar{V}_n$.

3 Results

3.1 Results of the bibliographic review

In 2015, the Agenda for 2030 was established by the United Nations Organization, which consists of 17 Sustainable Development Goals, in which a guide is proposed for the coming years to achieve, among other goals, societies with greater and better levels of access to justice instances. According to the Charter of Rights of Persons before Justice in the Ibero-American Judicial Environment adopted in 2017, it is stated that the Judicial Power must act more openly and transparently, the Summit defends a new model of justice that makes it more transparent, understandable, attentive to all people, responsible to the citizen, agile and technologically advanced, and that protects the weakest [15].

One of the models based on public governance that has been proposed in recent years is that of the "Open State", which was dealt with for the first time in 2013 by Oscar Oszlak, according this author, the change in the terminology of "Open Government " to “Open State” involves the fact of taking into account the inherent complexities that are intrinsic within it, since it is made up of public companies, universities, mixed public entities and all kinds of decentralized organizations, both state and non-state [16].

Among the principles of Open Government in the executive branch are transparency, the foundation of democracy. One strategy to achieve it is access to government information. Government action using technology should be made known to citizens in a clear and didactic way, which allows for meeting the needs of social information, improving the image, and regaining confidence in the government, in addition to generating growth and good governance results, fighting corruption, and promoting citizen participation.

Participation is another key element in achieving democracy, it is understood as a serious commitment of citizens to government affairs. The cooperation of citizens in the design of programs and through debates, assessments, criticisms, and complements of laws, decrees, measures, or other decisions made by governments through the opinions of citizens. Collaboration is another of the principles and this can occur between organizations and within them between employees, independent individuals, levels of government, and companies or between all. Its success depends on the achievement of the interaction between communication, trust, commitment, understanding, and results, of the participating actors.

The opening of data makes cooperation possible between the public administration and third parties that want to collaborate with it, so information must be treated as a resource and, therefore, managed properly to identify useful information that must be disclosed, such as documents of consultation, policies, plans, laws, regulations, programs, statistics and the one that the government must supply, such as results indicators, accounts and respond to the required requests.

The information generated by the Judiciary must be available as a whole, at a reasonable reproduction cost, and preferably available for download from the Internet. There must be no discrimination in terms of effort, individuals or groups to use, reuse, and redistribute the information. Access to information should not be restricted to certain uses or subject to copyright. The data must be in formats that allow its reuse, redistribution, and integration with other data, to facilitate the interactive use of the information. Sustainability is particularly relevant to consider whether the benefits of an activity or program can continue over time, regardless of who implements them. The data on the web pages must be kept up to date [17].

3.2 Application of the PESTEL method to identify the conditions to guarantee the application of open government in Ecuador based on the bibliographic review carried out.

Dimension	Condition
Political	Strengthen the judicial system through an increase in citizen participation mechanisms.
Economic	Allocate resources to face the high cost of massive popular consultation and citizen participation processes
Social	Carry out communication and information campaigns for communities on open government
Technological	Use of ICT and dissemination of how to use it
Ecological	No
Legal	Increase official feedback spaces

Table 1: PESTEL. Source: own elaboration. Note: based on the bibliographic review carried out.

Based on the conditions identified by the PESTEL method, the map shown in Figure1 was created.

1) Political
2) Economic
3) Social
4) Technological
5) Legal

A group of experts composed of jurists and law professors was selected. As an inclusion criterion, it was taken into account that the experts had a minimum of five years of professional experience, both as teachers and in practice, associated with the Autonomous University of the Andes.

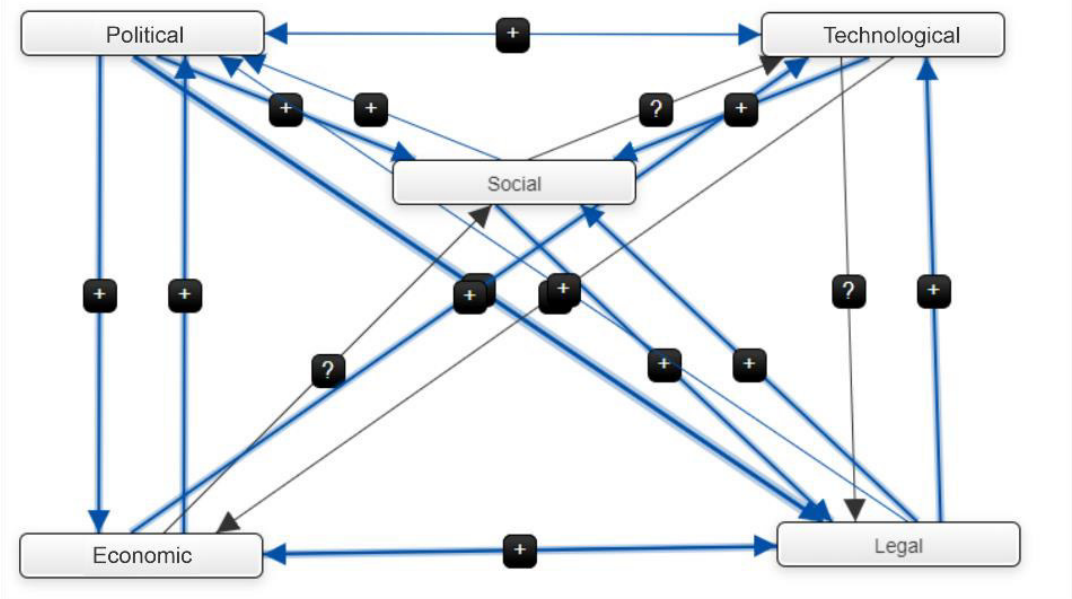


Figure 1: Neutrosophic Cognitive Map. Source: own elaboration.

	Political	Economic	Social	Technological	Legal
Political	0	0.32	0.24	0.16	0.62
Economic	0.21	0	0	0.44	0.13
Social	0.11	I	0	I	0.17
Technological	0.09	I	0.24	0	I
Legal	0.15	0.2	0.22	0.17	0

Table 2: Adjacency matrix. Source: own elaboration.

Component	Indegree	Outdegree	Centrality	Preferred State	Type
Political	0.56	1.34	1.9000000000000001		ordinary
Economic	0.52	0.78	1.3		ordinary
Social	0.7	0.28	0.98		ordinary
Technological	0.77	0.32999999999999996	1.1		ordinary
Legal	0.92	0.74	1.6600000000000001		ordinary

Figure 2: Static Analysis. Source: own elaboration.

3.3 Application of the neutrosophic model.

To carry out the neutrosophic analysis of the difficulties encountered, 4 experts were chosen, from those previously selected, for this purpose those who had at least 2 publications in scientific journals on the subject matter were chosen. The 4 experts consulted (e_1, e_2, e_3, e_4) issue their criteria regarding the conditions identified $(c_1, c_2, c_3, c_4, c_5)$, in triads of values from 0 to 100, to standardize truthfulness, negative and indeterminate answers, where the first score represents the certainty or relevance of the assertion raised, the second value indicates doubt or indeterminacy regarding the assertion described and the third value indicates the falsehood of that assertion.

Conditions:

- c_1: Strengthen the judicial system through an increase in citizen participation mechanisms.
- c_2: Allocate resources to face the high cost of massive popular consultation and citizen participation processes
- c_3: Carry out communication and information campaigns for communities on open government
- c_4 : Use of ICT and dissemination of how to use it
- c_5: Increase official feedback spaces

Expert/Condition	c1	c2	c3	c4	c5
e1	⟨86,12,14⟩	⟨68,16,7⟩	⟨74,7,9⟩	⟨90,5,11⟩	⟨69,11,9⟩
e2	⟨95,8,10⟩	⟨73,2,10⟩	⟨73,12,10⟩	⟨63,10,9⟩	⟨78,12,10⟩
e3	⟨88,9,12⟩	⟨62,18,12⟩	⟨88,10,6⟩	⟨59,8,12⟩	⟨66,16,12⟩
e4	⟨93,0,9⟩	⟨68,12,9⟩	⟨89,11,14⟩	⟨52,11,13⟩	⟨83,14,11⟩

Table 3: Result of the evaluation of the conditions according to the experts.

The above results are divided by 100 to bring them to a [0, 1] scale which is more common in neutrosophic theories.

Expert/Condition	c1	c2	c3	c4	c5
e1	⟨0.86,0.12,0.14⟩	⟨0.68,0.16,0.7⟩	⟨0.74,0.7,0.9⟩	⟨0.90,0.5,0.11⟩	⟨0.69,0.11,0.9⟩
e2	⟨0.95,0.8,0.10⟩	⟨0.73,0.2,0.10⟩	⟨0.73,0.12,0.10⟩	⟨0.63,0.10,0.9⟩	⟨0.78,0.12,0.10⟩
e3	⟨0.88,0.9,0.12⟩	⟨0.62,0.18,0.12⟩	⟨0.88,0.10,0.6⟩	⟨0.59,0.8,0.12⟩	⟨0.66,0.16,0.12⟩
e4	⟨0.93,0,0.9⟩	⟨0.68,0.12,0.9⟩	⟨0.89,0.11,0.14⟩	⟨0.52,0.11,0.13⟩	⟨0.83,0.14,0.11⟩

Table 4: Result of the evaluation of the conditions according to the experts, expressed in the form of neutrosophic numbers.

Soft sets are defined as:

$$F(yes) = \left\{ \begin{array}{c} (e_1, c_1, \langle 0.86,0.12,0.14\rangle), (e_1, c_2, \langle 0.68,0.16,0.7\rangle), (e_1, c_3, \langle 0.74,0.7,0.9\rangle), \\ (e_1, c_4, \langle 0.90,0.5,0.11\rangle), (e_1, c_5, \langle 0.69,0.11,0.9\rangle) \\ (e_2, c_1, \langle 0.65,0.8,0.10\rangle), (e_2, c_2, \langle 0.73,0.2,0.10\rangle), \\ (e_2, c_3, \langle 0.53,0.12,0.10\rangle), (e_2, c_4, \langle 0.63,0.10,0.9\rangle), (e_2, c_5, \langle 0.63,0.10,0.9\rangle) \\ (e_3, c_1, \langle 0.78,0.9,0.12\rangle), (e_3, c_2, \langle 0.62,0.18,0.12\rangle), \\ (e_3, c_3, \langle 0.68,0.10,0.6\rangle), (e_3, c_4, \langle 0.59,0.8,0.12\rangle), \\ (e_3, c_5, \langle 0.66,0.16,0.12\rangle)(e_4, c_1, \langle 0.73,0,0.9\rangle), \\ (e_4, c_2, \langle 0.68,0.12,0.9\rangle), (e_4, c_3, \langle 0.89,0.11,0.14\rangle), \\ (e_4, c_4, \langle 0.52,0.11,0.13\rangle), (e_4, c_5, \langle 0.83,0.14,0.11\rangle) \end{array} \right\}$$

$$F(No) = \left\{ \begin{array}{c} (e_1, c_1, \langle 0.86,0.12,0.14\rangle), (e_1, c_2, \langle 0.68,0.16,0.7\rangle), (e_1, c_3, \langle 0.74,0.7,0.9\rangle), \\ (e_1, c_4, \langle 0.90,0.5,0.11\rangle), (e_1, c_5, \langle 0.69,0.11,0.9\rangle) \\ (e_2, c_1, \langle 0.65,0.8,0.10\rangle), (e_2, c_2, \langle 0.73,0.2,0.10\rangle), \\ (e_2, c_3, \langle 0.53,0.12,0.10\rangle), (e_2, c_4, \langle 0.63,0.10,0.9\rangle), (e_2, c_5, \langle 0.63,0.10,0.9\rangle) \\ (e_3, c_1, \langle 0.78,0.9,0.12\rangle), (e_3, c_2, \langle 0.62,0.18,0.12\rangle), \\ (e_3, c_3, \langle 0.68,0.10,0.6\rangle), (e_3, c_4, \langle 0.59,0.8,0.12\rangle), \\ (e_3, c_5, \langle 0.66,0.16,0.12\rangle)(e_4, c_1, \langle 0.73,0,0.9\rangle), \\ (e_4, c_2, \langle 0.68,0.12,0.9\rangle), (e_4, c_3, \langle 0.89,0.11,0.14\rangle), \\ (e_4, c_4, \langle 0.52,0.11,0.13\rangle), (e_4, c_5, \langle 0.83,0.14,0.11\rangle) \end{array} \right\}$$

$G(yes) = \{(c_1, \langle 0.86,0.12,0.14\rangle), (c_2, \langle 0.62,0.18,0.12\rangle), (c_3, \langle 0.53,0.12,0.10\rangle), (c_4, \langle 0.52,0.11,0.13\rangle), (c_5, \langle 0.66,0.16,0.12\rangle)\}$

$G(no) = \{(c_1, \langle 0.14,0.12,0.86\rangle), (c_2, \langle 0.12,0.18,0.62\rangle), (c_3, \langle 0.10,0.12,0.53\rangle), (c_4, \langle 0.13,0.11,0.52\rangle), (c_5, \langle 0.66,0.16,0.12\rangle)\}$

From $G(yes)$ and $G(no)$ it is concluded that c_1 is relevant with a truth value of $\langle 0.56,0.12,0.14\rangle$, c_2 is relevant with a truth value of $\langle 0.62,0.18,0.12\rangle$, c_3 is relevant with a truth value of $\langle 0.53,0.12,0.10\rangle$, c_4 is relevant with a truth value of $\langle 0.52,0.11,0.13\rangle$, and c_5 is also relevant with a truth value of $\langle 0.66,0.16,0.12\rangle$.

This decision is made since $\overline{V}_1 = 0.87 > \overline{F}_1 = 0.39$; $\overline{V}_2 = 0.77 > \overline{F}_2 = 0.44$; $\overline{V}_3 = 0.84 > \overline{F}_3 = 0.48$; $\overline{V}_4 = 0.76 > \overline{F}_4 = 0.50$; $\overline{V}_5 = 0.79 > \overline{F}_5 = 0.43$.

The difficulties identified are ranked as follows: $c_1 \succ c_3 \succ c_5 \succ c_2 \succ c_4$, where all are relevant or important according to the results obtained.

Finally, the order of relevance of the identified difficulties is as follows:

1- c_1: Strengthen the judicial system through an increase in citizen participation mechanisms.
2- c_3: Carry out communication and information campaigns for communities on open government
3- c_5: Increase official feedback spaces

4- c_2: Allocate resources to face the high cost of massive popular consultation and citizen participation processes

5- c_4 : Use of ICT and dissemination of how to use it

Conclusions

The adoption of an open government is a need and aspiration of democratic countries. Its adoption is not exempt from challenges that must be overcome to achieve adequate performance in this regard. Taking into account the literature consulted, the regulatory framework that supports this type of government, its principles, and its main characteristics were identified. From this and using the PESTEL analysis, the conditions that must be guaranteed for the application of an open government in Ecuador are specified. In order to know the interrelationships between these conditions, neutrosophic cognitive maps were applied, a tool that allowed us to represent the relationships between each one, including those that by their nature were indeterminate.

Neutrosophic soft sets were then applied to rank these conditions, determining that in the first place the judicial system must be strengthened through an increase in citizen participation mechanisms. Then carry out communication and information campaigns to the communities about open government, increase official feedback spaces, allocate resources to deal with the high cost of massive popular consultation and citizen participation processes, and, finally, guarantee the use of ICTs and the dissemination of how to use them.

References

[1] K.-T. Tai, "Open government research over a decade: A systematic review," *Government Information Quarterly,* vol. 38, p. 101566, 2021.

[2] P. L. Barreto Granada and M. A. Osorio-Sanabria, "Análisis comparado de la adopción de gobierno abierto en países de América Latina," *Boletín mexicano de derecho comparado,* vol. 53, pp. 911-949, 2020.

[3] M. Khan, L. H. Son, M. Ali, H. T. M. Chau, N. T. N. Na, and F. Smarandache, "Systematic review of decision making algorithms in extended neutrosophic sets," *Symmetry,* vol. 10, p. 314, 2018.

[4] N. El-Hefenawy, M. A. Metwally, Z. M. Ahmed, and I. M. El-Henawy, "A review on the applications of neutrosophic sets," *Journal of Computational and Theoretical Nanoscience,* vol. 13, pp. 936-944, 2016.

[5] M. L. Vázquez, J. Estupiñan, and F. Smarandache, "Neutrosofía en Latinoamérica, avances y perspectivas," *Revista Asociación Latinoamericana de Ciencias Neutrosóficas. ISSN 2574-1101,* vol. 14, pp. 01-08, 2020.

[6] I. Deli, "Interval-valued neutrosophic soft sets and its decision making," *International Journal of Machine Learning and Cybernetics,* vol. 8, pp. 665-676, 2017.

[7] M. Abu Qamar and N. Hassan, "An approach toward a Q-neutrosophic soft set and its application in decision making," *Symmetry,* vol. 11, p. 139, 2019.

[8] M. I. Ali, F. Feng, X. Liu, W. K. Min, and M. Shabir, "On some new operations in soft set theory," *Computers & Mathematics with Applications,* vol. 57, pp. 1547-1553, 2009.

[9] G. K. Robles-Zambrano, P. M. Moreno-Arvelo, M. E. Gaspar-Santos, and A. R. Pupo-Kairuz, "A Trialist Perspective of the Labor Inclusion of Indigenous People in Ecuador through PESTEL and Neutrosophic Cognitive Maps," *Neutrosophic Sets and Systems,,* vol. 37, pp. 31-38, 2020.

[10] A. R. Pupo-Kairuz, D. V. Ponce-Ruiz, G. F. Viteri-Pita, and F. S. Bustillo-Mena, "PESTEL analysis of environment state responsibility in Ecuador," *Neutrosophic Sets and Systems,,* vol. 34, pp. 70-78, 2020.

[11] S. H. Al-subhi, E. I. Papageorgiou, P. P. Pérez, G. S. S. Mahdi, and L. A. Acuña, "Triangular neutrosophic cognitive map for multistage sequential decision-making problems," *International Journal of Fuzzy Systems,* vol. 23, pp. 657-679, 2021.

[12] N. Martin, A. Aleeswari, and W. Lilly Merline, "Risk Factors of Lifestyle Diseases – Analysis by Decagonal Linguistic Neutrosophic Fuzzy Cognitive Map," *Materials Today: Proceedings,* vol. 24, pp. 1939-1943, 2020/01/01/ 2020.

[13] M. D. L. L. Cepeda, J. V. P. Quilambaque, A. M. N. Quispe, E. T. M. Álvarez, and J. F. R. Pérez, "Hermeneutical Analysis of the Determinants of Obesity using Neutrosophic Cognitive Maps," *Neutrosophic Sets and Systems,* vol. 44, pp. 90-99, 2021.

[14] F. Smarandache, "Introduction to the IndetermSoft Set and IndetermHyperSoft Set," *Neutrosophic Sets and Systems,* vol. 50, p. 38, 2022.

[15] A. A. C. de Souza, M. J. d'Angelo, and R. N. Lima Filho, "Effects of Predictors of Citizens' Attitudes and Intention to Use Open Government Data and Government 2.0," *Government Information Quarterly,* vol. 39, p. 101663, 2022.

[16] J. J. S. González, "Transparentando los poderes públicos: Gobierno abierto, parlamento abierto y justicia abierta," *Revista Venezolana de Gerencia,* vol. 23, 2018.

[17] E. Ruijer, F. Détienne, M. Baker, J. Groff, and A. J. Meijer, "The politics of open government data: Understanding organizational responses to pressure for more transparency," *The American review of public administration,* vol. 50, pp. 260-274, 2020.

Received: August 18, 2022. **Accepted:** October 15, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Statistical Analysis of Behavioral Medicine Knowledge in University Students

Kenia Mariela Peñafiel Jaramillo[1]. Denisse Isabel Suaste Pazmiño[2] and Alex Ramón Valencia Herrera[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.keniapenafiel@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.denissesuaste@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.alexvalencia@uniandes.edu.ec

Abstract. In the present investigation, a neutrosophic statistical analysis was carried out to determine the level of knowledge of medical students about behavioral medicine. It is based on the recognition that Neutrosophic Descriptive Statistics includes all the techniques to summarize and describe the characteristics of the neutrosophic numerical data. That is why the objective of this investigation is to carry out a neutrosophic statistical analysis in behavioral medicine that allows identifying the level of knowledge of university students about behavioral medicine. Techniques from both classical and neutrosophic statistics were used, within the latter, the neutrosophic frequency distribution and the results obtained present an adequate level of validity and leave new edges of the investigated theme open for future investigations.

Keywords: statistics, neutrosophy, behavioral medicine, neutrosophic frequency distribution.

1 Introduction

Since the beginning of mankind with the development of the hominid ancestors of *homo sapiens*, in the prehistoric period, illness was considered a natural characteristic and was sufficient reason to abandon or isolate oneself from the sick person. A tendency that was stripped of all ethics and values that society should possess.

The field of behavioral medicine emerged basically from the initiative of psychologists working in the health field, but medical professionals were immediately attuned to the new approach given its scientific nature and its application in various scenarios. This is an area of health sciences that has been systematized from various approaches and perspectives.

The term "behavioral medicine" was proposed by Lee Birk in 1973 when he published his book "Biofeedback: Behavioral medicine" indicating the usefulness of biofeedback in various diseases. According to the aspects stated by Blanchard [1], who is considered one of the scientists who made important contributions to this subject.

On these arguments, the psychiatrist Engel, [2], proposed an alternative to the biomedical model, establishing the biopsychosocial model, emphasizing the emotional, behavioral, and contextual aspects of the human being. Important postulates for the development of behavioral medicine worldwide. These assessments contributed to the international scientific community to resume research in this area of knowledge.

On the other hand, this development was aimed at the fact that Behavioral Medicine offers a space for interdisciplinary discussion to exchange ideas and theoretical approaches in this regard. This is taken into account by several medical specialties in the treatment of complex diseases that require a look from this approach.

The conceptual basis of the topic addressed in this research has as important support the clinical models that have shown greater effectiveness in addressing health problems are those derived from the Cognitive Behavioral Theory. For this reason, it is essential to address topics related to the study and systematization of Behavioral Medicine during the medical courses or degrees where new physicians are trained.

An approach that should be considered in Behavioral Medicine is the use of behavioral modification techniques, which could change people's lifestyles and, therefore, improve their health, prevent various organic diseases and reduce their symptoms.

On the other hand, the researcher Agras [3], has pointed out that the development of behavioral medicine implies a different scientific approach to the field of Health-Disease, which leads to interdisciplinary research activities.

There is a consensus of several authors such as Baños [4]; Watson [5], who consider that behavioral medicine suggests a complex scenario of interaction of multiple variables (environmental, psychological, physiological,

sociological, and nutritional) at different levels, resulting in variations in physiological responses, in such a way that a change in a certain variable could determine an organic dysfunction.

It is important to point out that some other disciplines and sciences can enrich the work of Behavioral Medicine. Such is the case of neutrosophy, which according to researchers such as Smarandache [6], [7] is: a new branch of philosophy, which opened a new field of research in metaphilosophy, and which studies the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra.

Etymologically neutrosophy (from French neutre and Latin neuter meaning neutral and Greek sophia, knowledge) is the knowledge of neutral thoughts. It forms the basis for neutrosophic logic, neutrosophic sets, neutrosophic probability, and neutrosophic statistics [8].

The benefits offered by Behavioral Medicine are diverse, which is why it is required to know if during the training of doctors, and professionals of the health sciences in general, they have or receive knowledge of Behavioral Medicine. Based on the aforementioned criteria, the level of knowledge of undergraduate medical students of the Autonomous Regional University of the Andes (UNIANDES) in Ecuador is evaluated.

The objective of this research is to perform a neutrosophic statistical analysis in behavioral medicine that allows the identification of the level of knowledge of university students about behavioral medicine.

2 Materials and Methods

2.1 Subjects under study

At the time of conducting this research, the calculation of the population was done using neutrosophic statistical tools, since it is necessary to identify the total number of university students to be investigated. In accordance with the fact that the total population under study is known, the calculation shown in the following expression is used:

p = approximate proportion of the reference population to be studied in the present investigation, q = proportion of the reference population that does not present the subject under study (1 -p). The desired confidence level (Z). Indicates the degree of confidence that the true value of the parameter in the population will be found in the calculated sample. The absolute precision (d). It is the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points). N means the size of the investigated population.

A neutrosophic sample is a chosen subset of a population, a subset that contains some indeterminacy: either with respect to several of its individuals (who may not belong to the population under study or may only partially belong to it) or with respect to the subset as a whole. While classical samples provide precise information, neutrosophic samples provide vague or incomplete information [6], [28].

Following Smarandache's statement, in the present investigation a confidence level between 90 and 95% is desired, z= [1.645, 1.96], d= [0.05, 0.1] and p = [0.4,0.44], N=40. The result, known as the neutrosophic sample n= [10.1, 30.6], indicates that the sample should be in values between 10 and 31 university students [8], [21].

Once the neutrosophic sampling had been applied and the level of determination and indeterminacy of the sample had been identified, a total of 25 university students from the Medical School of the Autonomous Regional University of the Andes, in the Republic of Ecuador, were randomly selected. All of them have passed the third year of study. [29], [30]

2.2 Type of research

An exploratory, descriptive and non-experimental research was carried out. With a cross-sectional design [9, 24]. Therefore, the selected instruments are applied once. This is done to obtain reliable data on this topic to enrich the syllabus of the medical school of UNIANDES.

2.3 Instruments

Methods and techniques used in the research

Analytical-synthetic: it allowed a study on the theoretical and methodological foundations that support the neutrosophic statistical analysis of behavioral medicine in university students. It was used for the systematization, generalization, and concretization of the information processed.

Inductive-deductive: it made it possible to make inferences and generalizations from the neutrosophic statistical analysis on behavioral medicine in university students, as well as the interpretation of the data obtained, from which new logical conclusions are deduced.

Survey: It was carried out to 100% of the members of the sample under study since this was the instrument used to identify the knowledge of university students about behavioral medicine.

Measurement: It was used to attribute values to each of the survey questions and to be able to quantify the results derived from them.

Applied statistical analysis

Statistical analyses were performed with SPSS v. 20 software (SPSS Inc, Chicago, IL, United States). Data relating to descriptive statistics will be presented by frequency distribution and percentage analysis.

The present research takes into account Smarandache's [6], [22], [23], [26] evaluations of neutrosophic descriptive statistics, for whom it comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data. Within it, the neutrosophic frequency distribution will be used in particular.

2.3.1 Neutrosophic Method

For the realization of this research, the postulates of several researchers were taken into account, among which the following stand out [10], [11], [12], [13], [14], [15], [18], which make explicit the procedure for the realization of a statistical analysis using the neutrosophic frequency distribution. For this purpose, the knowledge of behavioral medicine in university students is taken into account. Assessed from a deterministic and indeterministic approach. [27]

For the development of the research with a neutrosophic approach, a flow of activities was taken into account, as illustrated in Figure 1.

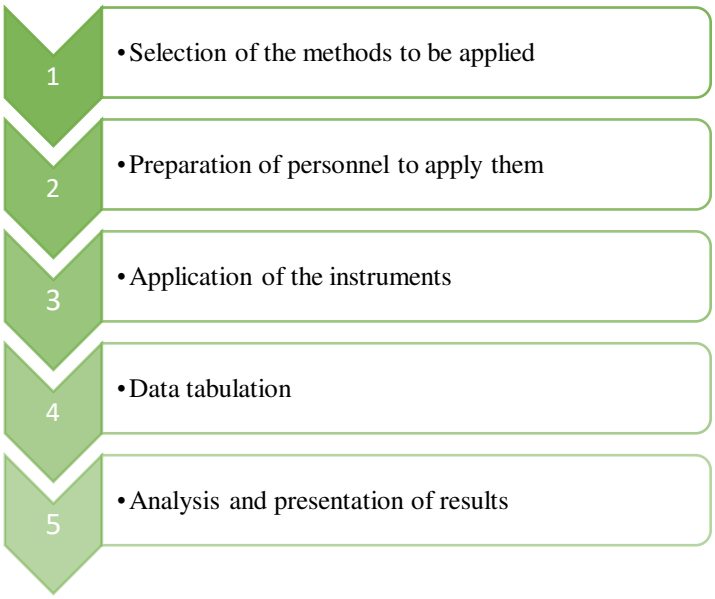


Figure 1: Logic followed for neutrosophic statistical analysis

According to authors who have systematized neutrosophic statistics such as [16], [17], [19], [20], [25] all agree that at the beginning there is imprecise information, which is why it is necessary to calculate the extremes (min and max) of the absolute or estimated frequencies, therefore, it is necessary to work as shown below:

$$min_{fn} = 3 + 2 + 6 + 11 = 22$$

$$max_{fn} = 4 + 3 + 8 + 17 = 32$$

Once the relative neutrosophic frequencies have been calculated, it is necessary to identify the minimum and maximum values for each of the results obtained as the level of knowledge of the university students. For this purpose, the following formula will be applied:

$$min_{fnri} = \frac{min_{fni}}{max_{fn}}$$

And

$$max_{fnri} = \frac{max_{fni}}{min_{fn}}$$

For the case of frequencies that do not present indeterminacy, it is satisfied that:

$$min_{fni} = max_{fni} = fni$$

Therefore:

$$min_{fnr0} = \frac{min_{fn0}}{max_{fn}} = \frac{3}{32} = 0{,}093$$

$$max_{fnr0} = \frac{max_{fn0}}{min_{fn}} = \frac{4}{22} = 0.181$$

$$min_{fnr3} = \frac{min_{fn3}}{max_{fn}} = \frac{2}{32} = 0{,}062$$

$$max_{fnr4} = \frac{max_{fn4}}{min_{fn}} = \frac{3}{22} = 0{,}136$$

$$max_{fnr6} = \frac{max_{fn6}}{min_{fn}} = \frac{6}{32} = 0{,}187$$

$$max_{fnr8} = \frac{max_{fn8}}{min_{fn}} = \frac{8}{22} = 0{,}363$$

$$max_{fnr11} = \frac{max_{fn11}}{min_{fn}} = \frac{11}{32} = 0{,}343$$

$$max_{fnr17} = \frac{max_{fn17}}{min_{fn}} = \frac{17}{22} = 0{,}772$$

The cumulative neutrosophic relative frequency value was obtained by summing the observed neutrosophic relative frequencies.

$$Frna = [0{,}093\ ,0.181] + [0{,}062, 0{,}136] + [0{,}187\ , 0{,}363] + \ [0{,}343\ , 0{,}772] = \ [0{,}685\ , 1{,}452]$$

Table 1 shows the results of the absolute and relative neutrosophic frequencies, which will be evaluated using graphs in the following section, as they will be described in greater depth.

Number of undergraduate students with knowledge of behavioral medicine	Neutrosophic absolute frequency	Neutrosophic relative frequency
2	5	[0,093 ,0.181]
4	10	[0,062, 0,136]
8	[10,20]	[0,187 , 0,363]
10	[11,19]	[0,343 , 0,772]
Total 2-10	[22,32]	[0,685 , 1,452]

Table 1. Results of absolute and relative neutrosophic frequencies. Source: own elaboration

3 Results

Once the results have been tabulated, they are presented. This is the basis of this section of the present research. Where the data of each of the questions of the survey applied to the medical students that were selected for the study are shown.

Question	Yes	No	Does not answer the question
Do you know what behavioral medicine consists of?	5	18	2

Table 2. Results of question 1 of the survey applied to UNIANDES medical students. Source: Results obtained by the researchers.

The results in Table 2 show that most of the university students participating in the research have little knowledge of what behavioral medicine consists of. Only 5 of them gave a positive answer to this question, a majority of 18 students reported not having any knowledge and 2 of them refused to answer the question. These results make it evident that further work is still needed to increase the knowledge of university students about what is behavioral medicine.

Question	Yes	No	Does not answer the question
Are you familiar with the objectives and contents of behavioral medicine?	4	20	1

Table 3. Results of question 2 of the survey applied to UNIANDES medical students. Source: Results obtained by the researchers

Once the results of question 2 of the survey applied to the university students were tabulated. It is observed that they are similar to those of the previous question, which denotes that the investigated university students present gaps in theoretical knowledge on this subject. Only 4 answered that they knew the objectives and contents of behavioral medicine. While the vast majority (20 of them) said they did not know them, nor had they studied them during their study program.

Question	Yes	No	Does not answer the question
Are you familiar with the methodological bases that support behavioral medicine?	2	22	1

Table 4. Results of question 3 of the survey applied to UNIANDES medical students. Source: Results obtained by the researchers

The results in Table 4 are those derived from the university students' answers to question 3 of the survey applied. It shows that there is little knowledge of the methodological bases that support behavioral medicine. Only 2 university students marked this option in the survey. On the other hand, the majority of them (22) selected the option "no". This supports the statement expressed above and only 1 student returned this question of the survey blank.

The results shown allow affirming that this line of research requires deepening the teaching-learning process of university students of medicine. They still have gaps in theoretical and methodological knowledge about Behavioral Medicine, which is why it is necessary to review the possible spaces for the inclusion of this topic in the medical curriculum of UNIANDES.

Conclusion

The analysis of the theoretical and methodological references on the study of Behavioral Medicine in university students evidences the existence of different bibliographic sources on the subject, however, tools are required to accurately assess the current state of this subject.

The methodological logic followed was based on general scientific methods such as measurement and survey, which made it possible to identify the level of knowledge of university students about Behavioral Medicine.

The interpretations of the results offer validity to the research developed because a neutrosophic statistical analysis allowed to open new lines of research that imbricate the neutrosophic sciences with Behavioral Medicine.

References

[1] Blanchard EB. Behavioral Medicine: Past, Present, and Future. J Consult Clin Psychol. 1982; 50(6):795-796. doi: 10.1037/h0077935

[2] Engel GL. The need for new medical model: A challenge for biomedicine. Science. 1977; 4286(196):129-136. doi: 10.1126/science.847460

[3] Agras, W. S. Behavioral Medicine in the 1980s: Nonrandom connections. Journal of consulting and clinical psychology, 50 (6), 1982. 797-803.

[4] Baños-Chaparro J. Medicina Conductual: Una revisión histórica. Rev Neuropsiquiatr. 2022; 85(1): 29-37

[5] Watson JB, Rayner R. Conditioned emotional reactions. J Exp Psychol. 1920; 3(1):1-14. doi: 10.1037/h0069608

[6] Smarandache, F. Introduction to Neutrosophic Statistics. 2014Infinite Study

[7] Smarandache, F. Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic Over-/Under-/Off-Logic, 2016 Probability, and Statistics.

[8] Smarandache, F., Quiroz-Martínez, M. A., Ricardo, J. E., Hernández, N. B., & Leyva Vázquez, M. Y. Application of neutrosophic offsets for digital image processing. Investigacion Operacional, 202041(5), 603-611.

[9] Vázquez, M. L., & Smarandache, F. Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre 2018. Infinite Study.
[10] Ramírez DM, YM Gordo, LA Zaldívar, JL Mateo, Sistema de superación de la cultura física profiláctica y terapéutica, MCML 2021
[11] Carballido, R. M., Paronyan, H., Matos, M. A., & Santillán Molina, A. L. (2019). Neutrosophic statistics applied to demonstrate the importance of humanistic and higher education components in students of legal careers. Neutrosophic Sets and Systems, 26(1), 26.
[12] Palacios, A. J. P., Ricardo, J. E., Piza, I. A. C., & Herrería, M. E. E. Phenomenological Hermeneutical Method and Neutrosophic Cognitive Maps in the Causal Analysis of Transgressions against the Homeless. 2021Neutrosophic Sets and Systems, 44, 147-156.
[13] Carballido, R. M., Paronyan, H., Matos, M. A., & Santillán Molina, A. L. Neutrosophic statistics applied to demonstrate the importance of humanistic and higher education components in students of legal careers. 2019 Neutrosophic Sets and Systems, 26(1), 26.
[14] Jansi, R., Mohana, K., & Smarandache, F. Correlation Measure for Pythagorean Neutrosophic Fuzzy Sets with T and F as Dependent Neutrosophic Components. 2019. Neutrosophic Sets and Systems, 30(1), 16.
[15] O. Mar, I. Santana, and J. Gulín, "Algoritmo para determinar y eliminar nodos neutrales en Mapa Cognitivo Neutrosófico," Neutrosophic Computing and Machine Learning, vol. 8, pp. 4-11, 2019.
[16] Jansi, R., Mohana, K., & Smarandache, F. Correlation Measure for Pythagorean Neutrosophic Fuzzy Sets with T and F as Dependent Neutrosophic Components. 2019. Neutrosophic Sets and Systems, 30(1), 16.
[17] Villamar, C. M., Suarez, J., Coloma, L. D. L., Vera, C., & Leyva, M. Analysis of Technological Innovation Contribution to Gross Domestic Product Based on Neutrosophic Cognitive Maps and Neutrosophic Numbers. 2019. Neutrosophic Sets and Systems, 34.
[18] C. A. Pérez Padilla, Z. Herrera Lazo, D. Cañizares Vásquez, J. García Conrado, F. Nieto Núñez. "Incidencia de Síndrome de Down en la sala de neonatología". Universidad y Sociedad, vol. 14 no. 2, pp 328-335, 2022.
[19] S. A. Machuca Vivar, N. V. Vinueza Ochoa, C. R. Sampedro Guamán & A. L. Santillán Molina. "Habeas data y protección de datos personales en la gestión de las bases de datos". Universidad y Sociedad, vol. 14 no. 2, pp 244-251, 2022.
[20] J. L. Acosta Espinoza, A. R. Lenin León Yacelga & W. G. Sanafria Michilena. "Las aplicaciones móviles y su impacto en la sociedad". Universidad y Sociedad, vol. 14 no. 2, pp 237-243, 2022.
[21] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.
[22] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.
[23] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[24] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[25] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.
[26] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.
[27] von Feigenblatt, O. F., & Linstroth, J. P. "Applied history and the teaching of leadership: a case for the use of historical case studies in leadership programs". Universidad y Sociedad, vol. 14 no. S3, pp 433-438, 2022. https://rus.ucf.edu.cu/index.php/rus/article/view/2973
[28] B. I. Lara Mafla, R. E. Chuga Quemac & J. M. Puetate Paucar. "La inmediación y los temores a la prisión preventiva en el Ecuador". Universidad y Sociedad, vol. 14 no. S3, pp 358-365, 2022. https://rus.ucf.edu.cu/index.php/rus/article/view/2965/2920
[29] D. F. Coka Flores, J. M. Puetate Paucar & R. E. Chuga Quemac. "El garantismo y su desigualdad en legislación ecuatoriana". Universidad y Sociedad, vol. 14 no. S3, pp 350-357, 2022. https://rus.ucf.edu.cu/index.php/rus/article/view/2964/2919
[30] D. F. Coka Flores, J. M. Puetate Paucar & R. E. Chuga Quemac. "El sistema informático "Business Intelligence" y la argumentación jurídica por su uso en el ámbito judicial". Universidad y Sociedad, vol. 14 no. S3, pp 340-349, 2022.

Received: August 19, 2022. **Accepted:** October 16, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Student Competences and Neutrosophic Personality Operators in Law Students at the University of Chimborazo

Paul Alejandro Centeno Maldonado[1], Alipio Absalón Cadena Posso[2], Gabriela Paulina León Burgos[3] and Leny Cecilia Campaña Muñoz[4]

[1] Universidad Regional Autónoma de Los Andes, Sede Riobamba. Ecuador. E-mail: ur.paulcenteno@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.alipiocadena@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.gabrielaleon@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.lenicampana@uniandes.edu.ec

Abstract. The objective of this study was to demonstrate the usefulness of neutrosophic logic to determine the relationship between student competencies and certain personality traits in law students at the National University of Chimborazo. For this, the study was carried out on a sample of 20 students in the last year of their degree. The Analytic Hierarchy Process method was used to support the decision-making process. Using this method, the most desirable competencies in the distance learning process and those personality traits of interest to the researchers were selected. The results obtained made it possible to determine that, on average, there is indeterminacy in some of the pairs of personality traits in students with average or low performance. The students who, on average, presented high levels of performance in the competencies analyzed, showed greater tendencies towards the trait than towards the anti-trait or indeterminacy.

Keywords: neutrosophic operators, personality traits, student skills, Neutrosophy.

1 Introduction

Neutrosophy is a branch of philosophy, introduced by F. Smarandache in 1980, which studies the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra [1]. This science constitutes a general framework for the unification of many existing logics, such as fuzzy logic (especially intuitionistic fuzzy logic), paraconsistent logic, intuitionistic logic, etc. [2]. It deals with imprecise and vague situations where exact analysis is difficult or impossible [3].

The essential idea of Neutrosophic Logic is to characterize each logical statement in a 3D-Neutrosophic Space. In this framework, each dimension of the space represents, respectively, the truth (T), the falsehood (F), and the indeterminacy (I) of the statement under consideration. T, I, F are standard or non-standard real subsets of]-0, 1+[without necessarily any connection between them [4][5].

The origin of Neutrosophy has conceived the analysis of the trilogy made up of (<A>, <neutA>, <antiA>). This means the conception of a proposition, theory, event, concept, or entity <A> in relation to its opposite <antiA>, and to its neutral <neutA>. As the dynamic of opposites and their neutrals, it constitutes an extension of dialectics (which is the dynamic of opposites only) [6].

The introduction of new elements in this branch has allowed, over time, new advances to be made in the implementation of this science in various sectors of science, economy, and society [7][8]. The use of neutrosophic logic has manifested itself in industry, medicine, building sciences, communications, image processing, management, meteorology, and hundreds of other fields where the presence of indeterminacy or vagueness [7].

Recently, the use of this tool has reached the study and analysis of the human psyche. This extension to the branch of psychology has seen the birth of interesting applications of great interest to society in general. Personality traits, human behavior, and temperament analysis are some of the most interesting categories that have been studied so far [10]. The neutrosophic analysis of these interactions seeks an effective and real way to understand the extremely complex system of simultaneous interactions between pluri-underegos, pluriegos, and pluri-superegos [11].

Neutropsychic personality traits constitute a dynamic psychological system open to tendencies to feel, think and act in a very specific way in each individual. In this way, it can be established that the neutrosophic psychological theory studies the concepts of traditional psychology, from a triad of possible states (<A> <neutA> <antiA>) [12].

The specialists dedicated to the branch of legal sciences constitute a fundamental pillar of all modern society. From the university stage to the exercise of the profession, these professionals require the acquisition of tools that allow them to be effective during their future work. The appearance of the COVID-19 pandemic highlighted the need to promote self-study and distance learning, and with it, the ability to develop the necessary skills to facilitate it throughout the world.

Competency-based learning refers to systems of instruction, assessment, grading, and academic reporting, which are based on the knowledge and skills that students demonstrate they have learned and are expected to learn as they progress through their education. This type of educational system tries to promote a functional capacity for dynamic knowledge in students, beyond the traditional theoretical and rote pedagogy. Innovative aspects are incorporated into it, among them, the active participation of the student to achieve significant learning through the creation, use, and enhancement of their skills [13].

Among the fundamental professional skills in the training of jurists and lawyers are those that enhance interpretation, systematization, integration, argumentation, and application. Together with this, knowing how to reflect, identify, choose, dominate and integrate social problems allows us to interpret the principles, theories, norms, and axioms, in order to understand and apply the discipline of law.

In this sense, the present study seeks to demonstrate the usefulness of neutrosophic logic to determine the relationship between student competencies and certain personality traits in law students at the National University of Chimborazo. For this, the study is carried out in a sample of 20 law students.

To achieve the study, the Analytic Hierarchy Process (AHP) method is used in its neutrosophic version, as support for the decision-making process. This model for solving multicriteria problems is an effective way to define comparison measures between its elements and use them to reach effective conclusions during the decision process [14].

In this way, in the present study, some basic concepts related to the Theory of Neutrosophic Psychology are firstly analyzed. Subsequently, the proposed decision method is analyzed. Consecutively, the bases on which the analysis is carried out are established, the results achieved are presented and, the conclusions derived from the study are presented.

2 Preliminaries

2.1 Preliminary Neutrosophic Psychological Theory

The triplet $(< A >, < neut\,A >, < antiA >)$ is extended to discrete refined neutrosophic memory, where $(< A > 1, < A > 2, \dots, < A > l; < neutA > 1, < neutA > 2, \dots, < neutA > m; < antiA > 1, < antiA > 2, \dots, < antiA > n)$ are defined based on refined neutrosophy.

Given a universe of discourse, subsets A, B, and C, then the crisp neutrosophic set satisfies the axioms: $A \cap B = \emptyset, B \cap C = \emptyset, C \cap A = \emptyset,$ and $A \cup B \cup C = U$. Therefore, A, B, C form a disjoint partition of the universe of discourse U.

The refined neutrosophic crisp set for type 2 (and similarly for types 1 and 3) is defined as: $A = A1 \cup A2 \cup \dots \cup Ap$, $B = B1 \cup B2 \cup \dots \cup Br$, $C = C1 \cup C2 \cup \dots \cup Cs$, with $A \cap B = B \cap C = C \cap A = \emptyset$, where p, r, s are integers ≥ 1, $p + r + s \geq 4$, and $Ai \cap Aj = \emptyset$ for $i, j \in \{1,2, \dots, p\}$, $i \neq j$; $Bk \cap Bl = \emptyset$ for $k, l \in \{1,2, \dots, r\}$, $k \neq l$; and $Cm \cap Cn = \emptyset$ for $m, n \in \{1,2, \dots, s\}, m \neq n$ [11].

Various experts and trait theorists have concluded that the position of the human being moves on the spectrum between two opposite traits, that is, it behaves dynamically. As an easy generalization of all trait models, any number n ≥ 1 of Traits $< Aj >$ and their corresponding antiTraits $< antiA\,j >$can be considered, for $1 \leq j \leq n$:

$< A\,1 > / < antiA1 >, < A\,2 > / < antiA2 >, \dots, < A\,n > / < antiAn >$.

If the degree of the Trait is greater than or equal to the Trait Threshold (ThT), then the individual is characterized by this Trait. Similarly, if the degree of antiTrait is less than or equal to the threshold of antiTrait (antiThr), then he is characterized by antiTrait. In a neighborhood of the midpoint [-ε, ε], it is the most confused (indeterminate) degree (almost half Trait and half antiTrait) or combination of Trait-antiTrait [15].

Personality traits are measurable by calculating the degree of <A> and the degree of <antiA>. Really, in the world, no individual fits completely (100%) to a personality trait since this is only possible idealistically. In this way, the constants: -antiThr, +Thr, and ε depend on each antiTrait/Trait pair, so they can be different from one antiTrait/Trait pair to another. These constants are generally determined by experts in psychology, depending on the research interests [16].

In this sense, let Trait/anti-Trait be any pair, and let x be an individual belonging to a group of people S, then it is defined that:

$dTrait : S \rightarrow [0, 1]$,

dTrait(x) = the degree of the Trait that characterizes the individual x, and

$dantiTrait: S \rightarrow [-1, 0]$,

dantiTrait(x) = the degree of the antiTrait that characterizes the individual x. The Neutrosophic Trait Operator, combining the opposites, is the cumulative degree of individual x with respect to both the Trait and the anti-Trait, and is defined as:

$dTrait\ and\ antiTrait: S \rightarrow [-1, 1]$,

$dTrait\ \&\ antiTrait(x) = dTrait(x) + dantiTrait(x)$.

For each Trait - antiTrait pair, the degree of the Trait dTrait(x) that characterizes the individual x, and the degree of the antiTrait dantiTrait(x) is calculated. Subsequently, the Neutrosophic Trait Operator dTrait & antiTrait(x) is used and compared with the two thresholds, Thr and antiThr:

- If $dTrait\ \&\ antiTrait(x) \geq +Thr$, then the individual is categorized as definitely belonging to the Trait,
- If d$Trait\ \&\ antiTrait(x) \leq -antiThr$, then the individual is categorized as definitely belonging to the antiTrait.
- If $dTrait\ \&\ antiTrait(x) \in (-\varepsilon, +\varepsilon)$, then the individual is classified as being in a totally indeterminate state between Trait and antiTrait.
- If $dTrait\ y\ antiTrait\ (x) \in (\varepsilon, Thr)$, then the individual is classified as belonging mainly to the Trait.
- And finally, if $dTrait\ \&\ antiTrait(x) \in (-antiThr, -\varepsilon)$, then the individual is categorized as mostly belonging to the antiTrait.

2.2 AHP method

Definition 1: The Neutrosophic set N is characterized by three membership functions, which are the truth-membership function TA, indeterminacy-membership function IA, and 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 $-0 \leq \inf TA(x) + \inf IA(x) + \inf FA(x) \leq \sup TA(x) + \sup IA(x) + \sup FA(x) \leq 3+$.

Notice that, according to the definition, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]-0, 1+[$ and hence, 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 $A = \{< x; TA(x), IA(x), FA(x) > : x \in U\}c$, 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 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, $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy, and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, \text{ otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3 \leq a_4$.

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

$$\text{Addition: } \tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle \quad (4)$$

$$\text{Subtraction: } \tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle \quad (5)$$

$$\text{Inversion: } \tilde{a}^{-1} = \langle ({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \text{ where } a_1, a_2, a_3, a_4 \neq 0 \quad (6)$$

$$\text{Multiplication by a scalar number: } \lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases} \quad (7)$$

Definitions 3 and 4 refer to the single-valued triangular neutrosophic number when the condition $a_2 = a_3$. For simplicity, the linguistic scale of triangular neutrosophic numbers is used, see Table 1 and also compare with the scale defined in [14], [23], [24].

The Analytic Hierarchy Process was proposed by Thomas Saaty in 1980. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision maker must break down the problem into its relevant components. [26], [28], [29], [30]

The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate level. At the lowest level, the decision options are understood. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (8).

$$S = \left\{ \frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9 \right\} \quad (8)$$

We can find in [14] the theory of the AHP technique in a neutrosophic framework. Thus, the indeterminacy of decision-making can be modeled by applying neutrosophic AHP or NAHP for short. Equation 9 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\widetilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (9)$$

Matrix $\widetilde{A}$ must satisfy condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4.

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined [14], [22], which are the so-called score and accuracy indexes, respectively, see Equations 10 and 11:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (10)$$

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (11)$$

Saaty's 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	$\tilde{2} = \langle (1,2,3); 0.40, 0.65, 0.60 \rangle$ $\tilde{4} = \langle (3,4,5); 0.60, 0.35, 0.40 \rangle$ $\tilde{6} = \langle (5,6,7); 0.70, 0.25, 0.30 \rangle$ $\tilde{8} = \langle (7,8,9); 0.85, 0.10, 0.15 \rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale. Source: [14]

Step 1 Select a group of experts.

Step 2 The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 9.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, i.e., $a_{ik} = a_{ij}a_{jk}$ for all i,j and k, then the comparison matrix is consistent, focusing only on the lower, median and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it into a deterministic matrix using Equations 12 and 13. To get the score and the accuracy degree of $\tilde{a}_{ji}$, the following equations are used:

$$S(\tilde{a}_{ji}) = {}^{1}\Big/_{S(\tilde{a}_{ij})} \tag{12}$$

$$A(\tilde{a}_{ji}) = {}^{1}\Big/_{A(\tilde{a}_{ij})} \tag{13}$$

With compensation by the accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, the following deterministic matrix is derived:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix}$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous 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 the use of the calculus of the Consistency Index (CI) when applying this technique, which is a function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that the consistency of the evaluations can be determined by the equation $CI = \frac{\lambda_{max} - n}{n-1}$, where n is the order of the matrix. In addition, the Consistency Ratio (CR) is defined by the equation CR = CI/RI, where RI is given in Table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated with every order.

If CR≤0.1 It can be considered that the expert's evaluation is sufficiently consistent and hence proceed to use NAHP. This procedure is applied to matrix A.

3 Methodology

The present study was carried out taking into account the students in the last year of the Law degree at the National University of Chimborazo, Ecuador. For this, a sample of 20 students was randomly selected. The sample consisted of members of both sexes, with similar ages, belonging to the same study group.

The study carried out was based on the selection, through the use of the NAHP method, of the elements to be studied in the selected sample of students. This means that, in order to better delve into the analyzes to be carried out, the selection of a set of both traits and competencies to be analyzed in accordance with the stated objective was proposed. [17], [18], [21], [25]

In this sense, the analysis of a set of student competencies is carried out to select those that offer a greater impact on the adequate distance learning process. Likewise, the same method (NAHP) is used to determine the main personality traits that students must have for academic achievement under these conditions, as well as future professional development during the exercise of the degree.

In this regard, taking into account the most used neutrosophic Trait-antiTrait personality pairs according to [19], [20], [27]:

- Extraversion – Introversion
- Conscientiousness – unconsciousness
- Perfectionism – Imperfectionism
- Sensitivism – Insensitivism
- Innovative – Conservative
- Self-esteem – Low self-esteem
- Kindness – Dislike
- Openness to intellect and experience – Closeness to intellect and experience

- Inhibition – Disinhibition
- Flexibility – Stiffness
- Emotivism – Not Emotivism
- obsessiveness – No obsessiveness
- Caution – Impulsiveness
- Timidity – Audacity
- Honesty – Dishonesty
- Hostility – No hostility.

The analysis of the competencies selected for the study is carried out with the support of Law school professors, and through self-inspections carried out by the students involved in the study. It is executed by obtaining the average of the evaluations obtained from both the teachers and the students, but greater weight is given to the opinion of the teachers. The evaluations of each of the competencies are considered in a range between high, medium, and low.

The analysis of the personality traits of the students is supported by 5 experts in the field of psychology. In order to guarantee reliable results, 3 sessions of interviews are carried out, in which the neutrosophic questionnaire is used. This questionnaire is constituted to obtain answers in a convenient format (degree of truth (t), degree of indeterminacy (uncertainty, lack of clarity), and degree of falsehood (f)) for each question. The processing of these data allows the subsequent obtaining of evaluations of the personality traits of the students analyzed.

4 Results

This section shows the results obtained after carrying out the study. For reasons of space, some of the steps to obtain them are omitted.

Table 3 shows the results of the application of the method for the selection of student competencies focused on distance learning. According to the experts' criteria, the most significant competencies in relation to the restrictions raised are the proper handling of ICT, as well as responsibility in learning.

Competencies	Eigenvalues	Weights Vector	Consistency Index
ICT Handling	25.56	0.103	
Communication skills	23.94	0.017	
Effective information management	27.66	0.134	
Critical and creative thinking	24.91	0.092	
Knowledge of self, task and strategies	22.98	0.028	
Planning, organization and time management	25.67	0.071	
Self-assessment, control, self-regulation	24.78	0.023	
Problem resolution	25.10	0.102	
Motivation and positive attitude towards learning and improvement	25.12	0.082	
Attributions	23.77	0.012	0.09
Self-concept, self-esteem, self-sufficiency	23.85	0.044	
Physical and emotional well-being	22.62	0.034	
Emotional self-regulation and anxiety control	24.30	0.063	
Social values	21.31	0.018	
Attitudes of cooperation and solidarity; relationships	21.84	0.018	
Teamwork	24.17	0.01	
Control of environmental conditions	22.35	0.01	
Responsibility in learning	28,030	0.123	
Civic and moral attitudes and values	23.31	0.008	
Respect to the ethical and deontological codes	22.91	0.008	

Table 3: Skills analyzed; eigenvalues and vector of weights related to the analysis of student competencies. Source: own elaboration.

On the other hand, Table 4 shows the results of the application of the method for determining the personality traits to be analyzed. According to the analysis carried out, the most prominent traits are focused on Perfectionism - Imperfectionism, Openness to intellect and experience - Closeness to intellect and experience, and Flexibility - Rigidity. These results turned out to be the basis for the analysis and comparison of the data collected in the study group.

Personality traits analyzed	Eigenvalues	Weights vector	Consistency Index
Extraversion – Introversion	18,356	0.019	0.08
Conscientiousness – unconsciousness	18,601	0.013	
Perfectionism – Imperfectionism	25,593	0.154	
Sensitivism – Insensitivism	21,429	0.107	
Innovative – Conservative	16,058	0.033	
Self-esteem – Low self-esteem	22,555	0.083	
Kindness – Dislike	19,142	0.027	
Openess to intellect and experience – Closeness to intellect and experience	21,376	0.113	
Inhibition – Disinhibition	21,696	0.095	
Flexibility – Stiffness	26,438	0.139	
Emotivism – Not Emotivism	19,590	0.053	
Obsessiveness – No obsessiveness	16,784	0.039	
Caution – Impulsiveness	20,381	0.072	
Timidity – Audacity	12,564	0.021	
Honesty – Dishonesty	14,886	0.020	
Hostility – Non-hostility	21,650	0.012	

Table 4: Skills analyzed; eigenvalues and vector of weights related to the analysis of personality traits. Source: own elaboration.

As can be seen in Figure 1, on average, those students who presented a higher level of information management showed greater tendencies towards intellectuality and lower tendencies towards rigidity. Students who presented medium levels in this competence showed greater perfectionism and flexibility than students with high levels in information management. On the other hand, students who showed the lowest levels of information management ability were found to be more prone to imperfectionism, less intellectual, and more rigid than their peers.

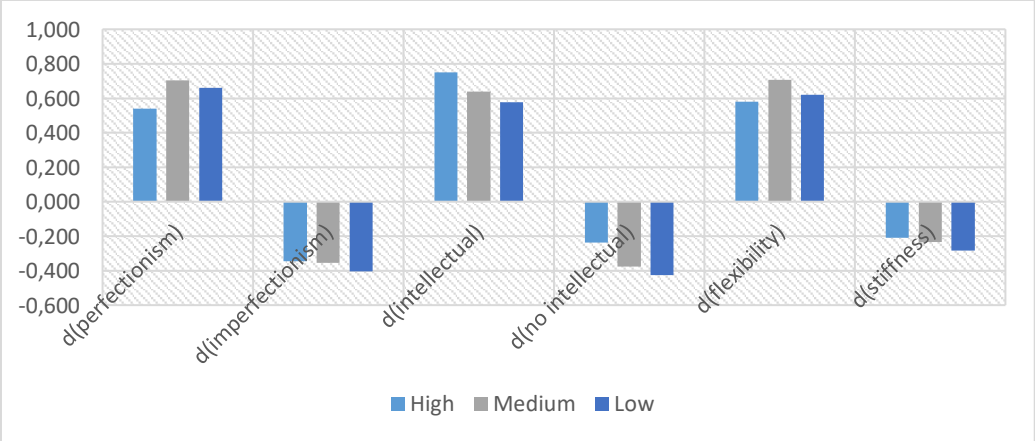


Figure 1: Average results of personality traits according to the level of competence in Efficient information management. Source: own elaboration.

On the other hand, when analyzing the results of the study taking into account the competence related to responsibility in learning, it can be observed that, in general, the students with high levels of this competence, on average, showed lower levels in the trait related to improvement, than the students with average results. In this sense, it was shown that this group of students was more intellectual and flexible than the rest of the groups.

In the case of students with medium levels of responsibility in learning, the high level of perfectionism trait achieved stands out. On the other hand, the students who showed less responsibility in learning were those who showed lower levels of perfectionism and greater rigidity.

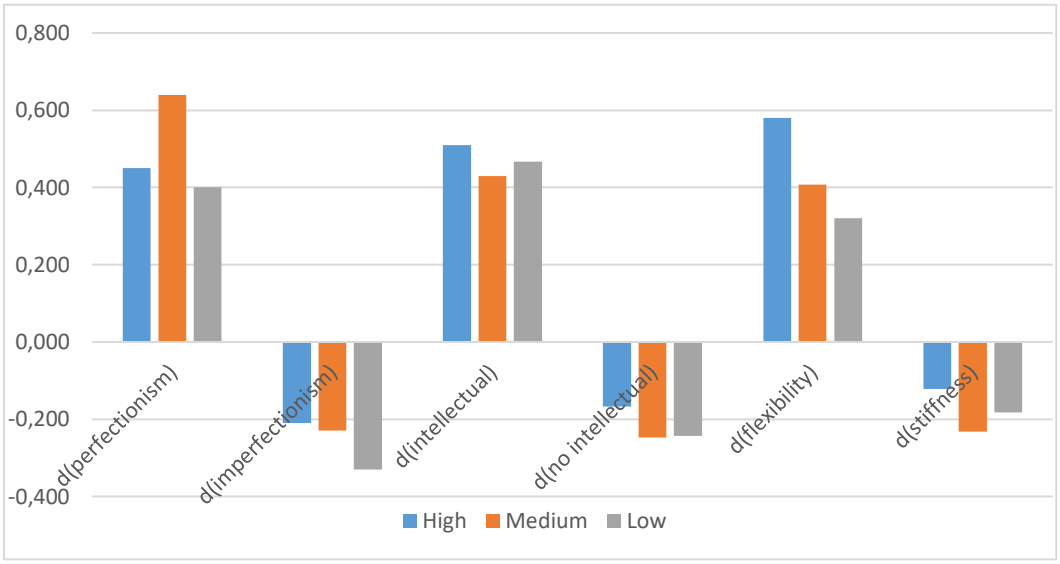
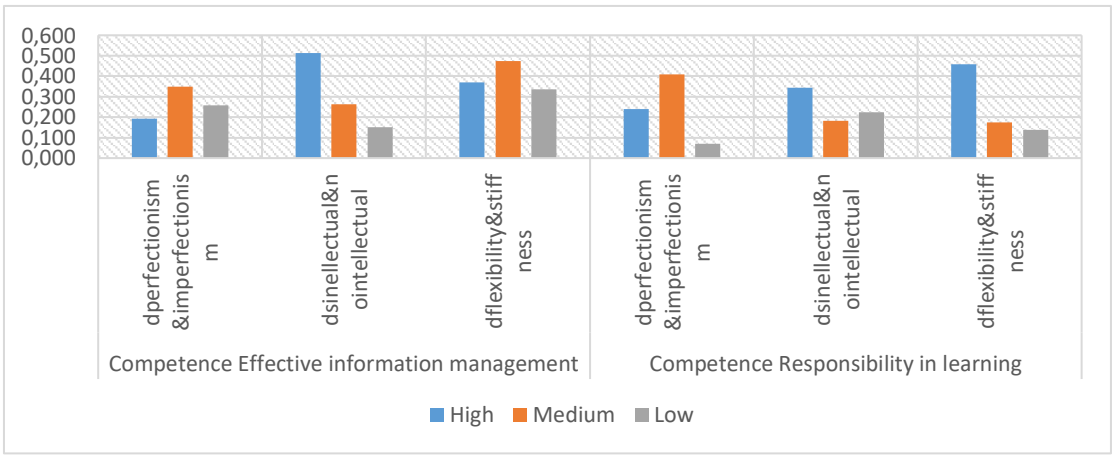


Figure 2: Average results of the personality traits according to the level of competence Responsibility in learning. Source: own elaboration.

Finally, when determining the personality operators for each of the analyzed traits, it can be observed that, in general, the students who obtained high levels of information management, on average, show that they are totally in an indeterminate state between the perfectionism and imperfectionism, while they presented greater traits of intellectuality than the rest of the groups analyzed. On the other hand, students with average levels in terms of information management, in all personality traits, remained in a range that indicates that most of them belong to that indicated trait. The students who presented lower levels in this competition are in a total state of indeterminacy between intellectuality and its opposite. See Figure 2.



ε

Figure 2: Average personality operators for each of the selected competencies. Source: own elaboration.

On the other hand, when analyzing the personality neutrosophic operators related to the responsibility in learning competence, it was observed that in all cases, students with a high level of this competence showed tendencies to the three traits analyzed. The students with medium performance, although they showed a tendency to perfectionism, also revealed the existence of indeterminacy between the trait of intellectuality and its opposite, and flexibility and rigidity. Students with lower performance in this competition were found in a similar situation. In them, indeterminacy was found in the perfectionism operator and its opposite, as well as in the operator related to flexibility-stiffness.

Conclusions

The study of psychology in all its forms is a field of study riddled with inaccuracies/indeterminacies for data collection and analysis of results. Neutrosophy, as a science dedicated to the study of indeterminacies, is a tool of

great value for deepening various branches of it. This study made it possible to demonstrate the usefulness of neutrosophic logic to determine the relationship between student competencies and operators of personality traits in law students under certain conditions. The NAHP method was used, with the support of experts to determine those elements of greatest interest for the study. The results obtained allowed us to determine that, on average, there is indeterminacy in some of the pairs of personality traits in students with medium or low performance in the skills analyzed. The students who, on average, presented high levels of performance in the competencies analyzed showed greater tendencies towards the trait than towards the anti-trait or indeterminacy.

References

[1] M. Mullai and R. Surya, "Neutrosophic Inventory Backorder Problem Using Triangular Neutrosophic Numbers.," *Neutrosophic Sets Syst.*, vol. 31 SRC-, pp. 148–155, 2020.

[2] B. Said *et al.*, "An Intelligent Traffic Control System Using Neutrosophic Sets, Rough sets, Graph Theory, Fuzzy sets and its Extended Approach: A Literature Review," *Neutrosophic Sets Syst.*, vol. 50, no. 1, p. 2, 2022.

[3] P. Biswas, S. Pramanik, and B. C. Giri, "Distance Measure Based with Interval Trapezoidal Neutrosophic Numbers.," *Neutrosophic Sets Syst.*, vol. 19 SRC-, pp. 40–46, 2018.

[4] M. Saeed, M. Saqlain, A. Mehmood, and S. Yaqoob, "Multi-polar neutrosophic soft sets with application in medical diagnosis andDecision-making," *Neutrosophic Sets Syst.*, vol. 33, pp. 183–207, 2020.

[5] J. Ye and Q. Zhang, "Single valued neutrosophic similarity measures for multiple attribute decision making.," *Neutrosophic sets Syst.*, vol. 2, pp. 48–54, 2014.

[6] F. Smarandache and M. Ali, "Neutrosophic Triplet Group (revisited)," *Neutrosophic sets Syst.*, vol. 26, no. 1, p. 2, 2019.

[7] J. Ye, "Another form of correlation coefficient between single valued neutrosophic sets and its multiple attribute decision-making method," *Neutrosophic Sets Syst.*, vol. 1, no. 1, pp. 8–12, 2013.

[8] S. A. Edalatpanah, "Systems of neutrosophic linear equations," *Neutrosophic sets Syst.*, vol. 33, no. 1, pp. 92–104, 2020.

[9] N. A. Nabeeh, A. Abdel-Monem, and A. Abdelmouty, "A novel methodology for assessment of hospital service according to BWM, MABAC, PROMETHEE II," *Neutrosophic Sets Syst.*, vol. 31, no. 1, pp. 63–79, 2020.

[10] L. K. B. VIllanueva, M. A. Mendoza, R. Salcedo, and A. M. I. Morán, "The transformational leadership, sustainable key for the development of ecuadorian companies. A neutrosophic psychology approach," *Neutrosophic Sets Syst.*, vol. 34, pp. 143–152, 2020.

[11] R. Aguilar Berrezueta, E. M. Sandoval, B. Villalta Jadán, and D. Palma Rivera, "An integrative neutrosophic model focused on personality (inmfp) for the adequate management of the level of work stress," *Neutrosophic Sets Syst.*, vol. 34, no. 1, p. 4, 2020.

[12] K. Mondal and S. Pramanik, "Multi-criteria group decision making approach for teacher recruitment in higher education under simplified neutrosophic environment," *Neutrosophic sets Syst.*, vol. 6, pp. 28–34, 2014.

[13] E. J. H. Antepara, J. E. A. Gamboa, M. R. C. Mndez, and M. E. P. Gonzlez, "Competencies Interdepencies Analysis based on Neutrosophic Cognitive Mapping," *Neutrosophic Sets Syst.*, vol. 16, pp. 89–92, 2017.

[14] M. F. S. Salgado, J. P. C. Pardo, and T. H. C. Palacios, "Application of the Neutrosophic AHP Method for the Development of a Training Project on the Adoption Process in Ecuador," *Neutrosophic Sets Syst.*, vol. 37, no. 1, p. 48, 2020.

[15] C. V. V. Chicaiza, O. G. A. Paspuel, P. Yesenia, C. Cuesta, and S. D. R. Á. Hernández, "Neutrosophic Psychology for Emotional Intelligence Analysis in Students of the Autonomous University of Los Andes, Ecuador," *Neutrosophic Sets Syst.*, vol. 34, pp. 1–8, 2020.

[16] M. Amat Abreu and D. Cruz Velázquez, "Neutrosophic model based on the ideal distance to measure the strengthening of values in the students of Puyo university.," *Neutrosophic Sets Syst.*, vol. 26, 2019.

[17] F. Smarandache, *Neutropsychic Personality. A mathematical approach to psychology*, 3rd ed. Brusels: Pons, 2018.

[18] E. M. Arroyo Lalama. "Utilización del localizador Apical durante la terapia endodóntica por parte de los profesionales de la ciudad de Ambato". Universidad y Sociedad, vol. 14 no. S2, pp 128-136, 2022.

[19] P. M. Moreno Arvelo, J. F. Molina Mora & R. E. Atencio González. "Influencia del derecho canónico en los sistemas jurídicos latinoamericanos: análisis desde el pluralismo jurídico". Universidad y Sociedad, vol. 14 no. S2, pp 106-111, 2022.

[20] M. A. Luzuriaga Zurita & C. Alonso Camaraza. "Metodología para la evaluación de la calidad de las maestrías en la Universidad Regional Autónoma de Los Andes". Universidad y Sociedad, vol. 14 no. S2, pp 96-105, 2022.

[21] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[22] Estupiñán Ricardo, J., Domínguez Menéndez, J. J., Barcos Arias, I. F., Macías Bermúdez, J. M., & Moreno Lemus, N. "Neutrosophic K-means for the analysis of earthquake data in Ecuador". Neutrosophic Sets and Systems, vol. 44 no. 1, pp. 29, 2021

[23] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.

[24] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica.

Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[25] Vega Falcón, V., Alarcón Quinapanta, M., Yancha Villacís, M., & Estupiñán Ricardo, J. Medición del capital intelectual: Caso hotelero. Dilemas Contemporáneos: Educación, Política y Valores, no. 96, pp 1-19, 2019.
[26] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.
[27] von Feigenblatt, OF, Pardo, P. & Cooper, M. "Corporativismo y autoritarismo benévolo: antídotos viables contra el populismo". Revista de perspectivas alternativas en las ciencias sociales. Vol. 11 no. 1, pp 95-98, 2021.
[28] L. C. Campaña Muñoz, B. A. Ordoñez Carrión, B. D. Narváez Montenegro & C. R. Hurtado Lomas. "Violencia contra los miembros del núcleo familiar en el cantón santo domingo de Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 469-477, 2022.
[29] L. M. Ochoa Escobar, S. F. Fiallos Bonilla, & R. C. Jimenez Martínez. "Analysis of the violation of the right to work in the lgtbiq+ community in Ecuador through neutrosophics cognitive maps and topsis". Universidad y Sociedad, vol. 14 no. S4, pp 447-458, 2022.
[30] A. A. Alvaracin Jarrón, V. H. Lucero Salcedo, R. L. Maldonado Manzano & H. E. Lozano Rojas. "Las cárceles de la exclusión. El fracaso del discurso resocializador y el emergente actuar criminológico". Universidad y Sociedad, vol. 14 no. S4, pp 438-446, 2022

Received: August 20, 2022. **Accepted:** October 16, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

SVNS-based multicriteria methods for the selection of management elements for academic diplomacy

Otto Federico von Feigenblatt[1]

[1] Fort Lauderdale, Florida, United States. E-mail: vonfeigenblatt@hotmail.com

Abstract. The objective of this study was to demonstrate the usefulness of neutrosophic set theories for the selection of key elements for the management of academic diplomacy in higher education. For this, neutrosophic correlation coefficients were used, as well as multicriteria problem solving methods adapted in the field of neutrosophy. The alternatives to be evaluated were subjected to the methods selected for the study, after which a comparison and analysis of the results was carried out. The application of the methods made it possible to obtain a very well-defined set of the most significant elements for proper management of academic diplomacy, according to the experts involved in the study. The use of indeterminacies during the process, it allowed obtaining results of greater precision and appropriate to the reality of decision-making. It was possible to conclude that there was coherence between the results obtained from both analyses, expressed in the similarities of the results in terms of the most and least preferred alternatives.

Keywords: management, academic diplomacy, COPRAS, correlation coefficient, neutrosophy

1 Introduction

A definitive part of any scientific research process, without a doubt, is found in the decision-making processes. This is an indispensable part of scientific and human functioning.[1]. The inherent need to consider uncertain data for the realization of this decision process, allowed[two]introduce fuzzy set theory (FS) to overcome uncertain and imprecise data.

In the years that followed this, intensive efforts continued to be made in various fields of research to incorporate the vagueness of the initial information. In this way, the ability to solve complex practical problems in real life was sought.[3].

In this framework, Florentín Smarandache presented the theory of neutrosophic sets in 1995 as a generalization of "fuzzy" sets and "intuitionist fuzzy" sets. Neutrosophy is a branch of philosophy that studies the origin, nature, and scope of neutralities.[4]. In this new branch, membership to truth, membership to indeterminacy, and membership to falsehood are understood to be independent and lie in the non-standard unit interval] 0−, 1 + [.[5]

Over the years, the use of neutrosophy has spread to various branches of science, engineering, society, psychology, and others. This has led various specialists in the field to develop neutrosophic models associated with different classical techniques for evaluating problems. In this way, solutions can be given, in a more personalized and real way, to the different problems that arise in these fields.[6]

To facilitate the practical side of neutrosophic ensembles, Wang et al. defined a single-valued neutrosophic set (SVNS) and proposed set-theoretical operations and some properties of SVNS[7]. Associated with this, the use of neutrosophy has recently been proposed, combined with tools for multi-criteria decision making (MCDM)[8]. In these cases, with the objective of incorporating the vagueness of the information to solve problems, decision makers usually use subjective evaluation methods.[9]–[11]

Subsequently, the use of SVNS correlation coefficients was presented, based on the extension of the correlation coefficient of intuitionistic fuzzy sets. This demonstrated that the SVNS cosine similarity measure is a special case of the SVNS correlation coefficient, and was then applied to single-valued neutrosophic numbers applied to decision-making problems.[12]

The field of educational leadership has gradually begun to integrate a wide range of theories and concepts to cope with increasing diversity and the concurrent process of internationalization. However, there is a need for a more systematic and holistic approach to address the many challenges posed by globalization and glocalization. In this sense, the integration of universities as part of the development strategies of nation-states resulted in the adoption of many practices of interstate diplomacy in the field of educational leadership.

Traditional leadership programs in the field of education integrate the teaching of the importance of community-school relations; but this is taught as part of the public policy process and decision-making process. Also, the emphasis is on theories borrowed from public relations and organizational behavior rather than diplomacy.

The development of academic diplomacy within educational leadership requires the integration of traditional diplomacy with educational leadership theories. Thus, while much can be learned from traditional diplomat training programs, those skills and theories must be tailored to the specific needs of educational leadership. While diplomats tend to be generalists by nature and can therefore learn quickly on a wide range of topics, in the field of educational leadership there are some basic topics that are basic knowledge for educational leaders, such as curriculum design and educational administration, among others.

The purpose of this paper is focused on demonstrating the usefulness of neutrosophic set theories for the selection of key management elements of academic diplomacy, applicable in higher education. For this, the extension of the COPRAS-SVNS method is carried out, as well as the use of neutrosophic correlation coefficients and the comparison between them.[13], [14]

For an adequate understanding of the study, the following section presents a description of the methods used to achieve the results, as well as their logic. The third section shows a practical example after which the results achieved and the conclusions derived from the study are described.

2 Preliminaries

2.1 Single - valued neutrosophic sets

Definition 1. Let X be a space of points (objects), with a generic element in X denoted by x. A neutrosophic set A in X is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. The functions $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or nonstandard subsets of $]0^-, 1^+[$, i.e., $T_A(x): X \rightarrow]0^-, 1^+[$, $I_A(x): X \rightarrow]0^-, 1^+[$ and $F_A(x): X \rightarrow]0^-, 1^+[$. There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, so $0^- \leq supT_A(x) + supI_A(x) + supF_A(x) \leq 3^+$.

Obviously, it is difficult to apply the neutrosophic set to practical problems. Therefore, introduced the concept of a single valued neutrosophic set (SVNS), which is an instance of a neutrosophic set, to be used in real scientific and engineering applications. In the following, we introduce the definition of a SVNS.

Definition 2. Let X be a space of points (objects) with generic elements in X denoted by x. A SVNS A in X is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$ for each point x in X, $T_A(x), I_A(x), F_A(x) \in [0,1]$. Thus, A SVNS A can be expressed as

$$A = \{x, T_A(x), I_A(x), F_A(x) \mid x \in X\}$$

Then, the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, satisfies the condition $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

Definition 3. The complement of a SVNS A is denoted by Ac and is defined as

$$Ac = \{x, F_A(x), 1 - I_A(x), T_A(x) \mid x \in X\}$$

Definition 4. A SVNS A is contained in the other SVNS $B, A \subseteq B$ if and only if $T_A(x) \leq T_B(x), I_A(x) \geq I_B(x)$, and $F_A(x) \geq F_B(x)$ for every x in X.

Definition 5. Two SVNSs A and B are equal, written as A = B, if and only if $A \subseteq B$ and $B \subseteq A$

Definition 6. For any two SVNSs A and B in the universe of discourse $X = \{x_1, x_2, \ldots, x_n\}$, the correlation coefficient between two SVNSs A and B is defined as follows:[15]

$$M(A,B) = \frac{1}{3n}\sum_{i=1}^{n}[\phi_i(1-\Delta T_i) + \varphi_i(1-\Delta I_i) + \psi_i(1-\Delta F_i)] \quad (1)$$

Where

$$\phi_i = \frac{3 - \Delta T_i - \Delta T_{max}}{3 - \Delta T_{min} - \Delta T_{max}}, \qquad \psi_i = \frac{3 - \Delta F_i - \Delta F_{max}}{3 - \Delta F_{min} - \Delta F_{max}},$$

$$\varphi_i = \frac{3 - \Delta I_i - \Delta I_{max}}{3 - \Delta I_{min} - \Delta I_{max}}, \qquad \Delta T_i = |T_A(x_i) - T_B(x_i)|,$$

$$\Delta I_i = |I_A(x_i) - I_B(x_i)|,$$

$\Delta T_i = |T_A(x_i) - T_B(x_i)|$,

$\Delta T_{min} = min_i|T_A(x_i) - T_B(x_i)|$,

$\Delta I_{min} = min_i|I_A(x_i) - I_B(x_i)|$,

$\Delta F_{min} = min_i|F_A(x_i) - F_B(x_i)|$,

$\Delta T_{max} = max_i|T_A(x_i) - T_B(x_i)|$,

$\Delta I_{max} = max_i|I_A(x_i) - I_B(x_i)|$,

$\Delta F_{max} = max_i|F_A(x_i) - F_B(x_i)|$,

for any $x_i \in X$ and i = 1, 2, . . ., n

However, the differences of importance are considered in the elements in the universe. Therefore, we need to take the weight of the element $x_i(i = 1, 2, \dots, n)$ into account. In the following, we introduce a weighted correlation coefficient between SVNSs.

Definition 7. Let w_i be the weight for each element x_i $(i = 1, 2, \dots, n)$, $w_i \in [0, 1]$, and $\sum_{i=1}^{n} w_i = 1$, then we have the following weighted correlation coefficient between the SVNSs *A* and *B*:

$$M_w(A, B) = \frac{1}{3}\sum_{i=1}^{n} w_i[\phi_i(1 - \Delta T_i) + \varphi_i(1 - \Delta I_i) + \psi_i(1 - \Delta F_i)] \quad (2)$$

Definition 8. Let $A = (T_A, I_A, F_A)$ and $B = (T_B, I_B, F_B)$ be two SVN numbers, then summation between A and B is defined as follows:

$$A + B = (T_A + T_B - T_A t_B, I_A I_B, F_A F_B) \quad (3)$$

Definition 9. Let $A = (T_A, I_A, F_A)$ and $B = (T_B, I_B, F_B)$ be two SVN numbers, then multiplication A and B is defined as follows:

$$A * B = (T_A T_B, I_A + I_B - I_A I_B, F_A + F_B - F_A F_B) \quad (4)$$

Definition 10. Let $A = (T_A, I_A, F_A)$ be a SVN number and $\lambda \in \mathbb{R}$ an arbitrary positive real number, then:

$$\lambda A = \left(1 - (1 - T_A)^{\lambda}, I_A^{\lambda}, F_A^{\lambda}\right), \lambda > 0 \quad (5)$$

Definition 11. If $A = \{A_1, A_2, \dots, A_n\}$, and $B = \{B_1, B_2, \dots, B_n\}$ (i= 1,2,…,m) are two single valued neutrosophic sets, then separation measure between *A* and *B* applying the normalized Euclidian distance can be expressed as follows:

$$q_n(A, B) = \sqrt{\frac{1}{3n}\sum_{j=1}^{n}\left(\left(T_A(x_i) - T_B(x_i)\right)\right)^2 + \left(\left(I_A(x_i) - I_B(x_i)\right)\right)^2 + \left(\left(F_A(x_i) - F_B(x_i)\right)\right)^2}$$

$(i = 1,2, \dots, n)$ (6)

Definition 12. Let $A = (T_A, I_A, F_A)$ be a single valued neutrosophic number, a score function is mapped $\tilde{N}_A$ into the single crisp output $S(\tilde{N}_A)$ as follows

$$S(\tilde{N}_A) = \frac{3 + T_A - 2I_A - F_A}{4} \quad (7)$$

where $S(\tilde{N}_A) \in [0,1]$. This score function is the modification of the score function and allows us to have the results in the same interval as we deal with single valued neutrosophic numbers.

2.2 Decision-making method using the correlation coefficient of SVNSs [15]

In the multiple attribute decision-making problem with single valued neutrosophic information, the characteristic of an alternative A_i $(i = 1, 2, \dots, m)$ on an attribute C_j $(j = 1, 2, \dots, n)$ is represented by the following SVNS:

$$A_i = \{C_j, T_{Ai}(C_j), I_{Ai}(C_j), F_{Ai}(C_j) | Cj \in C, j = 1, 2, \dots, n\}$$

Where $T_{Ai}(C_j)$, $I_{Ai}(C_j)$, $F_{Ai}(C_j)) \in [0, 1]$ and $0 \leq T_{Ai}(C_j)$, $I_{Ai}(C_j)$, $F_{Ai}(C_j) \leq 3$ for $Cj \in C, j = 1, 2, \dots, n, and\ i = 1, 2, \dots, m.$

For convenience, the values of the three functions $T_{Ai}(C_j)$, $I_{Ai}(C_j)$, $F_{Ai}(C_j)$ are denoted by a single valued neutrosophic value (SVNV) $d_{ij} = < t_{ij}, i_{ij}, f_{ij} >$ $(i = 1, 2, \dots, m;\ j = 1, 2, \dots, n)$, which is usually derived from the evaluation of an alternative A_i with respect to a criterion C_j by the expert or decision maker. Thus, we can elicit a single valued neutrosophic decision matrix $D = (d_{ij})_{mxn}$.

In multiple attribute decision making problems, the concept of ideal point has been used to help identify the best alternative in the decision set. Although the ideal alternative does not exist in real world, it does provide a useful theoretical construct against which to evaluate alternatives.

In the decision-making method, an ideal SVNV can be defined by $d_j^* =< t_j^*, i_j^*, f_j^* >=< 1,0,0 > (j = 1,2,\dots,n)$ in the ideal alternative A^*. Hence, by applying Equation (2) the weighted correlation coefficient between an alternative A_i $(i = 1,2,\dots,m)$ and the ideal alternative A^* is given by:

$$M_w(A_i, A^*) = \frac{1}{3}\sum_{j=1}^{n} w_j\left[\phi_{ij}\left(1-\Delta t_{ij}\right) + \varphi_{ij}\left(1-\Delta i_{ij}\right) + \psi_{ij}\left(1-\Delta f_{ij}\right)\right] \quad (8)$$

Where

$$\phi_{ij} = \frac{3-\Delta t_{ij}-\Delta t_{i\,max}}{3-\Delta t_{i\,min}-\Delta t_{i\,max}},$$

$$\varphi_i = \frac{3-\Delta i_{ij}-\Delta i_{i\,max}}{3-\Delta i_{i\,min}-\Delta i_{i\,max}},$$

$$\psi_i = \frac{3-\Delta f_{ij}-\Delta f_{i\,max}}{3-\Delta f_{i\,min}-\Delta f_{i\,max}},$$

$$\Delta t_{ij} = \left|t_{ij} - t_j^*)\right|,$$

$$\Delta i_{ij} = \left|i_{ij} - i_j^*)\right|,$$

$$\Delta f_{ij} = \left|f_{ij} - f_j^*)\right|,$$

$$\Delta t_{i\,min} = min_j\left|t_{ij} - t_j^*\right|,$$

$$\Delta i_{i\,min} = min_j\left|i_{ij} - i_j^*\right|,$$

$$\Delta f_{i\,min} = min_j\left|f_{ij} - f_j^*\right|,$$

$$\Delta t_{i\,max} = max_j\left|t_{ij} - t_j^*\right|,$$

$$\Delta i_{i\,max} = max_j\left|i_{ij} - i_j^*\right|,$$

$$\Delta f_{i\,max} = max_j\left|f_{ij} - f_j^*\right|,$$

for $i = 1,2,\dots,m$ and $j = 1,2,\dots,n$. By the correlation coefficient $M_w\ (A_i, A^*)$ $(i = 1,2,\dots,m)$, we can obtain the ranking order of all alternatives and the best one(s).

2.3 COPRAS-SVNS

The concept of a linguistic variable is very useful for solving decision making problems with complex content. The value of a linguistic variable is expressed as an element of its term set. Such linguistic values can be represented using single valued neutrosophic numbers.

In the COPRAS-SVNS method, there are k-decision makers, m-alternatives and n-criteria. k-decision makers evaluate the importance of the m-alternatives under n-criteria and rank the performance of the n-criteria with respect to linguistic statements converted into single valued neutrosophic numbers. The importance weights based on single valued neutrosophic values of the linguistic terms is given as Table 1.

Linguistic terms	**SVNNs**
Extremely good (EG)/ 10 points	(1.00, 0.00, 0.00)
Very very good (VVG)/ 9 points	(0.90, 0.10, 0.10)
Very good (VG)/ 8 points	(0.80, 0.15, 0.20)
Good (G) / 7 points	(0.70, 0.25, 0.30)
Medium good (MG) / 6 points	(0.60, 0.35, 0.40)
Medium (M) / 5 points	(0.50, 0.50, 0.50)
Medium bad (MB) / 4 points	(0.40, 0.65, 0.60)
Bad (B) / 3 points	(0.30, 0.75, 0.70)
Very bad (VB) / 2 points	(0.20, 0.85, 0.80)
Very very bad (VVB) / 1 point	(0.10, 0.90, 0.90)
Extremely bad (EB) / 0 points	(0.00, 1.00, 1.00)

Table 1: Linguistic variable and SVNSs. Source:[13]

The performance of the group decision making applying COPRAS-SVNS approach can be described by the following steps:

- Step 1. Determine the importance of the experts. In the case when the decision is made by a group of the experts (decision makers), firstly the importance or share to the final decision of each expert is determined. If a vector $\lambda = (\lambda_1, \lambda_2, \dots, \lambda_k)$ is the vector describing the importance of the each expert, where $\lambda_k \geq 0$ and $\sum_{k=1}^{K} \lambda_k = 1$.
- Step 2. In the framework of this step, each decision maker performs his evaluations concerning the ratings of the alternatives with respect to the attributes and the attribute weights. If we denote by $x_{ij}^k, i = 1,2,\dots,m; j = 1,2,\dots,n$ the k^{th} expert's evaluation of the i^{th} alternative by the j^{th} criterion. This evaluation is expressed in linguistic terms presented in the table 1. So the decision matrix for any particular expert can be constructed

$$X^k = \begin{bmatrix} x^k{}_{11} & x^k{}_{12} \dots & x^k{}_{1n} \\ x^k{}_{22} & x^k{}_{22} \dots & x^k{}_{2n} \\ \vdots & \vdots & \vdots \\ x^k{}_{m1} & x^k{}_{m2} \dots & x^k{}_{mn} \end{bmatrix} \quad (9)$$

- Step 3. Calculate the weights of the criteria. The aggregated weights of the criteria are determined by

$$\mathrm{w}_j = \lambda_1 \mathrm{w}_j^{(1)} \cup \lambda_2 \mathrm{w}_j^{(2)} \cup \dots \cup \lambda_k \mathrm{w}_j^{(k)} = \left(1 - \prod_{k=1}^{K} \left(1 - T_j^{(w_k)}\right)^{\lambda_k}, \prod_{k=1}^{K} \left(I_j^{(w_k)}\right)^{\lambda_k}, \prod_{k=1}^{K} \left(F_j^{(w_k)}\right)^{\lambda_k}\right) \quad (10)$$

- Step 4. Construction of the aggregated weighted single valued decision matrix

$$\tilde{X} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} \dots & \tilde{x}_{1n} \\ \tilde{x}_{22} & \tilde{x}_{22} \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} \dots & \tilde{x}_{mn} \end{bmatrix} \quad (11)$$

where any particular element $\tilde{x}_{ij} = (\tilde{T}_{ij}, \tilde{I}_{ij}, \tilde{F}_{ij})$ represents the rating of the alternative A_i with respect to j criterion and is determined as follows

$$\tilde{x}_{ij} = \lambda_1 \mathrm{x}_{ij}^{(1)} \cup \lambda_2 \mathrm{x}_{ij}^{(2)} \cup \dots \cup \lambda_k \mathrm{x}_{ij}^{(k)} = \left(1 - \prod_{k=1}^{K} \left(1 - T_j^{(x_k)}\right)^{\lambda_k}, \prod_{k=1}^{K} \left(I_j^{(x_k)}\right)^{\lambda_k}, \prod_{k=1}^{K} \left(F_j^{(x_k)}\right)^{\lambda_k}\right) \quad (12)$$

- Step 5. Determine the weighted decision matrix. The weighted decision matrix can be expressed as $D = \lfloor d_{ij} \rfloor, d = 1,2,\dots,m; j = 1,2,\dots,n$, where $d_{ij} = \tilde{x}_{ij} * w_j$. a single element of the weighted decision matrix can be calculated as

$$d_{ij} = T_{ij}^{\tilde{x}} T_j^w, I_{ij}^{\tilde{x}} + I_j^w - I_{ij}^{\tilde{x}} I_j^w, F_{ij}^{\tilde{x}} + F_j^w - F_{ij}^{\tilde{x}} F_j^w \quad (13)$$

- Step 6. Perform summation of the values for the benefit. Let $L_+ = \{1,2,\dots,L_{max}\}$ be a set of the criteria to be maximized. Then the index of the benefit for each alternative can be determined

$$P_{+i} = \sum_{j=1}^{L_{max}} d_{+ij} \quad (14)$$

- Step 7. Perform summation of the values for cost. Let be $L_- = \{1,2,\dots,L_{min}\}$ a set of the criteria to be minimized. Then the index of the cost of each alternative can be determined

$$P_{-i} = \sum_{j=1}^{L_{min}} d_{-ij} \quad (15)$$

- Step 8. Determine the minimal value of the P_{-i}.

- Step 9. Determine the score value of each alternative Q_i. At the beginning the score values are calculated from the aggregated values for benefit and the cost $S(P_{+i})$ and $S(P_{-i})$ by using equation (7). The score values of the alternatives van be expressed as

$$Q_i = S(P_{+i}) + \frac{S(P_{-min})\sum_{i=1}^{L_{min}} S(P_{-i})}{S(P_{-min})\sum_{i=1}^{L_{min}} \frac{S(P_{-min})}{S(P_{-i})}} \quad (16)$$

- Step 10. Determine optimality criterion K for the alternatives:

$$K = max_i Q_i; i = 1,2,\dots,m \quad (17)$$

- Step 11. Determine the priority of the alternatives. The greater score value Q_i for the alternative corresponds to the highest priority (rank) of the alternative.

3 Methodology

To some degree, all educational leaders must serve as academic diplomats. Therefore, the need and functions are not new, but the need for a conscious and purposeful understanding of the role is relatively new. Educational leaders understand that they must commit to maintaining good relationships with the community and with a wide range of stakeholders. In addition to good stakeholder relations, educational leaders must also be aware of the need for a wide range of methods to communicate with the broader community.

The challenge is to carve out a clear role and status within the educational leadership community for academic diplomacy. Many universities have internationalization offices that focus on international relations and study abroad programs. Internationalization offices have a range of functions that do not always coincide with those of a diplomatic mission.

One aspect that is often lacking in particular is an office to receive international visitors on official visits. One of several exceptions to this is Harvard University, which has the office of Marshall University. This office supervises the reception of foreign delegations visiting the University. Members of the office are trained in diplomatic etiquette for welcoming a variety of guests, including heads of state. The difference between the Marshall University office at Harvard University and internationalization offices at other universities is that it is designed to receive foreign delegations and is trained to do so following an international standard of etiquette.

In this case, the emphasis is on the role and status of an academic diplomat, and therefore issues of training and basic knowledge of diplomatic etiquette are relevant. Diplomacy involves a certain set of skills employed to promote relationships between entities. Traditionally, diplomacy has focused on the development of a range of skills that combine communication, negotiation and leadership framed in the knowledge of and respect for certain norms and social practices. Therefore, diplomacy transcends technical knowledge in internationalization and international relations in general.

Bearing this in mind, and for the development of this study, the work team selected, through documentary support and brainstorming, the set of elements for analysis. In this sense, eight elements were considered that, in the opinion of the experts, constitute key factors for an adequate management of academic diplomacy in any university organization. These elements were evaluated under 3 decision criteria and tested under each of the initially proposed methods.

For the evaluation of the elements to be evaluated, with respect to the selected criteria, the five experts that make up the work team are asked to complete a small form that includes an evaluation as precise as possible of the subject evaluated. Likewise, they are asked to grant a level of importance to each of the evaluated criteria. For this, the evaluations to be granted must specify to what extent the expert considers that the alternative Ai is good (Tx), bad (Fx) or is not entirely sure (Ix) with respect to the criterion Cj, for which the Table 1. The same level of importance was considered among the experts involved in the study.

The subsequent evaluation and comparison of the results obtained constitutes an effective way of validating the efficient selection or screening of those elements of special importance according to the judgment of the experts.

4 Results and discussion

Based on the evaluations carried out by the experts, and in accordance with the logic proposed by the COPRAS-SVNS method, the necessary transformations were carried out to obtain all the elements that allow obtaining the decision matrix. Subsequently, the application of equation (12) allowed obtaining the weighted decision matrix for this analysis. Table 2 summarizes the results achieved in this regard.

Alternatives	Criterion 1	Criterion 2	Criterion 3
Establish a system of values focused on the commitment to good relations with the community	(0.531;0.469;0.433)	(0.497;0.503;0.466)	(0.277;0.802;0.835)
Properly manage the promotion of participation and the development of beneficial agreements for the parties	(0.531;0.469;0.433)	(0.4;0.6;0.591)	(0.303;0.756;0.775)
Establish a continuous training system on international diplomatic etiquette	(0.753;0.247;0.232)	(0.618;0.382;0.361)	(0.531;0.469;0.413)
Develop skills for negotiating specific articulation agreements	(0.573;0.427;0.383)	(0.581;0.419;0.387)	(0.542;0.458;0.424)
Management of academic leadership oriented to the achievement of objectives	(0.586;0.414;0.394)	(0.495;0.514;0.508)	(0.542;0.458;0.424)
Development of effective methods for an adequate level of communication with the community in general	(0.531;0.469;0.433)	(0.481;0.528;0.494)	(0.428;0.582;0.552)
Promote the opening of channels and structures capable of operating even in cases of political tensions between States	(0.61;0.39;0.34)	(0.537;0.463;0.418)	(0.476;0.534;0.489)
Establish cooperation approaches capable of providing effective and immediate solutions to common problems between the parties	(0.573;0.427;0.383)	(0.497;0.503;0.466)	(0.428;0.582;0.552)

Table 2: Weighted decision matrix. Fuente: own

After obtaining this information, we proceeded to determine the coefficients proposed by the method for the selection between the alternatives. At this point, it is necessary to clarify that criteria 2 and 3 were considered benefit criteria, so their maximization is sought. Criterion 1 was considered a cost criterion, so its minimization is considered a greater benefit. Table 3 shows the results obtained after the analysis and calculation of the data.

Alternatives	Pi+	Pi-	S(P+)	S(P-)	Q
Establish a system of values focused on the commitment to good relations with the community	(0.636; 0.403; 0.389)	(0.531; 0.469; 0.433)	0.61	0.5400	1.26
Properly manage the promotion of participation and the development of beneficial agreements for the parties	(0.582; 0.454; 0.458)	(0.531; 0.469; 0.433)	0.55	0.5400	1.2
Establish a continuous training system on international diplomatic etiquette	(0.821; 0.179; 0.149)	(0.753; 0.247; 0.232)	0.83	0.7570	1.29
Develop skills for negotiating specific articulation agreements	(0.808; 0.192; 0.164)	(0.573; 0.427; 0.383)	0.82	0.5840	1.41
Management of academic leadership oriented to the achievement of objectives	(0.769; 0.235; 0.215)	(0.586; 0.414; 0.394)	0.77	0.5910	1.36
Development of effective methods for an adequate level of communication with the community in general	(0.703; 0.307; 0.273)	(0.531; 0.469; 0.433)	0.7	0.5400	1.35
Promote the opening of channels and structures capable of operating even in cases of political tensions between States	(0.757; 0.247; 0.204)	(0.61; 0.39; 0.34)	0.76	0.6230	1.33
Establish cooperation approaches capable of providing effective and immediate solutions to common problems between the parties	(0.712; 0.293; 0.257)	(0.573; 0.427; 0.383)	0.72	0.5840	1.32

Table 3: Values of Pi, S(P) and Q score value for each alternative. Source: own

As can be seen, in this case, alternative 4 was the one that obtained the highest score level, which makes it the most preferred by the experts. In this case, more preferred alternatives were evaluated to apply to the university process, therefore, a broader set of alternatives is considered, instead of only choosing the one with the highest score. That said, Table 3 indicates the three alternatives that obtained a higher score in the decision index. Alternatives 4, 5 and 6 were the most important according to the experts, although alternatives 7 and 8 could also be considered, taking into account the level of precision and interest of the researchers.

On the other hand, when carrying out the evaluation using the method focused on the neutrosophic correlation indices, the values of the operators φ, μ and ψ were determined to obtain the correlation coefficients, according to the logic of the method. The determination of these elements allowed us to calculate and obtain the correlation coefficients, as shown in Table 4.$M_w(A_i, A^*)$

	φ_{ij}			μ_{ij}			ψ_{ij}			
	C1	C2	C3	C1	C2	C3	C1	C2	C3	M_w
Establish a system of values focused on the commitment to good relations with the community	0.84	1	0.89	0.87	1	0.96	0.96	1	1	0.599
Properly manage the promotion of participation and the development of beneficial agreements for the parties	0.94	1	0.89	0.91	1	1	1	0.96	0.9	0.558
Establish a continuous training system on international diplomatic etiquette	0.9	0.95	1	1	0.96	1	1	0.96	1	0.697
Develop skills for negotiating specific articulation agreements	1	0.9	0.86	1	1	0.96	0.96	1	1	0.704
Management of academic leadership oriented to the achievement of objectives	1	0.95	0.95	0.96	1	0.96	1	1	1	0.612
Development of effective methods for an adequate level of communication with the community in general	1	0.95	0.9	1	0.96	1	1	0.96	1	0.697
Promote the opening of channels and structures capable of operating even in cases of political tensions between States	0.95	1	0.95	1	1	0.96	1	0.96	1	0.697
Establish cooperation approaches capable of providing effective and immediate solutions to common problems between the parties	0.84	1	0.84	1	0.96	0.92	0.96	1	1	0.633

Table 4: Values of φ, μ and ψ and Mw for each selection alternative. Source: own

In this case, the most prominent correlation coefficient was the one referring to the fourth alternative. However, alternatives 3, 6 and 7 were alternatives with a similar level of evaluation, which makes them equally good options to be considered by the evaluators.

When making a comparison between the results obtained from both methods, it was possible to verify the existence of certain similarities in the results achieved in the two cases.

Both with the use of the COPRAS method, and through the use of correlation coefficients, it was possible to obtain a clear preference or significance over alternative 4, referring, in this case, to the development of skills for the negotiation of agreements. Likewise, alternative 5 was selected, in both methods, among those most preferred by the experts.

Similarly, although other alternatives such as 3 and 7 did not have an extremely relevant significance in the COPRAS method, their inclusion within the second method makes it possible to evaluate them as some of the favorites to implement.

For its part, the low significance of alternatives 1 and 2 in each of the methods carried out, can lead to their

discarding, or failing that, to a relegation in terms of priority level.

The results obtained make it possible to determine the existence of coherence between the methods used in terms of the selected decision alternatives. In principle, it was found that the most significant alternative for the experts was the same in both methods.

The same happened with the less desired or lower-scoring alternatives. The rest of the alternatives had some variation in terms of the levels of significance or score according to the method; however, these variations could be due to clear differences between the calculation methods between the methods, or even to external factors such as the subjectivity of the experts.

It is considered that, if more precise results were sought, each of the methods could be carried out, as was done in the present study, and select as elements of interest only those that were common and relevant to both methods.

Conclusions

All branches of science, and practically life, have found in neutrosophy a novel tool for solving complex problems in real life. The possibility of incorporating indeterminacies in the decision process allows us to approach real solutions and, therefore, more effective ones. The development of this study allowed us to demonstrate the usefulness of neutrosophic set theories for the selection of different key management elements for academic diplomacy, applicable in higher education. For this, the COPRAS-SVNS method was used, as well as the use of neutrosophic correlation coefficients.

The application of the methods made it possible to obtain a very well-defined set of the most significant elements for proper management of academic diplomacy, according to the experts involved in the study. The use of indeterminacies during the process allowed obtaining results of greater precision and adequate to the reality of decision-making for human beings. Likewise, the analysis carried out allowed the comparison of results between the methods used. It was possible to conclude that there was coherence between the results obtained from both analyses, expressed in the similarities of the results in terms of the most and least preferred alternatives.

References

[1] R. M. Zulqarnain, X. L. Xin, M. Saqlain, F. Smarandache, and M. I. Ahamad, "An integrated model of neutrosophic TOPSIS with application in multi-criteria decision-making problem," *Neutrosophic Sets Syst.*, vol. 40, pp. 253–269, 2021.

[2] L. Zadeh, G. Klir, and B. Yuan, *Conjuntos difusos, lógica y sistemas difusos: artículos seleccionados*, Vol. 6. World Scientific, 1996.

[3] L. K. B. VIllanueva, M. A. Mendoza, R. Salcedo, and A. M. I. Morán, "The transformational leadership, sustainable key for the development of ecuadorian companies. A neutrosophic psychology approach," *Neutrosophic Sets Syst.*, vol. 34, pp. 143–152, 2020.

[4] M. Saqlain, N. Jafar, S. Moin, M. Saeed, and S. Broumi, "Single and multi-valued neutrosophic hypersoft set and tangent similarity measure of single valued neutrosophic hypersoft sets," *Neutrosophic Sets Syst.*, vol. 32, no. 1, pp. 317–329, 2020.

[5] M. F. S. Salgado, J. P. C. Pardo, and T. H. C. Palacios, "Application of the Neutrosophic AHP Method for the Development of a Training Project on the Adoption Process in Ecuador," *Neutrosophic Sets Syst.*, vol. 37, no. 1, p. 48, 2020.

[6] P. Biswas, S. Pramanik, and B. C. Giri, "Distance Measure Based with Interval Trapezoidal Neutrosophic Numbers.," *Neutrosophic Sets Syst.*, vol. 19 SRC-, pp. 40–46, 2018.

[7] G. Shahzadi, M. Akram, and A. B. Saeid, "An application of single-valued neutrosophic sets in medical diagnosis," *Neutrosophic sets Syst.*, vol. 18, pp. 80–88, 2017.

[8] D. Ajay, S. Broumi, and J. Aldring, "An MCDM method under neutrosophic cubic fuzzy sets with geometric bonferroni mean operator," *Neutrosophic Sets Syst.*, vol. 32, no. 1, pp. 187–202, 2020.

[9] M. Grida, R. Mohamed, and A. H. Zaid, "A novel plithogenic MCDM framework for evaluating the performance of IoT based supply chain," *Neutrosophic Sets Syst.*, vol. 33, no. 1, pp. 323–341, 2020.

[10] A. S. S. L. F. Autran, M. Gomes, and K. R. Vijayalakshmi, "Assessment of MCDM problems by TODIM using aggregated weights," *Neutrosophic sets Syst.*, vol. 35, no. 1, pp. 78–99, 2020.

[11] V. Uluçay, A. Kılıç, İ. Yıldız, and M. Şahin, "An outranking approach for MCDM-problems with neutrosophic multisets," *Neutrosophic Sets Syst.*, vol. 30, no. 1, pp. 213–224, 2019.

[12] S. Pramanik, R. Roy, T. K. Roy, and F. Smarandache, "Multi criteria decision making using correlation coefficient under rough neutrosophic environment," *Neutrosophic Sets Syst.*, vol. 17, pp. 29–37, 2017.

[13] H. Hashim, L. Abdullah, A. Al-Quran, and A. Awang, "Entropy measures for interval neutrosophic vague sets and their application in decision making," *Neutrosophic Sets Syst.*, vol. 45, pp. 74–95, 2021.

[14] C. E. P. Hernández, E. T. M. Á. E. Toni, V. Shagnay, and S. G. Enríquez, "Priorization of educational strategies on nutrition and its correlation in anthropometry in children from 2 to 5 years with neutrosophic topsis," *Neutrosophic Sets Syst.*, vol. 34, no. 1, pp. 9–15, 2020.

[15] J. Ye, "Another form of correlation coefficient between single valued neutrosophic sets and its multiple attribute decision-making method," *Neutrosophic Sets Syst.*, vol. 1, no. 1, pp. 8–12, 2013.

Received: August 21, 2022. **Accepted:** October 17, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Use of Neutrosophy in the Evaluation of a Health Education Program for Undergraduate Medical Students

Andrea Suárez López[1], María Isabel Fong Betancourt[2] and Diana Lorena Jordán Fiallos[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: docentetp45@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. E-mail: ua.mariafong@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. E-mail: ua.dianajordan@uniandes.edu.ec

Abstract. The study of problems that contribute to health education in university students is increasingly demanded by the scientific community, as it contributes to the prevention of diseases and thus encourages healthy lifestyles. In correspondence with the bibliographic review carried out in this research, it was found that this topic has been addressed by various scientific disciplines, but undoubtedly it is still required to deepen the link with Neutrosophy. Based on these arguments, the present research aims to apply Neutrosophy in the evaluation of a health education program for undergraduate medical students of the Regional Autonomous University of the Andes, in the Republic of Ecuador. During the development of this study, theoretical, empirical and statistical methods were taken into account, particularly descriptive neutrosophic statistics. The results obtained allow asserting that the program presented has a high level of relevance and can be applied in university educational practice.

Keywords: neutrosophic linguistic scale, neutrosophic statistics, medicine, health education.

1 Introduction

According to the World Health Organization (1948), health is considered to be a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Health is understood in this case as a positive concept, in which social, personal, and physical aspects are reflected.

Another material that gives a vision of the concepts and contents that are needed to know about this topic is the Director Program for Health Promotion and Education, which states that: Health education is the process of permanent education based on the reports and actions aimed at acquiring knowledge, healthy habits, and skills that enable and facilitate negative behavior changes and the strengthening of others in the process of promoting healthier lifestyles [1].

According to Álvarez, [1] who considers that health education "is teaching that aims to lead the individual and the community, to a process of changing attitudes and behavior, for the application of means that allow them to preserve and improve their health". It is also an action that tends to make them responsible for both their own health and that of the social group to which they belong.

Health education seeks to incorporate a culture based on making students personally responsible, through the incorporation of knowledge, attitudes, and healthy habits. In addition, it allows decisions to be made to facilitate the care of the health of others, and integrate it with Physical Education in the educational environment, to favor the harmonious growth of their personality, developing an educational and socio-cultural process [2].

These topics must be recognized by university students, so that they can acquire the knowledge of health education, being able to have personal and collective hygiene habits and demonstrate a pleasant personal appearance at all times, exert a transforming action on caring for the environment, and become aware of its importance for the preservation of their health [3].

There is a wide range of studies and knowledge on health education in the university context. The main researchers have directed their studies from approaches such as pedagogical, gnoseological, and health, just to mention a few. However, the use of Neutrosophy has been little systematized in the scientific bibliography, aspects that will be used to carry out the analysis presented in this research.

That is why the present investigation has the objective to apply Neutrosophy in the evaluation of a health education program for undergraduate medical students of the Autonomous Regional University of the Andes, in the Republic of Ecuador.

2 Methodology

The research starts from the postulates of neutrosophy, which have been systematized by researchers such as [4] [5] [6], who agree that this is a new branch of philosophy, which opened a new field of research in metaphilosophy, and which studies the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra. It was created by Professor Florentin Smarandache in 1995.

Etymologically neutrosophy (from the French *neutre* and the Latin *neuter* meaning neutral and the Greek *sophia*, knowledge) is the knowledge of neutral thoughts. It forms the basis for neutrosophic logic, neutrosophic sets, neutrosophic probability, and neutrosophic statistics.

According to the aspects discussed above, each of the analyses of this research will be carried out, both statistical and in the selection of the sample and the use of neutrosophic linguistic scales. Which will be discussed below.

2.1 Study subjects

In correspondence with the criteria of the authors discussed above, the sample selection criteria proposed by Smarandache [4] are assumed, who considers that a neutrosophic sample is a chosen subset of a population, a subset that contains some indeterminacy: either with respect to several of its individuals (which may not belong to the population we are studying, or may only partially belong to it) or with respect to the subset as a whole. While classical samples provide accurate information, neutrosophic samples provide vague or incomplete information.

Where the letter p = means the approximate proportion of the reference population, the letter q = refers to the proportion of the reference population that does not present the research (1 -p). The desired confidence level for the statistician (Z), this letter is indicative of the level of confidence that will be had in the true value of the parameter in the population found in the calculated sample. For its part, absolute precision is represented by the letter (d). Which in turn means the desired width of the confidence interval on either side of the true value of the difference between the two proportions (in percentage points). While the N refers to the size of the population.

That is why Smarandache also says that any sample is neutrosophic since it can be considered that its determination is equal to zero. A neutrosophic population is a population that has not determined the membership of its members (that is, it is not known with certainty whether some individuals belong to the population or not) [4], [22], [23, 26].

Being consistent with the selected formula and to increase the validity of the research, a confidence level between 90 and 95% is desired, z= [1.642, 1.99], d= [0.04, 0.2] and p = [0.5, 0.43] , N=40. The result called the neutrosophic sample n= [10.1, 30.9], indicates that the sample must be in values between 10 and 32 medical students of the Autonomous Regional University of the Andes, in the Republic of Ecuador.

This research selects 32 undergraduate students who will be users of the health education program presented. All of them passed their third year and were randomly selected using the Tombola technique.

2.2 Instruments used

In the investigation, methods and techniques of the sciences, in general, were used, such as those of a theoretical nature such as the analytical-synthetic, and the inductive-deductive, which facilitated the work with the bibliography selected for the present investigation.

Within the empirical ones, the survey and the user criteria were used, for the latter, the recommendations of authors such as Matos, and Matos, Brito, who consider it important to consult those who will benefit from a certain proposal, are followed [7] [8].

These consulted bibliographic sources [7], [21], [24], [25], [26], [27], [28] consider that the user criterion refers to *"the opinions expressed by the subjects who become users or direct beneficiaries of a proposal, who are or will be responsible for the application of such results in the immediate or mediate future"*. In addition, they defend the criterion that it is a method of a qualitative nature and include it at the empirical level. (p.46).

Within the mathematical statistics, neutrosophic descriptive statistics are used, and within this, the percentage calculation.

2.3 Neutrosophic method

Within the neutrosophic techniques used, the Neutrosophic Likert scales, where the values under consideration are composed of PA (x), IA (x), NA (x), where PA(x) denotes a positive membership, IA(x) is indeterminate, and NA(x) is negative. The user can assess whether the health education program belongs to the three sets of satisfaction criteria.

This scale used single-value neutrosophic numbers (SVNS) [4], [5]. For this case study, the universe of discourse, an SVNS on which is an object with the following form [12], [13], [14].

Where With for all x

The interval [0, 1] represents the true, undetermined, and false memberships of x in A, respectively. For convenience, an SVN number will be expressed as A, where a, b, c, and $+b+c \leq 3$

To represent inconsistent, imprecise, and uncertain information from the real world, the membership of indeterminacy is represented independently together with the membership of truth and falsehood in the set of neutrosophy, this has been recommended by several researchers such as [4], [5], [15], [16], [20]. The interval represents the true, undetermined, and false memberships of x in A, respectively.

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}d \quad (1)$$

Where

$$u_a(x): X \to [0,1], r_a(x): X \to [0,1]\ y\ \ v_a(x): X \to [0,1]$$

With

$$0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \qquad \forall\, x \in X$$

The intervals $u_a(x), r_a(x)$ and $v_a(x)$ denote the true, indeterminate, and false memberships of x in A, respectively.

For convenience, an SVN number will be expressed as A, where a, b, c [0,1], and +b +c ≤ 3.

Linguistic term	SVN numbers
Excellent (E)	(1,0,0)
Very good (VG)	(0.70,0.35,0.28)
Good (G)	(0.50,0.50,0.49)
Regular (R)	(0.40,0.85,0.75)
Bad (B)	(0,1,1)

Table 1: Linguistic terms of the scale

Let A = (T, I, F) be a single-valued neutrosophic number, a score function S related to a single-valued neutrosophic value, based on the degree of truth membership, the degree of indeterminacy membership and the degree of belonging to falsehood is defined by [4], [17]:

The scoring function for single-valued neutrosophic sets is proposed to make the distinction between the numbers.

Its execution algorithm basically exploits the notion of distance measurements between any two entities and based on this, the clusters are formed. The most commonly used distance formula for these values is the Euclidean:

$$\mathrm{d(A-B)} = \sqrt{\frac{1}{3}\sum_{i=1}^{n}[P_A(x_i)-P_B(x_i)]^2 + [I_A(x_i)-I_B(x_i)]^2 + [N_A(x_i)-N_B(x_i)]^2} \quad (2)$$

Neutrosophy, as already discussed, was proposed by Smarandache [9] for the treatment of neutralities. This has formed the basis for a series of mathematical theories that generalize classical and fuzzy theories such as neutrosophic sets and neutrosophic logic [12].

For the implementation of the research, the neutrosophic model proposed in the methodological steps presented below is used.

Step 1. Select the researchers and who can be the receiving users

Step 2. Preparation of a preliminary survey

Step 3. Explain in the survey questionnaire it is necessary to detail and explain to the users what is to be evaluated

Step 4. Determination of the procedure to follow for the collection of information

Step 5. Information processing and analysis

Components of the program for health education

Components	Contents	Actions
System of objectives	General and specific	Identification of general and specific objectives
Block 1. Orientation	Healthy lifestyles Nutritional orientation	Conduct orientation seminars Conduct educational talks

Block 2. Systematization	Toxic habits Systematic educational activities Community educational intervention	Systematization of significant experiences Organization of community forums

Table 2: Summary of the components of the health education program.

3 Results

Before applying the survey to the selected users, who in this case are the medical students at the Autonomous Regional University of the Andes, a brochure with the entire program was given to them a week before so that they could study it. Subsequently, it is applied to a survey to know its level of relevance.

Results of the users to question 1 of the applied survey

Question 1	Excellent 6	Very Good 5	Good 4	Regular 3	Bad 2
How do you assess the system of objectives of the health education program presented?	11 (34.3%)	8 (25.2%)	6 (18.7%)	4 (12.5%)	3 (9.3%)

Table 3: Results of the assessment of the patients regarding question 1.

In correspondence with the results of Table 3, the categories with the highest score were the most indicated by the university students. Well, 11 for 34.3% of the total sample value the components of the program as excellent. On the other hand, 8 of them for 25.2% value it as Very good. While 6 for 18.7%, estimated that these are Good. On the other hand, they value it as Regular only 4 for 12.5%, and a minority of the students consider that the program is qualified as Bad. This is reflected in 3 students for 9.3%.

Question 2	Excellent 6	Very Good 5	Good 4	Regular 3	Bad 2
How do you rate the blocks of the health education program	19 (59.3%)	4 (12.5%)	4 (12.5%)	3 (9.3%)	2 (6.4%)

Table 4: Results of the assessment of university students regarding question 2 of the survey

The results of question 2 of the survey applied to university students, it is evident as in the previous one that there is a regularity that the students indicate in their majority the categories with the highest score. This is reflected in the fact that only 19 for 59.3% stated that the health education program presented is of excellence, while 4 for 12.5% rated it as Very good, the same number rated it as good (4 for 12.5%) For their part, only 3 for 9.3% value it as regular and only a minority of 2 students for 6.4% state that the program is bad. A result that coincides with what was expressed in the previous question.

Question 3	Excellent 6	Very Good 5	Good 4	Regular 3	Bad 2
How do you value the contents and actions of the health education program?	21 (65.6%)	5 (15.6%)	3 (9.6%)	1 (3.1%)	1 (3.1%)

Table 5: Results of the assessment of university students regarding question 3 of the survey

Table 5 illustrates the results of the students' responses to question 3 of the survey. Where it is appreciated that

the majority of university students consider that the program is Excellent (22 for 65.6%), while 5 for 15.6% consider that it is Very Good, only 3 for 9.6% consider that this is Good and the two lowest categories of the scale had 1 student respectively (Regular 1 for 3.1 and Bad 1 for 3.1). What has been assessed so far makes evident the relevance of the program presented according to the criteria of the users [18], [19], [29].

Conclusion

From the analysis carried out, it becomes evident that health education has been systematized from different approaches and perspectives. However, the use of Neutrosophy for the assessment of the relevance of a program has been little treated in the specialized bibliography on this subject.

Through the use of a linguistic neutrosophic scale and with the help of the user criterion technique, the relevance of a health education program in medical university students was demonstrated.

References

[1] R. Álvarez. Educación para la salud. México: Manual Moderno, 2005
[2] R. Borrero. Estrategia didáctica para dirigir la educación para la salud en la secundaria básica. (Tesis doctoral). La Habana. 2008
[3] C. Carvajal. Temas de educación para la salud y educación de la sexualidad. La Habana. Editorial Pueblo y Educación. 2003
[4] F. Smarandache. "Introduction to Neutrosophic Statistics". Ed. Infinite Study, 150, 2014
[5] F. Smarandache. "Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic" Over-/Under-/Off-Logic, Probability, and Statistics. 2016
[6] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018
[7] Brito, E. La formación continua de los profesionales de natación artística en Cuba. (Tesis doctoral) Universidad de Ciencias de la Cultura Física y el Deporte. La Habana. 2017
[8] Matos, Z., y Matos, C. El método de criterio de usuarios. Su utilización en la investigación educativa. Guantánamo, Cuba: Instituto Superior Pedagógico "Raúl Gómez García".2006
[9] F. Smarandache, "of Neutrosophic Numbers". Critical Review, Vol. 13, 2016. 13: p. 103. 2016
[10] N.B Hernández. Validation of the pedagogical strategy for the formation of the competence entrepreneurship in high education through the use of neutrosophic logic and Iadov technique. Neutrosophic Sets & Systems, 2018. 23.
[11] Y M Gordo Gómez, D M Ramírez Guerra, L A Zaldívar Castellanos, R González Piña. Análisis del emprendimiento comunitario en las actividades físico-terapéuticas desde la Universidad. Neutrosophic Computing and Machine Learning, Vol. 8, 2019
[12] Smarandache, F., A Unifying Field in Logics: Neutrosophic Logic. Philosophy, 1999: p. 1 -141.
[13] Jansi, R., Mohana, K., & Smarandache, F. (2019). Correlation Measure for Pythagorean Neutrosophic Fuzzy Sets with T and F as Dependent Neutrosophic Components. Neutrosophic Sets and Systems, 30(1), 16.
[14] O. Mar, I. Santana, and J. Gulín, "Algoritmo para determinar y eliminar nodos neutrales en Mapa Cognitivo Neutrosófico," Neutrosophic Computing and Machine Learning, vol. 8, pp. 4-11, 2019.
[15] R. G. Ortega, M. Rodríguez, M. L. Vázquez, and J. E. Ricardo, "Pestel analysis based on neutrosophic cognitive maps and neutrosophic numbers for the sinos river basin management," Neutrosophic Sets and Systems, vol. 26, no. 1, pp. 16, 2019.
[16] S. A Edalatpanah, & Smarandache, F. (2019). Data envelopment analysis for simplified neutrosophic sets. Infinite Study.
[17] Y. G. Calva Vega, M. A. Torres Villamarín, F. P. Cañizares Galarza & J. C. Narváez Moncayo. "La ley orgánica de Servicio Público y los derechos sindicales de la clase obrera". Universidad y Sociedad, vol. 14 no. S3, pp 525-536, 2022.
[18] J. L. Maldonado Cando, M. A. Torres León, J. R. Santillán Andrade & G. F. Acurio Hidalgo. "La delincuencia generada por la violencia infantil". Universidad y Sociedad, vol. 14 no. S3, pp 513-524, 2022.
[19] M. E. Machado Maliza, M. E. Paredes Moreno & C. D. Siza Pillajo. "La administración de justicia en la población indígena, discriminación cultural". Universidad y Sociedad, vol. 14 no. S3, pp 504-512, 2022.
[20] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.
[21] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.
[22] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.
[23] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[24] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[25] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.
[26] von Feigenblatt, O. "Mediation for management: Dealing with Conflict in the Workplace". Innovaciones de Negocios,

vol. 18 no. 35, pp 113-119, 2021.
[27] S. A. Montecé Giler, T. J. Mendoza Palma, J. C. Nevarez Moncayo & E. L. Hernandez Ramos. "Limitación de acceso a los medicamentos para las personas que padecen enfermedades catastróficas". Universidad y Sociedad, vol. 14 no. S4, pp 241-251, 2022.
[28] I. X. León Rodríguez, E. A. Rojas Silva, L. C. Campaña Muñoz & P. A. Centeno Maldonado. "Violencia física a la mujer: una visión desde el cantón Santo Domingo en Ecuador durante el último trienio". Universidad y Sociedad, vol. 14 no. S4, pp 234-240, 2022.
[29] C. X. Galarza Castro, R. C. Ilaquiche Licta, E. J. Naranjo Luzuriaga & J. D. Bósquez Remache. "La facultad discrecional y la vulneración a la democracia directa en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 225-233, 2022.

Received: August 22, 2022. **Accepted:** October 18, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Study on the Levels of Physical Activity in Undergraduate Medical Students

Daniela Abigail Cobo Álvarez[1], Jeanneth Elizabeth Jami Carrera[2] and Gerardo Emilio Medina Ramírez[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.danielacobo@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.jeannethjami@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.gerardomr59@uniandes.edu.ec

Abstract. In this study, an assessment is made of the levels of physical activity of a group of university medical students. This is based on the benefits of physical activity for human health. Considering the above-mentioned arguments, the objective of the research was to assess the levels of physical activity of undergraduate medical students using neutrosophic tools. During the study, theoretical, empirical, and mathematical-statistical methods and techniques were presented. After applying the techniques and instruments, it was possible to identify the different levels of physical activity in the sample studied. These results allowed to open future research lines that imbricate Neutrosophy and sciences applied to physical activity.

Keywords: neutrosophic statistical analysis, neutrosophic graph, physical activity, health, university students.

1 Introduction

The practice of physical activity on a regular basis and healthy body weight are relevant actions to prevent the appearance of antisocial and harmful behaviors, in addition to social exclusion, associated with poor physical and mental health and a sedentary lifestyle [1].

From the holistic point of view of the concept of health, promoting a physically active lifestyle improves the quality of life of people from childhood. More active students interact better with their parents, show higher academic performance, have fewer socio-affective disorders, and even have healthier eating habits [2].

The beneficial effects of performing physical activity in daily life are undeniable, specially if habits are established from the beginning of the life cycle; therefore, the need to promote patterns of physical activity in all age groups is highlighted.

Physical activity is any movement that the human body performs and requires energy expenditure. That is why one of the important postulates in raising the quality of life of university students.

According to authors such as Airasca, physical activity and its link with health play a fundamental leading role, oriented to well-being, preventive and rehabilitative. In the present work, the first two are taken into consideration [3].

An important component of physical activity is health promotion and encouragement of physical activity in health services, school and community contexts, and comprehensive care institutions, among others. Well, this is aimed at preventing the appearance of diseases, generally of a non-communicable type [4], [17], [20].

The literature suggests that disjointed actions are developed in the promotion of physical activity in the university context: these efforts do not have the expected impact. Therefore, studies are required from other perspectives such as Neutrosophy.

Based on the arguments raised above, the following research objective is formulated: assess the levels of physical activity of undergraduate medical students from neutrosophic tools.

2 Methodology

2.1 Study subjects

For this investigation, the bases of Neutrosophy were taken into account on the samples systematized by several authors such as [5], [7], [17]. Those who state that there are different formulas for their selection. The ones

developed in this research are shown below.

p = approximate proportion of the phenomenon under study in the reference population
q = proportion of the reference population that does not present the phenomenon under study (1 -p)
The desired confidence level (Z). Indicates the degree of confidence that the true value of the parameter in the population is found in the calculated sample.
The absolute precision (d). It is the desired width of the confidence interval on either side of the true value of the difference between the two proportions (in percentage points).
N is the population size

For the present study, it proceeds as follows:

In this case, a confidence level between 90 and 95% is desired, z= [1.644, 1.97]
d= [0.05, 0.0] and p = [0.4, 0.43], N=40.

The result that is called the neutrosophic sample n= [10.3, 30.8] indicates that the sample must be in values between 11 and 33 medical school students.
According to this, a sample of 12 students from the Autonomous Regional University of the Andes, in Ecuador, is selected. This was done randomly, of them 8 are female, and 4 are male. With an average age of 28.5 years. All with medical experience.
All students signed the informed consent in accordance with the Declaration of Helsinki. Where they were given a detailed analysis of the research, its objectives, and the need to deepen this topic.

2.2 Instruments used

During the investigation, theoretical methods and techniques were applied, such as synthetic analytical and inductive-deductive, both of which were important for working with theoretical references. Within the empirical methods, the survey and the measurement were used, the first was used to obtain the data, and the second for the analysis of the results that, together with the mathematical statistics, would contribute to illustrating them. Calculations of measures of central neutrosophic tendencies were also performed. Particularly the average, to know how it is revealed by each of the selected levels. [22]

2.3 Neutrosophic method

For the development of the research, the following neutrosophic model is followed. As represented in Figure 1.

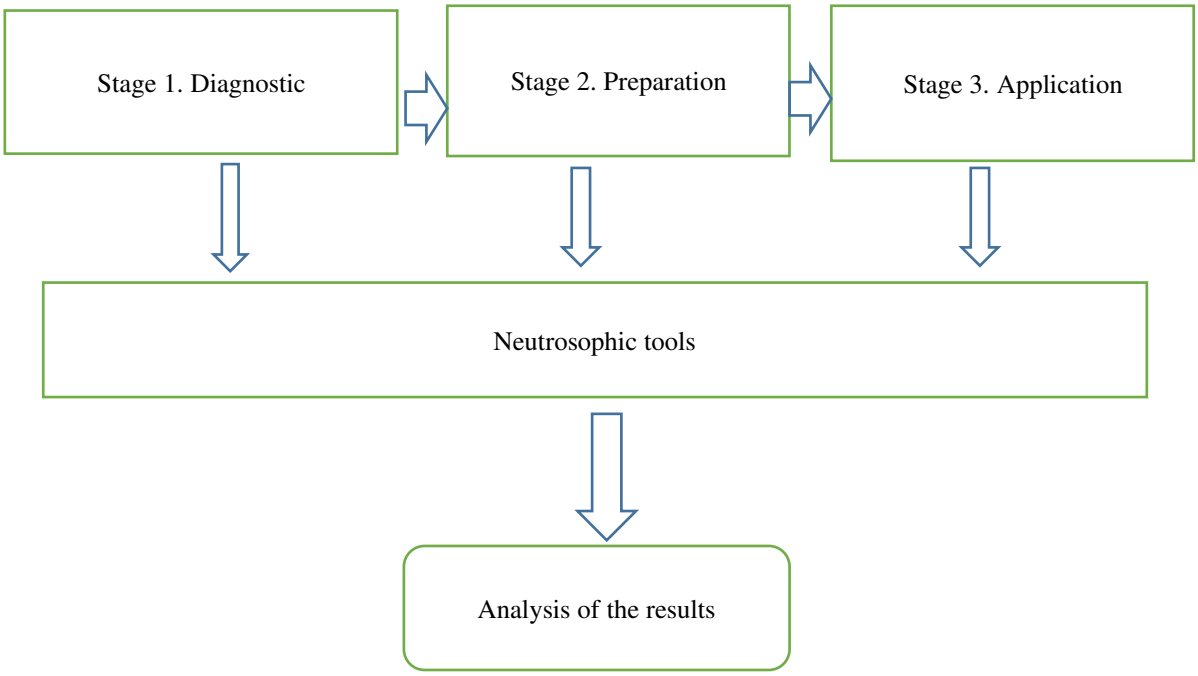


Figure 1: Neutrosophic model for the instrumentation of the research

2.4 Procedure used

For the assessment of physical activity levels, the Minnesota Physical Activity survey was used. Which consists of relating the main activities carried out by university students in the last week.

Which had a modification in correspondence with the characteristics and culture of the Republic of Ecuador. Subsequently, the energy expenditure calculations are made according to physical activity as described by the researcher Roig [8], [13], [16], [21] and then they are classified in the levels proposed by this same author. Which is presented in Table 1.

Levels	Energy expenditure
Light:	0.031 kcl
Active:	0.049 kcl
Very active:	0.096 kcl

Table 1: Levels of energy expenditure by physical activity. Prepared from data from F Grande Covián. Source: [8].

3 Results

The results are presented in correspondence to the neutrosophic model that appears in Figure 1 of the present investigation. It begins with a diagnosis of students' knowledge of the definition and classification of physical activity, for which a survey with two questions is applied. The results of which are presented below.

Stage 1 of the neutrosophic model

Questions	Yes		No	
	Quantity	Percentage	Quantity	Percentage
Know the definition of physical activity	4	33.4	8	66.6
They know what the main manifestations of physical activity are	3	12	9	75

Table 2: Results of the diagnostic survey on knowledge of the physical activity.

When assessing the results of the survey on the knowledge of medical students about physical activity, as shown in Table 2. Their knowledge is low. These results are supported by the answers to the two questions of the survey. Which are discussed below.

When evaluating the results of question 1, it can be stated that only 4 students for 33.4% expressed knowledge about the definitions of physical activity.

While the majority of these 8 for 66.6% reported not knowing definitions. Which denotes little knowledge of the students about this question.

Similar results were obtained in question 2, where 3 for 12% reported not knowing the main manifestations of physical activity.

On the other hand, most of the students reported not knowing them, this was reflected in 9 for 75%. Like the previous one, the majority of students are unaware of the main manifestations of physical activity, which limits the application of the subsequent Minnesota survey.

That is why the model has conceived a stage of preparation that will be described below. [18], [19], [23], [24], [25]

Stage 2 of the neutrosophic model

Once the results of the initial diagnosis were assessed, four workshops were held to prepare the students before applying the Minnesota survey.

The contents refer to the definitions of physical activity, main manifestations, types of physical activity, and the relationship between energy expenditure and physical activity. Once the knowledge has been verified and only when 100% of the sample masters the content, the Minnesota physical activity survey is applied.

Stage 3 of the neutrosophic model

Levels	Quantity	Percentage
Light	7	58.3
Active	3	25
Very active	2	16.7

Table 3: Minnesota Physical Activity Survey Results

After applying the survey, Table 3 is constructed in Minnesota to find out the levels of university students. Where its results show that the majority of students are at the light level, this is reflected in 7 for 58.3%. This places these students at risk factors for suffering from any of the non-communicable diseases or others that cause physical inactivity.

On the other hand, only 3 students for 25% are located according to their energy expenditure as active. Which favors that they are in the permissible ranges of levels of physical activity. Although they should perform more physical activity to continue improving their quality of life. On the other hand, only 2 students for 16.2% are classified as very active, a reason that places them in better conditions in the prevention of the risk factors of some diseases

Tools of neutrosophic statistics

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, and neutrosophic regression.

It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and to the methods to analyze them.

Based on the above criteria, the neutrosophic mean of the three levels of physical activity is calculated, taking into account the indeterminacy of some of the students' daily activities [9], [10], [14], [17].

In this case, to calculate the mean of the recorded data, let us assume that the following values are observed for the 3 levels of physical activity.

Quantities containing an uncertainty component are represented as classical neutrosophic numbers, of the form:

N= a + Bi

Control	Number of students
1	7+4I
3	3+2I
4	2+1I

Table 4: Ranking of the data with indeterminacy

To calculate the mean of these values, the same equation is applied as in classical statistics, taking into account the peculiarities of operations with neutrosophic numbers [11], [15].

$$\bar{x}_N = \frac{(7+4I)+(3+2I)+(2+1I)}{3} = \frac{7+3+2}{3} + \frac{4+2+1}{3} \cdot I$$

$$\bar{x}_N = 4 + 2{,}3I = 6{,}3$$

Next, a neutrosophic graph [12] is shown, illustrating the relationship between determination and indeterminacy of weekly physical activity carried out by university students. This contributes to giving robustness to the results obtained.

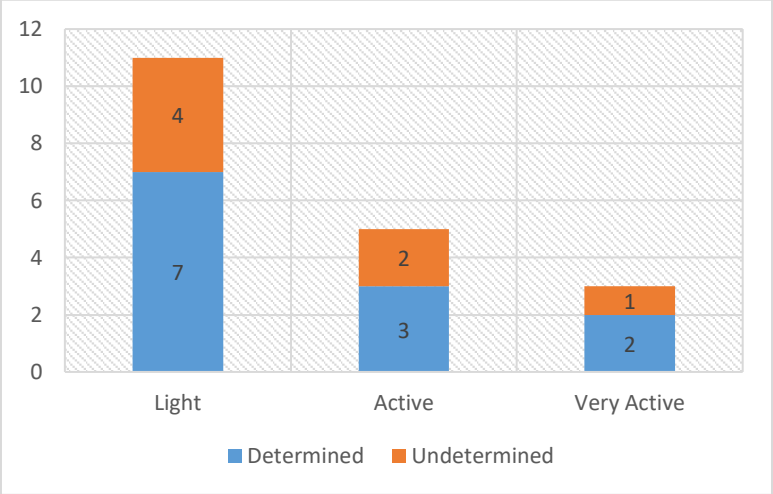


Figure 2: Graphic representation of the relationship between determination and indeterminacy

Conclusion

The assessment of the theoretical and methodological references on the use of neutrosophic techniques in the study of physical activity levels in university students shows the need to deepen this subject investigated from a neutrosophic approach.

The interpretation of the results, through a descriptive neutrosophic study, allowed to reveal the level of internal validity of the results presented in the selected sample.

References

[1] B Pérez. Salud: Entre la actividad física y el sedentarismo. An Venez Outrun [cited 2019 Jun 17]; 27(1):119. Available from: https:// bit.ly/3ef2Jk3. 2014

[2] D Moscoso, Moyano E. Deporte, salud y calidad de vida [internet]. Barcelona: Fundación "La Caixa". Available from: https://bit.ly/2N9EiZi. 2018

[3] D Airasca. Actividad Física y Salud. [Versión HTML] Recuperado de http://www.actividadfisica.net. 2002

[4] Instituto Colombiano de Bienestar Familiar [Internet]. Anexo técnico para orientar la prestación de servicios en Centros de Desarrollo Infantil; [Cited 2019 Feb 4]. Available from: https://bit.ly/2N3RoaG. 2017

[5] F Smarandache. Introduction to Neutrosophic Statistics. Infinite Study. 2014

[6] F Smarandache. Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic Over-/Under-/Off-Logic, Probability, and Statistics. 2016

[7] M. L Vázquez & Smarandache, F. Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre. Infinite Study. 2018

[8] Roig N. Estudio del desarrollo morfofuncional. En: Alfonso Villasuso CF. Control médico. La Habana: Deportes; p. 57-153, 2012

[9] R. Carballido, Paronyan, H., Matos, M. A., & Santillán Molina, A. L. Neutrosofic statistics applied to demonstrate the importance of humanistic and higher education components in students of legal careers. Neutrosophic Sets and Systems, 26(1), 26. 2019

[10] D. M. Ramírez Guerra, Y. M. Gordo Gómez, L. J. Cevallos Torres, F. G. Palacios Ortiz. Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment. International Journal of Neutrosophic Science (IJNS), Vol. 19, No. 01, PP. 389-402, 2022

[11] R. G. Ortega, M. Rodríguez, M. L. Vázquez, and J. E. Ricardo, "Pestel analysis based on neutrosophic cognitive maps and neutrosophic numbers for the sinos river basin management," Neutrosophic Sets and Systems, vol. 26, no. 1, pp. 16, 2019.

[12] Carballido, R. M., Paronyan, H., Matos, M. A., & Santillán Molina, A. L. Neutrosofic statistics applied to demonstrate the importance of humanistic and higher education components in students of legal careers. Neutrosophic Sets and Systems, 26(1), 26. 2019.

[13] R. E. Atencio González, J. F. Molina Mora & G. A. Andrade Olvera. "La legislación ecuatoriana y los derechos humanos desde su perspectiva. Universidad y Sociedad, vol. 14 no. S3, pp 498-503.

[14] J. F. Molina Mora, R. E. Atencio González& P. M. Moreno Arvelo. "La Constitución Ecuatoriana y los principios democráticos". Universidad y Sociedad, vol. 14 no. S3, pp 487-497, 2022.

[15] M. M. Grijalva Palacios, N. S. Ponce Reyes & D. C. Burbano Pijal. "Irrigación ultrasonica en endodoncia: análisis del estado del arte". Universidad y Sociedad, vol. 14 no. S3, pp 476-486, 2022.

[16] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[17] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.

[18] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.
[19] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[20] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[21] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.
[22] von Feigenblatt, O. F. "Un estudio de caso sobre la competencia diplomática entre la República Popular China y la República de China (Taiwán): La experiencia de la República de Costa Rica de 1995 a 2010". Dilemas contemporáneos: Educación, Política y Valores. Vol. 9no. (Edición especial), pp 1-19, 2021.
[23] G. P. León Burgos, D. S. Paredes Miranda, M. I. Mora Verdezoto & C. R. Hurtado Lomas. "Matrimonio igualitario como mecanismo de protección de los derechos de la comunidad LGBTI". Universidad y Sociedad, vol. 14 no. S4, pp 202-209, 2022.
[24] V. H. Lucero Salcedo, R. A. Falconi Herrera & G. C. Robles Santana. "Student skills in the teaching of international law the Central University in Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 191-201, 2022.
[25] R. F. Sánchez Santacruz, M. D. R. Mosquera Endara & J. J. Santander Moreno. "Analysis of money laundering crimes through multi-criteria decision methods". Universidad y Sociedad, vol. 14 no. S4, pp 181-190, 2022.

Received: August 23, 2022. **Accepted:** October 18, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Linguistic Scale for Self-Assessment of Knowledge about Non-Communicable Diseases in Medical Students

Daniela Abigail Cobo Álvarez[1], Karla Indira Hurtado Serrano[2], Abdel Bermúdez del Sol[3] and María de Lourdes Llerena Cepeda[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.danielacobo@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.karlahs43@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.abdelbermudez@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. E-mail: ua.mariallerena@uniandes.edu.ec

Abstract. Every day there is an increase in the number of non-communicable diseases in different population sectors of Latin America, aspects that lead to dissimilar deaths per year, which has made these an important line of research in the scientific community. That is why during the training of professionals in the medical sciences these are an important unit of knowledge. However, it is still required to use neutrosophic tools to identify the level of knowledge of university students about them. That is why the objective of this research is oriented towards applying a Neutrosophic Linguistic Scale for the self-assessment of knowledge about non-communicable diseases in medical students. During the study, theoretical, empirical, and mathematical-statistical methods were used. The results obtained make evident the need to change the teaching approach of these in the investigated field.

Keywords: neutrosophic scale, medical students, neutrosophic method, knowledge.

1 Introduction

Noncommunicable diseases (NCDs) represent a global problem, especially for developing countries, where they have become a major public health burden in recent years. The statistics published by the World Health Organization (WHO) are alarming and worrying. Morbidity and mortality from NCDs increase practically for years, not only with population aging as life expectancy increases but also increases in very active ages of life [1].

These diseases affect all age groups and represent a heterogeneous group of conditions such as diabetes and high blood pressure, among others, constituting a public health problem for being a cause of morbidity, in the framework of the aging process of the Latin American population and due to the unhealthy way of life [2], [3].

The time series of mortality from the highest impact cardiovascular diseases (heart and cerebrovascular diseases) showed a decrease in the adjusted rate per 100 000 population of 1.3% per year, on average, between 1970 and 2017. Reason that makes it an important area of research since, within the NCD, this is the one with the highest mortality.

According to studies of the 2020s, the WHO warns of an even greater increase in the current decade [1], [4]. They are so for several reasons: the large number of affected cases with their increasing incidence rates, their gradual contribution to overall mortality because they are the most frequent cause of disability, and the high cost of hospitalization, medical treatment, and subsequent rehabilitation [4], [23].

That is why during the training of medical professionals from most universities in Latin America, they include it as an important subject to be passed by their graduates. Well, the incidents show that it is one of the ones that interact the most during the exercise of their profession.

Because of the above-mentioned, a bibliographic search was carried out where authors such as [3], [4], [5], [6] stand out, and their main results are oriented to the linking of this subject with related disciplines. However, the study of neutrosophic tools in the assessment of university medical students on the NCD unit has not been systematized.

Based on the arguments raised above, this research aims to apply a Neutrosophic Linguistic Scale for the self-assessment of knowledge about non-communicable diseases among medical students of the Autonomous Regional University of the Andes, in the Republic of Ecuador.

2 Methodology

2.1 Study subjects

For the selection of the sample, the procedures described by [7], [8], [9], [22], [26] for neutrosophic research were considered. These same authors state that a neutrosophic sample is a chosen subset of a population, a subset that contains some indeterminacy: either with respect to several of its individuals (which may not belong to the population under study or may only partially belong to it) or with respect to the subset as a whole.

For the case of this investigation, the following neutrosophic logic was followed, where:

- p = approximate proportion of the phenomenon under study in the reference population
- q = proportion of the reference population that does not present the phenomenon under study
- Z = desired confidence level
- d= the desired width of the confidence interval on either side of the true value of the difference between the two proportions (in percentage points)
- N= size of the sample that will be studied

When working with a confidence level between 95 and 99%, z= [1.645, 1.96], = [0.05, 0.1] and p = [0.4,0.44], N=40. Where n= [10.1, 30.6] indicates that the sample must be in values between 10 and 31 university students.

In correspondence with the previous formula, a random sample of 30 university medical students of the Autonomous Regional University of the Andes, in the Republic of Ecuador, was selected. 18 of them are female and 12 are males. All with the third year completed and approved. [27], [28]

2.2 Classical methods and techniques used

During the investigative process, classical methods of scientific research were used, such as synthetic analytical and inductive-deductive. Which were used for the work with the different bibliographic sources.

Among the empirical ones, the student survey was used, which was the main technique for collecting information. While measurement was also used to attribute value to each of the terms of the Neutrosophic linguistic scale applied in scientific research.

Also, classical statistical methods, such as descriptive statistics, were used within this frequency distribution analysis. In addition, the Pearson correlation test was employed to identify whether there were coincidences in the answers of the patients to the questions of the survey, the latter was carried out with the help of the statistical program SPSS in its version 20.0.

2.3 Neutrosophic method

The neutrosophic method of investigation is used to consider the contradiction and uncertainty in linguistic labels, and the use of neutrosophic statistics to handle indeterminacy in the sample.

Moment 1. Informative

The Autonomous Regional University of the Andes "UNIANDES" of the Faculty of Medical Sciences researches students' knowledge of non-communicable diseases. For this reason, you are asked to answer this survey as honestly as possible. It is anonymous, so you are guaranteed total confidentiality of the information provided. Thank you in advance for your cooperation.

Moment 2. Determination of the objective

The objective of the same is to assess the knowledge of students about chronic non-communicable diseases

Moment 3. Preparation of the questionnaire

Question 1. How do you rate your knowledge regarding the classification of non-communicable diseases?

Question 2. How do you rate your knowledge about the treatment of non-communicable diseases?

Question 3. How do you rate your knowledge about ways to prevent non-communicable diseases?

A neutrosophic Likert scale was used to determine the relevance, where the values under consideration are composed of PA (x), IA (x), NA (x), where PA (x) denotes a positive belonging, IA (x) is indeterminate, and NA(x) is negative. The patient can evaluate the belonging of his self-assessment criteria to the three sets.

This scale used single-value neutrosophic numbers (SVNS) [10]. Let X be a universe of discourse, an SVNS A over X has the following form [11], [16], [19], [24], [25].

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}d$$

Where

$$u_a(x): X \to [0,1], r_a(x): X \to [0,1] \text{ and } v_a(x): X \to [0,1]$$

With

$$0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \qquad \forall\, x \in X$$

The interval $u_a(x), r_a(x)$ and $v_a(x)$ represents the true, undetermined, and false memberships of x in A, respectively. For convenience, an SVN number will be expressed as A, where a, b, c [0,1], and +b +c ≤ 3

Linguistic term	SVN numbers
Very High (VH)	(1,0,1)
High (H)	(0.70,0.30,0.25)
Medium (M)	(0.50,0.50,0.50)
Low (L)	(0.30,0.70,0.75)
Very Low (VL)	(0,1,1)

Table 1. Linguistic terms of the scale.

Let A = (T, I, F) be a single-valued neutrosophic number, a score function S related to a single-valued neutrosophic value, based on the degree of truth membership, the degree of indeterminacy membership and the degree of belonging to falsehood is defined by:

The scoring function for single-valued neutrosophic sets is proposed to make the distinction between the numbers.

According to the criteria expressed by [12], [13], [14], [15], [21] that in order to obtain more reliable results, conglomerate or cluster analysis can be used, which is a multivariate technique that seeks to group elements or variables trying to achieve the maximum homogeneity in each group and the greatest difference between them, through a hierarchical structure to be able to decide which hierarchical level is the most appropriate to establish the classification.

Its execution algorithm exploits the notion of distance measurements between any two entities and based on this, the clusters are formed. The most commonly used distance formula for these values is the Euclidean one, [7], [17], [29]:

$$d(A-B) = \sqrt{\frac{1}{3}\sum_{i=1}^{n}[P_A(x_i) - P_B(x_i)]^2 + [I_A(x_i) - I_B(x_i)]^2 + [N_A(x_i) - N_B(x_i)]^2}$$

Based on the formulas and procedures described above, an analysis is carried out following the characteristics of classical statistics. Which is described in the next section.

3 Results

Question 1	Very High (6)	High (4)	Medium (3)	Low (2)	Very low (1)
How do you rate your knowledge regarding the classification of non-communicable diseases?	4 (13.3%)	6 (20%)	10 (33.4%)	6 (20%)	4(13.3%)

Table 2. Results of question 1 of the student survey

Table 2 refers to the results of question 1 of the survey applied to students. Whose results are displayed as follows: 4 students, for 13.3%, self-assessed their knowledge as Very High, meanwhile 6, for 20%, assigned themselves the High category. While 10, for 33.4%, indicated having a Regular category, 6 for 20% of the total number of students surveyed selected the Low option, while the rest of the members of sample 4 for 13.3%, chose the Very low category.

Question 2	Very High (6)	High (4)	Medium (3)	Low (2)	very low(1)
How do you rate your knowledge about treatments for non-communicable diseases?	3 (10%)	6(20%)	12 (40%)	6(20%)	3(10%)

Table 3. Results of question 2 of the student survey

Table 3 shows the results, where only 3 students, for 10% of the studied sample, chose Very High, while 6 students, for 20%, selected the High category. On the other hand, the linguistic term Medium was valued by 12 students for 40% of the sample. The Low was selected by 6 students for 20% and the rest of the sample, 3 for 10%, self-assessed as Very Low.

Question 3	Very High (6)	High (4)	Medium (3)	Low (2)	Very low(1)
How do you rate your knowledge about ways to prevent non-communicable diseases?	5 (16.6%)	4 (13.3%)	15 (50%)	5 (16.6%)	1(3.5%)

Table 4. Results of question 3 of the student survey

Table 4 shows the results of question 3 of the applied survey, where 5, for 16.6%, rated themselves as Very high in the investigated subject, while 4 of them, for 13.3%, rated themselves as High. While the intermediate category of the neutrosophic Likert scale was the most indicated by the students as 15 for 50% self-assessed their knowledge as Medium. On the other hand, the category of Low was indicated by 5 students for 16.6% and the remaining 1 for 3.5% as Very low.

The results shown revealed that there is still a growing need to continue delving into this subject in the training stage of the medical sciences professional since they still feel that they can acquire more knowledge on this subject.

Study Validation

To deepen the validity of the results, a study of correlations was carried out, since this marks the relationships between 2 or more variables, that is, the degree of possibility that they have to coincide. Table 5 presents the correlation matrix between the variables corresponding to the content of the three questions of the survey applied to university students. Correlation coefficients have been calculated for all possible pairs of study variables.

This statistical analysis has been carried out from the Pearson Correlation, where significant results were considered in r, ($p<0.005$). In this sense, the answers to the content of the survey questions correlate with each other. All the above makes evident the level of significance of the results obtained in this research. [18], [20]

Correlations		Classification	Treatments	Prevention
Classification	Pearson correlation	1	.945**	.919**
	Next (2-sided)	-	,000	,000
	N	30	30	30
Treatments	Pearson correlation	.945**	1	.901**
	Next (2-sided)	,000	-	,000
	N	30	30	30
Prevention	Pearson correlation	.919**	.901**	1

Correlations		Classification	Treatments	Prevention
	Next (2-sided)	,000	,000	-
	N	30	30	30
**. The correlation is significant at the 0.01 level (bilateral).				

Table 5. Results of the application of the Pearson Correlation. Source: Processing with SPSS version 20

Conclusion

The theoretical elements consulted in the present investigation allowed the creation of a theoretical base to support the results obtained, in addition to the interweaving of contents of the medical sciences with Neutrosophy.

After applying the instruments of this research, it can be stated that it is still necessary to go deeper into the knowledge of non-communicable diseases among students of medical sciences at the Autonomous Regional University of the Andes.

The application of the neutrosophic linguistic scale made it possible to give greater robustness to the results obtained since it created a range of possible answers for the university students who were part of the sample.

References

[1] Organización Mundial de la Salud. Noticias ONU. Retos de salud urgentes para la próxima década según la OMS [Internet]. Ginebra: OMS; 2010

[2] RS, Cooper Kennelly JK, Orduñez García P. Health in Cuba. Int J Epidemiol; 35(4):
817–24, 2006

[3] MA Serra, Serra M, Viera M. Las enfermedades crónicas no transmisibles: magnitud actual y tendencias futuras. Finlay [revista en Internet]. 8(2), 2018

[4] P Varona-Pérez, Bonet-Gorbea M, Chang-De la Rosa M, Suárez-Medina R. Implementation of chronic disease risk factor surveillance in 12 Cuban municipalities. MEDICC Rev; 16(1), 2014

[5] JI Fernández-Montequín, Betancourt BY, Leyva-González G, Mola EL, GalánNaranjo K, Ramírez-Navas M, et al. Intralesional administration of epidermal growth factor-based formulation (Heberprot-P) in chronic diabetic foot ulcer: treatment up to complete wound closure. Int Wound J.;6(1):67–72. 2009

[6] P Patel, Orduñez P, Di Pette D, Escobar MC, Hasell T, Wyss F, et al. Improved blood pressure control to reduce cardiovascular disease morbidity and mortality: The Standardized Hypertension Treatment and Prevention Project. J Clin Hypertens (Greenwich);18(12):1284–94, 2016

[7] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018

[8] G E, Sara; Z R Nazate Chugá; R I Tavera; M C Villareal Gel; D M Ramírez Guerra. Neutrosophic Statistical Analysis of Arthrofirosis of the KneeRehabilitation." Neutrosophic Sets and Systems 44, (1). 2021

[9] A. Palacios, Jesús Estupiñán Ricardo, Iyo Alexis Cruz Piza, y Marcia Esther España Herrería. «Phenomenological Hermeneutical Method and Neutrosophic Cognitive Maps in the Causal Analysis of Transgressions against the Homeless». Neutrosophic Sets and Systems 44: 147-56. 2021

[10] F Smarandache. Of Neutrosophic Numbers. Critical Review, Vol. 13, 2016, 2016. 13: p. 103.

[11] F Smarandache. On Multi-Criteria Decision Making problem via Bipolar Single-Valued Neutrosophic Settings. Neutrosophic Sets & Systems, 2019. 25.

[12] R. G. Ortega, M. Rodríguez, M. Leyva Vázquez, and J. E. Ricardo, "Pestel analysis based on neutrosophic cognitive maps and neutrosophic numbers for the sinos river basin management," Neutrosophic Sets and Systems, vol. 26, no. 1, pp. 16, 2019.

[13] R. M Carballido, Paronyan, H., Matos, M. A., & Santillán Molina, A. L. Neutrosofic statistics applied to demonstrate the importance of humanistic and higher education components in students of legal careers. Neutrosophic Sets and Systems, 26(1), 26. 2019.

[14] D. M. Ramírez Guerra, Y. M. Gordo Gómez, L. J. Cevallos Torres, F. G. Palacios Ortiz. Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment. International Journal of Neutrosophic Science (IJNS), Vol. 19, No. 01, PP. 389-402, 2022

[15] J. Estupiñán, Diego Fernando Coka Flores, Jorge Alfredo Eras Díaz, y Karina Pérez Teruel. «An Exploration of Wisdom of Crowds using Neutrosophic Cognitive Maps». Neutrosophic Sets and Systems 37 (1): 2, 2020.

[16] R. Martínez Martínez, C. D. Castañeda Guillot, & I. Pimienta Concepción. "Microbiota intestinal y diabetes". Universidad y Sociedad, vol. 14 no. 2, pp 158-163, 2022.

[17] C M. Méndez Cabrita, M. G. Gordón Martínez, M. R. Dávila Castillo, & J. R.Cadena Morillo. "El derecho natural convergente y la justificación ética del derecho". Universidad y Sociedad, vol. 14 no. 2, pp 120-123, 2022.

[18] L. A. Llerena Ocaña, F. A. Viscaino Naranjo, & W. V. Culque Toapanta. "Desarrollo de software con Net Core". Universidad y Sociedad, vol. 14 no. 2, pp 85-89, 2022.

[19] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[20] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.
[21] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[22] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[23] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.
[24] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.
[25] von Feigenblatt, O. F., Peña-Acuña, B., & Cardoso-Pulido, M. J. "Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones". Ediciones Octaedro, 2022.
[26] L. O. Albarracín Zambrano, D. V. Ponce Ruiz, & C. M. Marín Vilela. "La inclusión familiar de personas con discapacidad física mediante la automatización aplicada". Universidad y Sociedad, vol. 14 no. S3, pp 291-308, 2022.
[27] J. L. Maldonado Cando, B. A. Quiñonez Guerrero, J. R. Santillán Andrade & G. F. A. Acurio Hidalgo. "La corresponsabilidad económica de niñas, niños y adolescente". Universidad y Sociedad, vol. 14 no. S3, pp 280-290, 2022.
[28] J. L. Maldonado Cando, J. R. Cabrera Granda, R. V. Coppiano Ocampo & J. R. Santillán Andrade. "Agravantes genéricas en los delitos con concurso de dos personas". Universidad y Sociedad, vol. 14 no. S3, pp 271-279, 2022.
[29] G. M. Morales Torres, D. L. Lema Rodriguez, S.I. Marcillo Singaucho & M. de Mela Quintela, "Investigación de la enfermedad periodontal en adolescentes escolarizados". Universidad y Sociedad, vol. 14 no. S3, pp 262-270, 2022.

Received: August 24, 2022. **Accepted:** October 19, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Study of Knowledge about Hemiplegia

Alex Gabriel Lara Jacome[1], Mercedes Isabel Guamán Guamán[2], Kenia Mariela Peñafiel Jaramillo[3] and Kathya Verónica Suaste Pazmiño[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.alexlara@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.mercedesguaman@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.keniapenafiel@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.kathyasuaste@uniandes.edu.ec

Abstract. In this research, an analysis of the knowledge of a group of university medical students about hemiplegia is carried out, using neutrosophic tools. Since derived from the theoretical study carried out, it was evidenced that there were few studies linking both branches of knowledge. That is why the present research had as the objective to carry out a neutrosophic evaluation of the knowledge of hemiplegia in medical students at the Autonomous Regional University of the Andes in the Republic of Ecuador. Theoretical, empirical, and statistical mathematical methods were used. These allowed to give a certain level of validity to the results obtained.

Keywords: neutrosophic model, neutrosophic sample, hemiplegia, university students.

1 Introduction

Several diseases and accidents affect the human brain, including stroke, which generically represents a group of disorders that include cerebral infarction, cerebral hemorrhage, and subarachnoid hemorrhage. *Ictus* is a Latin word which, like its Anglo-Saxon counterpart, "stroke", means "blow" and perfectly describes the abrupt and sudden nature of the process. The terms cerebrovascular accident, cerebral attack, and apoplexy are synonyms [1].

A stroke occurs in the recesses of the brain. The symptoms of a stroke are easy to detect. These include the following: sudden numbness or weakness, especially on one side of the body, sudden confusion or problems with speech or understanding, and sudden vision problems. Derived from its consequences, there are several syndromes as is the case of Hemiplegia [2].

Paralysis of one side of the body (hemiplegia) is a common sign of these conditions, although it can also be triggered by other causes such as cerebral palsy and head trauma [3].

The paralysis or weakness experienced by the subjects may affect a hemiface, an arm, a leg, or an entire hemibody. This compromises their functional independence to perform daily activities [3].

Hemiplegia is a neurological syndrome that can be caused by different causes, such as: derived from cerebral palsy, a cranioencephalic trauma, or a cerebrovascular accident; characterized by the paralysis of the striated muscles of one hemibody, producing a picture of profound disability, which acts on the patient's psyche, it is also a nervous tissue injury characterized by the impossibility of actively performing movement or loss of voluntary mobility in a vertical half of the body.

Several researchers attach great importance to this disease and have carried out studies aimed at improving the social life of people who have suffered a cerebrovascular accident, where cognitive therapeutic exercises are used for the motor re-education of the hemiplegic.

Where all the authors consulted agree in stating the need for rehabilitation treatment as early as possible [4], [5].

That is why it is increasingly necessary to stimulate knowledge of this syndrome among medical students so that they can follow appropriate behavior in the different action protocols.

To achieve greater precision in the evaluation of knowledge, neutrosophy is used as a discipline, due to the various potentialities it possesses.

Under the arguments expressed above, the present study has the objective to carry out a neutrosophic evaluation of the knowledge about hemiplegia in medical students at the Autonomous Regional University of the Andes in the Republic of Ecuador.

2 Methodology

2.1 Study subjects

In the selection of the sample, the considerations of [6] were considered. Who states that from the neutrosophic set, a generic element x belongs to the neutrosophic population P in the following way, x(v, i, f) P, which means: x belongs v % to the population P, f % x does not belong to the population P, while the percentage *i* of *x*, of the population P, is indeterminate (unknown, not clear, neutral: neither in nor out of the population).

Applying what is systematized by [7], [8], [9], [10], [17], it agrees that this procedure has a high degree of reliability in the sample studied.

- Where p = approximate proportion of the phenomenon under study in the reference population
- q = proportion of the reference population that does not present the phenomenon under study (1 -p). The desired confidence level (Z). Indicates the degree of confidence that the true value of the parameter in the population is found in the calculated sample. absolute precision
- (d). It is the desired width of the confidence interval on either side of the true value of the difference between the two proportions (in percentage points).
- N is population size. When making the corresponding calculations, it is determined that the sample must be between 10 and 31 individuals. The reason that led to the selection in correspondence with what is described below.

For the development of the research, a sample of 25 university medical students at the Autonomous Regional University of the Andes in the Republic of Ecuador was selected. Of this, 19 are female and 6 are male, with an average age of 23.8 years. All gave their consent to participate in the research. A selection was made using the raffle technique.

2.2 Classical methods and techniques used

Analytical-synthetic: it allowed to carry out a study about the theoretical and methodological foundations that support neutrosophic evacuation. It was used for the systematization, generalization, and specification of the processed information. It was useful in interpreting the empirical information obtained. [18], [19], [20]

Inductive-deductive: it made it possible to make inferences and generalizations in the neutrosophic evaluation of the knowledge about hemiplegia in medical students at the Autonomous Regional University of the Andes in the Republic of Ecuador, as well as the interpretation of the data obtained, from which new logical conclusions are deduced. [23], [24], [25], [26]

Survey: It was carried out on all the university students of the study sample since this was the instrument used to collect the data derived from this neutrosophic study.

2.3 Neutrosophic method

The neutrosophic model proposed in this paper is presented in Figure 1. The model consists of four stages: Data collection, Neutrosophication, Rule generation, and Deneutrosophication.

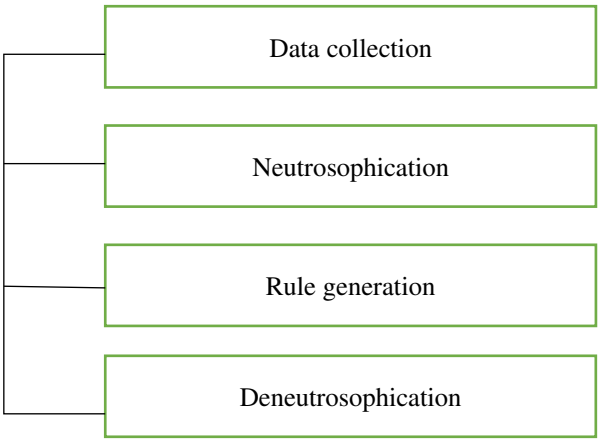


Figure 1. Proposed neutrosophic model.

First component: Knowledge about the general characteristics of hemiplegia

This is the highest level of the hierarchy because to be able to perform an adequate treatment after graduation, it is essential to know what the characteristics, signs, and symptoms of this syndrome are.

Second component: Knowledge about the main pillars of treatment

This component is important because it is where the therapy to be followed with patients is defined and therefore it is an important aspect to be known by university medical students. This component includes physical therapeutic and educational treatment of comprehensive care for these patients.

Third component: Knowledge of treatment effectiveness evaluation techniques

This component is based on the different functional tests, clinical scales, and questionnaires that the student must know to evaluate the treatment received and if it is effective or not, this allows making adjustments in the treatment in correspondence with the patient's evaluation.

By applying the rules of neutrosophic inference, a categorization is established, that is, the possibility of detecting a certain type of behavior pattern in the knowledge of medical students in correspondence to the subject under investigation.

This rule is based on the technique of the survey of university students, where they answer the question in correspondence with the three components described. That is why this same algorithm is followed for the analysis and interpretation of the results obtained in this investigation.

If X1 = A1 =X1 =A2 …. …. And Xn =An then Z =B

Where, both the values of the linguistic variables of the antecedent (X1, X2…Xn) and the consequent (Z) are neutrosophic sets, in essence, linguistic results with associated semantics.

Deneutrosophication performs the process of adapting the neutrosophic values generated in the inference, in this process the method of membership of the mean of the maximum is used [11], [14], [15], [21]. With deneutrosophication, the value Y is determined for the output variable, which has a maximum in its membership function X, if there is more than one maximum value in the membership function, the average of them is taken [12], [13], [16].

3 Results

The results obtained in the investigation for each of the questions are presented below.

Question 1	Good (5)	Regular (3)	Bad (1)
How do you rate your knowledge about hemiplegia and its main characteristics?	8 (32%)	10 (40%)	7 (28%)

Table 1. Results of question 1 of the survey

Table 1 shows the results of the question with the same number of the survey applied to the students. Where 8 of them, for a 32%, selected the category with the highest value on the scale used. On the other hand, most of the students selected the intermediate category, that is, this was reflected in 10 of them, for 40% of the study sample. While only 7 students, for 28%, selected the category of Bad, which reflects that in this component there is a knowledge of good in most of the students. [22]

Question 2	Good (5)	Regular (3)	Bad (1)
How do you rate your knowledge about the main pillars of treatment in hemiplegia?	6 (24%)	9 (36%)	10 (40%)

Table 2. Results of question 2 of the survey.

Table 2 shows the results of question 2 of the survey where only 6 students, for 24%, selected the category of Good. While 9, for 36%, Good and Bad were the most indicated, where they were 10 for 40%. These results denote that where there is greater difficulty in the students' knowledge is in the treatments to be used with these patients.

Question 3	Good (5)	Regular (3)	Bad (1)
How do you rate your knowledge about the different ways of evaluating the treatment of hemiplegia?	8 (32%)	9 (36%)	8 (32%)

Table 3. Results of question 3 of the survey

In Table 3, eight students marked the Good category, for 32%; while 9, for 36%, selected Regular and 8, for 32%, chose Bad. This is another component in which it is necessary to continue working with the students because there are still difficulties with some of them regarding the different forms of evaluation and follow-up of these patients.

Neutrosophic evaluation techniques are used in correspondence with the model proposed in the present investigation. In the Neutrosophication process, the following linguistic variables were identified:

- Component I: REAL
- Component II: REAL
- Component III: REAL

NEUTROSOPHY

TERM CI:= (0.85, 0) (0.9, 1) (1, 1)

TERM CII:= (0.4, 0) (0.45, 1) (0.55, 1) (0.55, 0)

TERM CIII := (0.5, 0) (0.55, 1) (0.75, 1) (0.8, 0)

In the inference of neutrosophic rules, the 3 components and the 3 linguistic values (Good, Regular, Bad) were considered. Subsequently, the deneutrosophication process was carried out.

To perform the deneutrosophication, the center of gravity is used, which implies the value to be obtained for the components selected for the present investigation.

DENEUTROSOPHICATION Component I

TERM mb:= (0.3, 1) (0.4, 1) (0.45, 0);

TERM ba:= (0.4, 0) (0.45, 1) (0.5, 1) (0.55, 0);

TERM me:= (0.5, 0) (0.55, 1) (0.75, 1) (0.8, 0);

TERM al := (0.75, 0) (0.8, 1) (0.85, 1) (0.9, 0);

TERM ma:= (0.85, 0) (0.9, 1) (1, 1);

METHOD: COG;

DEFAULT := 0.3;

RANGE (: = 0.3 .. 1);

Conclusion

The analysis of the theoretical and methodological references on neutrosophic evaluation of the knowledge of hemiplegia in medical students at the Regional University of the Andes in the Republic of Ecuador shows the existence of different bibliographic sources of the subject, however, tools are required that promote neutrosophy as a useful discipline for medical sciences.

The interpretations of the results offer validity to the research developed since the use of neutrosophic tools allowed to carry out an adequate neutrosophic evaluation of the knowledge of hemiplegia in medical students at the Regional University of the Andes in the Republic of Ecuador.

In accordance with the results obtained, it is necessary to continue delving into the subject of hemiplegia, particularly in the different treatments and forms of evaluation and follow-up of patients.

References

[1] E. Díez-Tejedor. Nomenclatura de las Enfermedades Cerebrovasculares. Rev.Ecuat.Neurol, 3 (11). 2001

[2] M. Knight. Presentación del programa de pacientes hemipléjicos, y de los resultados del diagnóstico realizado en la clínica Prosurg, Arima, Trinidad y Tobago. 2015

[3] J. Coll. Programa de ejercicios físicos terapéuticos para la rehabilitación de pacientes hemipléjicos en la atención primaria de salud (p 31). Tesis de Doctorado. ISCF "Manuel Fajardo, La Habana, Cuba. 2012

[4] M Knight. La cultura física terapéutica: una mirada desde la rehabilitación de pacientes con accidentes cerebrovasculares en Trinidad y Tobago, Rev Acción (5). 2014

[5] M. Oddy, Humphrey, M., y Uttley, D. Stresses upon the relatives of head injured patients. British Journal of Psychiatry, 133. PP 507-513, 1978

[6] MY. Leyva Vázquez, & Smarandache, F. Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre. Infinite Study. 2018

[7] MY. Leyva-Vázquez, Smarandache, F., & Ricardo, J. E. Artificial intelligence: challenges, perspectives, and neutrosophy role. (Master Conference). Dilemas Contemporáneos: Educación, Política y Valores, 6(Special). 2020

[8] Smarandache, F. P., & Pramanik, S. D. Conjuntos y Sistemas Neutrosóficos (Vol. Vol.1). Nuevo Mexico: Biblioteca Del Congreso, Washington DC, Estados Unidos. Obtenido de http://fs.unm.edu/NSS/NSS-2-2014.pdf, 2013

[9] A. Palacios, Jesús Estupiñán Ricardo, Iyo Alexis Cruz Piza, y Marcia Esther España Herrería. «Phenomenological Hermeneutical Method and Neutrosophic Cognitive Maps in the Causal Analysis of Transgressions against the Homeless». Neutrosophic Sets and Systems 44: 147-56. 2021

[10] D. M. Ramírez Guerra, Y. M. Gordo Gómez, L. J. Cevallos Torres, F. G. Palacios Ortiz. Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment. International Journal of Neutrosophic Science (IJNS), Vol. 19, No. 01, PP. 389-402, 2022

[11] NB Hernandez, M.B.R. Cueva, and B.N.M. Roca, Prospective analysis of public management scenarios modeled by the Fuzzy Delphi method, 2018

[12] NB Hernández, R.O. Guerrero, and W.A. Quiñonez, UNIVERSIDAD Y PLANIFICACIÓN ESTRATÉGICA EN EL ECUADOR. Revista Didasc@ lia: Didáctica y Educación. ISSN 2224-2643, 2016. 7(2): p. 171 -180.

[13] J. Estupiñán, Diego Fernando Coka Flores, Jorge Alfredo Eras Díaz, y Karina Pérez Teruel. «An Exploration of Wisdom of Crowds using Neutrosophic Cognitive Maps». Neutrosophic Sets and Systems 37 (1): 2, 2020.

[14] K. L. Baque Villanueva, A. M. Izquierdo Morán, & D. A. Viteri Intriago. "Estructura metodológica de plan estratégico para mejorar las ventas en las Mipymes del cantón Quevedo". Universidad y Sociedad, Vol. 14 Num. 2, pp- 66-74, 2022.

[15] I E. Montenegro Bósquez, D. F. Granja Zurita, M. R. Aguilar Martínez, & D. P. Gordillo Cevallos. "Las aclaraciones a testigos por parte de los jueces penales en las audiencias de juicio, un análisis desde el estándar de prueba". Universidad y Sociedad, Vol. 14 Num. 2, pp- 51-56, 2022.

[16] L. A. Llerena Ocaña, & L. A. Lombardo Bajaña. "Aplicación web para la gestión administrativa en la estrategia plan vacunarse". Universidad y Sociedad, Vol. 14 Num. 2, pp- 40-45, 2022.

[17] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[18] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.

[19] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[20] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[21] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.

[22] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.

[23] Acuña, B. P., & Von Feigenblatt, O. F. "La lengua y la literatura en el aula del futuro enmarcado en el aprendizaje personalizado. In Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones"

(pp. 13-24). Ediciones Octaedro, 2022.
[24] A. Miranda Anchundia, J. I. Castillo González & M. B. Sánchez Villacís. "Procedimiento quirúrgico para la despigmentación gingival". Universidad y Sociedad, vol. 14 no. S3, pp 257-261, 2022.
[25] G. A. Andrade Olvera, M. A. Zambrano Olvera, & C. E. Paucar Paucar. "La custodia de los menores y el principio de igualdad". Universidad y Sociedad, vol. 14 no. S3, pp 248-256, 2022.
[26] M. E. Gaspar Santos, G. N. Rivera Segura & M. A. Zambrano Olvera. "Las cárceles ecuatorianas y la seguridad para individuos privados de libertad". Universidad y Sociedad, vol. 14 no. S3, pp 238-247, 2022.

Received: August 25, 2022. **Accepted:** October 20, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the Self-Assessment of Pharmacology Knowledge in Medical Students

María Gabriela Balarezo García[1], Jeanneth Elizabeth Jami Carrera[2] and Álvaro Paúl Moina Veloz[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.mariabalarezo@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.jeannethjami@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.alvaromoina@uniandes.edu.ec

Abstract. In this research, the results obtained from the linking of medical sciences and Neutrosophy are shown. All while the theoretical referents systematized in this work, denote a poor imbrication of neutrosophic contents in the investigations of medical students. For its development, one of the contents with a greater degree of complexity for students such as pharmacology is used. That is why this research has the objective to perform a neutrosophic analysis of the self-assessment of pharmacology knowledge in medical students. During the investigation, theoretical methods and techniques were used, such as the synthetic analytical and inductive-deductive, as well as empirical ones, where the survey and measurement stand out. While within the statistical mathematical ones, the frequency distribution was used, in addition to a specific neutrosophic model as a general guide for the investigation. The results obtained make evident the need to delve into some of the pharmacology topics in the investigated specialty, which generates future research areas.

Keywords: neutrosophic analysis, neutrosophic model, pharmacology, medicine.

1 Introduction

In the training of medical professionals, there are various subjects that converge and coexist with each other to achieve comprehensive training and a profile of basic skills that contribute to adequate professional performance once graduated. Well, in this profession a deep knowledge is required, because in the hands of these professionals is the life of various human beings.

That is why pharmacology is one of these, since it is the one that provides these professionals with knowledge on how to administer different medications, depending on the disease and the age of the patient. Therefore, students are required to specifically learn this subject.

Pharmacology is not an easy subject for students, it is very wide and varied, with a considerable part of memory to remember the names of medicines. It is not surprising that the use of cinema in his teaching is relatively recent. In most cases, films have been used to delve into the social aspects of drug use and the clinical research process and/or its ethical aspects [1],[2].

There are many contents of this matter, but according to the authors consulted, they agree that the following stand out: interpret the prescription of medications and follow the norms and administration guidelines, to obtain an optimal therapeutic response; identify the patient and inform him about the treatment, its effects and the techniques to be used, and when necessary, the student must be able to inform and instruct him about self-administration techniques; correctly handle medications in their forms of administration, knows and describes the techniques of preparation and administration of medications by different routes, as well as the forms and techniques of handling waste and adequately handling the information available about medicines and taking into account the benefit/risk ratio in their clinical use. Just to mention the main ones [3], [4], [5], [22].

There are several approaches and disciplines that have been integrated into the analysis and research of pharmacology, where physiology, biochemistry, clinical pathology, among others, stand out. However, in correspondence with the bibliographic search carried out, there are few studies that use the neutrosophic technique for the analysis and investigation of this medical discipline and therein lies the main problem of this research.

Hence the objective of this research is to carry out a neutrosophic analysis of the self-assessment of knowledge of pharmacology in medical students in the Autonomous Regional University of the Andes (UNIANDES) of the Republic of Ecuador.

2 Methodology

2.1 Study subjects

During the sample selection process, the following elements of classical statistics are considered, according to the criteria of [6], [7], [8], [24], [26], [27], [28].

- Ip = corresponds to the approximate proportion of the phenomenon in the reference population,
- q = refers to the proportion of the reference population that does not present the phenomenon (1 - p).
- (Z) = refers to the desired level of confidence, it is also indicative of the degree of confidence that the true value of the parameter in the population will be found in the calculated sample.
- (d) = is indicative of the absolute precision (d), which in turn is the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points).
- N = refers to the size of the reference population.

During the investigation some results were evaluated on the degree of a scale between 0 and 10. Intervals are also allowed. So, elements of neutrosophic statistics were used, which will be explained below.

In the investigation, a confidence level of 95%, z = 1.96, d = 0.05 and N = 321 will be used.

So, the neutrosophic sample is n = 175.12≈176.

In correspondence with the previously declared neutrosophic criteria, from a population of 321 students eligible for the study, 176 from the Autonomous Regional University of the Andes of the Republic of Ecuador were selected. Of these, 48 are male and 128 are female. All students have passed the third year of the medical degree.

2.2 Classical methods and techniques used

During the investigation, theoretical methods such as the synthetic analytical and the inductive-deductive were used. Both were useful in the work with the bibliographic sources and the data, since they facilitated the analysis of the results obtained.

Within the empirical ones, a survey with a Likert scale with three categories (Good), (Regular) and (Bad) was used. Where the university medical student had to carry out a self-assessment of his knowledge about pharmacology. Results are illustrated in the following section.

The measurement was also used, since values were attributed to each of the three categories mentioned above (Good, 5), (Regular, 3) and (Bad, 2). This facilitated a better analysis of the results presented.

Regarding the statistical methods, elements of descriptive statistics were used and, within this, the distribution of classical and neutrosophic frequencies. The combination of both offered an adequate level of validity to the results obtained in this investigation. [21]. [25]

2.3 Neutrosophic method

This section presents the neutrosophic model proposed in this work, which is schematically represented as shown in Figure 1. The model consists of four stages: data collection, Neutrosophication, conception of rules and Deneutrosophication. It led to an important scheme in the work with the data obtained, derived from the survey of students [9], [10], [20].

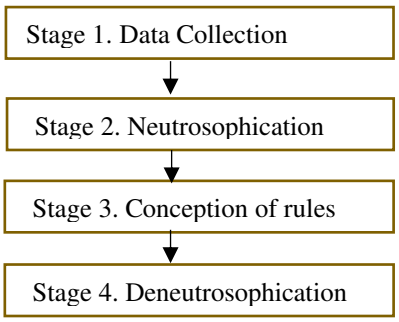


Figure 1. Neutrosophic model followed for the development of the research

2.4 Grouping procedure used in the research

For the presented study, three important components are established, which allow the development of self-assessment of medical students, these are:

Component 1. Knowledge about the objectives and essential categories of pharmacology

Component 2. Main medications by typical disease pattern

Component 3. Main dosages of medicines for children and adults

The analysis of the neutrosophic statistics will be carried out considering these components. For they are the basis for an adequate Neutrosophication of the data obtained in correspondence to Figure 1.

The Neutrosophication is performed from the data obtained, in order to define the variables and linguistic values, as well as the membership function to perform the Neutrosophication. The linguistic variables that were identified are the components that support the self-assessment process of university students, related to each component [9], [10], [11], [12], [19].

By applying the rules of neutrosophic inference, a categorization is established, that is, the possibility of detecting a certain type of behavior pattern in the self-assessment of university students. This rule is based on the survey applied to the subjects selected in the sample of this research, considering the three components presented in this study.

The proposed neutrosophic model responds to a type of structure that is modeled based on the definition of a set of rules of the form:

If X 1= A1 and X2 and … Xn= An, then Z =B

Where, both the values of the linguistic variables of the antecedent (X 1, X2 … Xn), and of the consequent (Z), are neutrosophic sets, in essence, linguistic results with associated semantics.

The Deneutrosophication performs the process of adapting the neutrosophic values generated in the inference, in this process the method of membership of the mean of the maximum is used [13], [14], [15]. With the Deneutrosophication the value Y is determined, for the output variable, which has a maximum in its membership function B, if there is more than one maximum value in the membership function, the average of them is taken [16], [17], [23].

3 Results

In correspondence with the elements of the neutrosophic method followed in the present investigation, the *data collection* stage is obtained and shown in Table 1. Where the presentation of the data of each of the components is made in correspondence with the score by the students. After this, a more detailed analysis is carried out on the different levels located by the students.

Component 1		Component 2		Component 3	
Scale score	Number of students	Scale score	Number of students	Scale score	Number of students
5	25	5	15	5	28
3	66	3	81	3	79
3	85	3	80	3	69
Total	176		176		176

Table 1. Results obtained as part of the grouping procedure used.

In the Neutrosophication process, the following linguistic variables were identified:

component I: REAL
component II: REAL
component III: REAL

Neutrosophication
TERM CI = (0.85, 0) (0.9, 1) (1, 1)
TERM CII = (0.4, 0) (0.45, 1) (0.55, 1) (0.55, 0)
TERMS CIII = (0.5, 0) (0.55, 1) (0.75, 1) (0.8, 0)

Deneutrosophication
TERM Good = (0.3, 1) (0.4, 1) (0.45, 0);
TERM Regular = (0.4, 0) (0.45, 1) (0.5, 1) (0.55, 0);
TERM Bad = (0.85, 0) (0.9, 1) (1, 1);
METHOD: COG;
DEFAULT 0.3;
RANGE = (0.3 .. 1)

Then, an analysis is carried out for each of the categories of the Likert scale designed for this research. Which will be analyzed in correspondence with the three questions of the survey applied to the students.

Results of question 1 of the applied survey

Question 1	Good		Regular		Bad	
	Quantity	%	Quantity	%	Quantity	%
Could you please self-your knowledge about the objectives and essential categories of pharmacology	25	14.2	66	37.5	85	48.3

Table 2. Results of question 1 of the student survey

When performing an analysis of the students' self-assessment regarding question 1 of the applied survey. It is observed that only 25 for 14.2% selected the category with the highest score on the scale. On the other hand, the intermediate score was selected by 66 for 37.5%. While the majority 85 for 48.3% selected the low level. Question that reflects that we must continue working on this content.

Question 2	Good		Regular		Bad	
	Quantity	%	Quantity	%	Quantity	%
Could you self-assess your knowledge of the main medications by typical disease pattern?	15	8.5	81	46.1	80	45.4

Table 3. Results of question 2 of the student survey

Results of question 2 are shown in table 3. Where, as in the previous question, only a minority of students self-rated with the category with the highest score on the scale (15 for an 8, 5%). The intermediate category was the most selected (80 for 46.1%), although by one student with respect to the bad category, which was indicated by 80 for 45.4%.

Question 3	Good		Regular		Bad	
	Quantity	%	Quantity	%	Quantity	%
Could you please self-assess your knowledge about the main dosages of medicines for children and adults?	28	15.9	79	44.8	69	39.3

Table 4. Results of question 3 of the student survey

The results of question 3 are shown in table 4, where the minority of students selected the scale with the highest score in their self-assessment. This was reflected in 28 for 15.9% of the total number of students surveyed. On the other hand, most of the students indicated the regular category, since 79 of them self-assessed with this, it represents 44.8% of the total sample. While the bad category was selected by 69 students for 39.3%.

In general, the greatest difficulties of the students are in question 1 of the survey. Although, in general, this subject must continue to be deepened both in teaching and in research. Reason for which it is suggested to continue with this theme in experimental studies to transform the situation detected in this investigation. [18], [23]

Conclusion

In correspondence with the theoretical references consulted in this research, the lack of use of neutrosophic techniques in the self-assessment of university students in the content of pharmacology becomes evident, which generates the need to deepen this topic investigated from a neutrosophic perspective.

The interpretation of the results, through neutrosophic techniques, allows identifying the level of validity of the results obtained in the selected sample, which has generated the need to carry out investigations of a higher degree of complexity to transform the aspects detected in this investigation.

References

[1] M Farré, Roset PN, Bosch F, Baños JE. Putig clinical pharmacology in context: the use of popular movies. J Clin Pharmacol ;44(1):30-6. 2004

[2] B Katzung, Brunton L, Hernández A. Farmacología general. México: McGraw-Hill. 1678 p, 2016.

[3] R Hilal-Dandan, Bruton L. Goodman y Gilman Manual de farmacología y terapéutica. 2° ed. México: McGraw-Hill. 1270 p, 2014

[4] H Sumano, Ocampo L. Farmacología veterinaria. 3° ed. México. McGraw-Hill. 1082p. 2006

[5] T Lemke, Williams D. Foye´s Principles of medicinal chemistry. 7th ed. Philadelphia, USA: Lippincott Williams and Wilkins. 1500 p. 2013

[6] A Al-Masarwah,. and A.G. Ahmad, Structures on Doubt Neutrosophic Ideals of BCK/BCI-Algebras under (S, T)-Norms. Neutrosophic Sets and Systems, 2020. 33: p. 275-289.

[7] E González-Caballero, M. Leyva, and F. Smarandache, On Neutrosophic Uninorms. Neutrosophic Sets and Systems, Under Review.

[8] D. M. Ramírez Guerra, Y. M. Gordo Gómez, L. J. Cevallos Torres, F. G. Palacios Ortiz. Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment. International Journal of Neutrosophic Science (IJNS), Vol. 19, No. 01, PP. 389-402, 2022

[9] D Nagarajan, M. Lathamaheswari, S. Broumi, and J. Kavikumar, Blockchain Single and Interval Valued Neutrosophic Graphs. Neutrosophic Sets and Systems, 2019: p. 23

[10] N.B Hernández, et al., Validation of the pedagogical strategy for the formation of the competence entrepreneurshipin high education through the use of neutrosophic logic and Iadov technique. Neutrosophic Sets & Systems, 2018.

[11] J. Estupiñán, Diego Fernando Coka Flores, Jorge Alfredo Eras Díaz, y Karina Pérez Teruel. «An Exploration of Wisdom of Crowds using Neutrosophic Cognitive Maps». Neutrosophic Sets and Systems 37 (1): 2, 2020.

[12] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018

[13] N.B Hernandez, M.B.R. Cueva, and B.N.M. Roca, Prospective analysis of public management scenarios modeled by the Fuzzy Delphi method.

[14] Smarandache, F., Neutrosophic set–a generalization of the intuitionistic fuzzy set. Journal of Defense Resources Management (JoDRM), 1(1): p. 107-116, 2010.

[15] Abdel-Basset, M., Atef, A., & Smarandache, F. A hybrid Neutrosophic multiple criteria group decision making approach for project selection. Cognitive Systems Research, 57, 216-227. 2019.

[16] W A Cacpata Calle, T. L Bautista Sierra, A. S. Gil Betancourt & E. B. Prado Calderón. "Admisibilidad y eficacia de la acción extraordinaria de protección en Santo Domingo de los Tsáchilas". Universidad y Sociedad, Vol. 14 Num. S2, pp-498-505, 2022.

[17] D. F. Tixi Torres, J. X. Iglesia Quintana, L. X. Cangas Oña, & C. A. Bonilla Villa. "El elemento descriptivo cohabitación, en relación con el núcleo familiar en materia de violencia intrafamiliar. Universidad y Sociedad, Vol. 14 Num. S2, pp-493-497, 2022.

[18] N F. Freire Sánchez, & L. F. Piñas Piñas. "El impacto de los derechos humanos en la justicia para todos". Universidad y Sociedad, Vol. 14 Num. S2, pp- 488-492, 2022.

[19] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[20] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.

[21] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[22] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[23] Ricardo, J. E., & Vázquez, I. R. S. "La educación sexual para padres de niños con retraso mental, una vía para su consolidación". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 4 no. 3, pp 137-144, 2019.

[24] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.

[25] von Feigenblatt, O. F., Calderon, R. D., & MacDonald, T. "The Case for an Eclectic and Flexible Leadership Research

Agenda: Dealing with Social Justice and Diversity in the 21st Century Workplace". Centro Sur, vol. 6 no. 1, pp 130-142, 2022.

[26] J. C. Arandia Zambrano, I. J. Díaz Basurto, O. I. Ronquillo Riera & S. J. Macias Cedeño. "Derechos sobre la propiedad de sus territorios del pueblo Sarayaku". Universidad y Sociedad, vol. 14 no. S3, pp 231-237, 2022.

[27] A. R. León Yacelga, J. L. Acosta Espinoza & M. A. Checa Cabrera. "Wordpress para el diseño de sitios web en la fundación Santo Domingo de Guzmán". Universidad y Sociedad, vol. 14 no. S3, pp 218-230, 2022.

[28] C. W, Maldonado Gudiño, W. M. Arias Collaguazo, O. G. Arciniegas Paspuel & L. G. Castro Morales. "Gestión de riesgos frente al virus de la COVID-19 y su evaluación en varias empresas públicas del Ecuador". Universidad y Sociedad, vol. 14 no. S3, pp 208-217, 2022

Received: August 26, 2022. **Accepted:** October 20, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Linguistic Scale in the Assessment of Knowledge of Psychosomatic Medicine in University Students

Walter Alberto Vayas Valdiviezo[1], Lester Wong Vázquez[2] and Francisco Xavier Poveda Paredes[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.waltervayas@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.lesterwong@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.franciscopoveda@uniandes.edu.ec

Abstract. Psychosomatic medicine research has been of interest to the scientific community, due to the benefits it provides in the treatment of different diseases. Its techniques have facilitated the clinical management of some pathologies. This aspect of medical sciences has been systematized from different approaches and perspectives, but undoubtedly it is still necessary to deepen the link with neutrosophy. Based on these arguments, the present research aims to apply a neutrosophic linguistic scale for the assessment of psychosomatic medicine knowledge in university students. During the development of this study, theoretical, empirical, and statistical methods were taken into account, particularly neutrosophic descriptive statistics. The results obtained reveal the need for further study of this subject in medical school.

Keywords: Neutrosophic linguistic scale, neutrosophic statistics, knowledge, psychosomatic medicine.

1 Introduction

Research in the field of health plays a leading and transcendental role since its objectives in the vast majority are aimed at preventing, educating, or curing diseases that society faces. That is why it is characterized by a humanistic approach, where several applied sciences and branches of knowledge converge. One of them, psychosomatics, is the one that will be deepened in this research based on the benefits that it brings in the cure of diseases.

Medicine in its origins, according to the researcher Sokkegui [1], was psychological medicine. Derived the art of healing like all other activities of primitive peoples from the animistic conception of the Universe. This idea is one of the bases that gave rise to the development of psychosomatic medicine.

The term "psychosomatic" has often been used to refer to different phenomena, thus denoting or generating a certain ambiguity in its meaning. Sometimes it has been used to refer to a renovating movement in Medicine; others, to refer to research on psychological factors involved in the etiology of physical illnesses, to classify illnesses in which psychological factors are hypothesized to play a crucial role, or even as a generic label to name all those somatic symptoms for that there is no proven medical explanation [2].

Psychosomatic medicine presents a wide field of research and work, but most researchers agree that the relationship between psychological factors and physiological phenomena in general and the mechanisms in pathogenesis converge in it [3].

Psychosomatic medicine is the answer, or answers, that medicine has given to the mind-body problem. Each of the theoretical models adheres to some of the theories on the mind-body relationship that have been studied by philosophy, but this topic exceeds the scope of these sciences and disciplines. Hence, it is considered a discipline with a multidisciplinary field of action [4], [5].

Based on the arguments raised above, it is argued that the psychosomatic orientation implies a change in the assessment and integration of the data collected in the interrogation and exploration, ordering them in a current biographical and historiographical sense.

An important aspect to take into account is the multifactorial etiopathogenic conception and the transactional criterion, which allow us a much more real and therefore much more effective prognostic-evolutionary consideration [6].

As evidenced in what has been described above, psychosomatic medicine is so important in the field of health that all professionals in the process of training must study it and keep in mind its models and forms of action.

That is why in the present investigation the assessment of the level of knowledge of the medical students of

the Autonomous Regional University of the Andes (UNIANDES) is deepened. For the sake of being able to perfect the design of this study program. For this, neutrosophy comes to help because it is a new branch of philosophy, which opened a new field of research in metaphilosophy, and which studies the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra [7], [20], [25], [26].

Based on the arguments raised above, this research aims to apply a neutrosophic linguistic scale for the assessment of knowledge of psychosomatic medicine in university students.

2 Methodology

2.1 Study subjects

From the first moments of the investigation, the postulates of neutrosophic statistics were taken into account, whose objective was to calculate the population. In the case of the present investigation, the population is known, so the formula presented below is applied.

Where the letter p = means the approximate proportion of the reference population, while the letter q = refers to the proportion of the reference population that does not present the research (1 -p). The desired confidence level for the statistician (Z), this letter is indicative of the level of confidence that will be had in the true value of the parameter in the population found in the calculated sample. For its part, absolute precision is represented by the letter (d). Which in turn means the desired width of the confidence interval on either side of the true value of the difference between the two proportions (in percentage points). While the N refers to the size of the population.

Before making the selection of the sample by applying the selected formula, it is necessary to know what is meant by a neutrosophic sample, for this what is proposed by Smarandache is assumed, who agrees in stating that it is a chosen subset of a population, a subset that contains some indeterminacy: either with respect to several of its individuals (which may not belong to the population we are studying, or may only partially belong to it) or with respect to the subset as a whole. While classical samples provide accurate information, neutrosophic samples provide vague or incomplete information. [23]

That is why Smarandache also says that any sample is neutrosophic since it can be considered that its determination is equal to zero. A neutrosophic population is a population that has not determined the membership of its members (that is, it is not known with certainty whether some individuals belong to the population or not). [8], [9], [21], [22].

Being consistent with the selected formula and to increase the validity of the research, a confidence level between 90 and 95% is desired, z= [1.642, 1.99], d= [0.04, 0.2] and p = [0.5, 0.43], N=40. The result that we call the neutrosophic sample n= [10.1, 30.9] indicates that the sample must be in values between 10 and 32 university students.

Once the procedure was applied to know the number of university students that could be part of the sample, a raffle technique was applied where 30 university medical students of the Autonomous Regional University of the Andes (UNIANDES) were selected. Of them, 19 are female and 11 are male with an average age of 26.9 years.

2.2 Instruments used

Both classical methods of research methodology were used in the study, particularly those proposed by authors such as Herbas [10], as well as neutrosophic techniques. In this study, descriptive exploratory research is carried out and on these arguments, the methods and techniques of the research were planned.

Of a theoretical nature, the synthetic-analytic method stands out, this was useful in the first moments of the investigation since it facilitated the work with the bibliographic sources and in turn allowed the processing of the information offered by the different instruments applied to diagnose the current state problem and draw conclusions.

The inductive-deductive method was also used: this was useful for making inferences and generalizations of the answers given by the students to the survey and in the selection of the aspects contained in the applied scale.

Within the empirical methods and techniques, the student survey was used, which allowed identifying the level of knowledge of university students regarding the contents of psychosomatic medicine. [27], [28], [29]

The measurement was used to attribute values to each of the responses and opinions of university students regarding the subject under investigation.

Within the mathematical statistics, descriptive statistics were used, particularly the percentage analysis, and inferential statistics were also used, within it the Pearson correlation test to identify whether or not there were coincidences in the answers of the students to the questions of the survey.

2.3 Neutrosophic method

The neutrosophic method of investigation is used to take into account the contradictions and uncertainties in the linguistic labels, for which processing is carried out using techniques of neutrosophic statistics to handle the indeterminacy in the sample. The research follows the neutrosophic model proposed in this work, it is presented, as illustrated below:

Stage 1. Initial diagnosis for the selection of personnel who will apply the survey

Stage 2. Selection of the questions that make up the survey

Stage 3. Preparation meeting to unify criteria on how to apply it

Stage 4. Application of the survey

Stage 5. Tabulation of the results

Stage 6. Neutrosophication of the data

Stage 7. Analysis and interpretation of the results

Stage 8. Rules of neutrosophic inference

Neutrosophic Evaluative Scale:

This scale used single-value neutrosophic numbers (SVNS) [11]. For this case study, the universe of discourse is an SVNS which is an object with the following form [12], [24].

To represent inconsistent, imprecise, and uncertain information from the real world, the membership of indeterminacy is represented independently together with the membership of truth and falsehood in the set of neutrosophy this has been recommended by several researchers such as Smarandache, [7], [13], [14], [15], [16]. The interval represents the true, undetermined, and false memberships of x in A, respectively.

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}d \quad (1)$$

Where

$u_a(x): X \to [0,1], r_a(x): X \to [0,1]\ y\ \ v_a(x): X \to [0,1]$

With

$0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \qquad \forall\ x \in X$

The intervals $u_a(x), r_a(x)$ y $v_a(x)$denote the true, indeterminate, and false memberships of x in A, respectively.

For convenience, an SVN number will be expressed as A, where a, b, c [0, 1], and +b +c ≤ 3.

Linguistic term	SVN numbers
Excellent (E)	(1,0,0)
Very good (VG)	(0.70,0.35,0.30)
Good (G)	(0.50,0.50,0.50)
Regular (R)	(0.40,0.85,0.70)
Bad (B)	(0,1,1)

Table 1: Linguistic terms of the scale.

Where A = (T, I, F) is a single-valued neutrosophic number, a scoring function S is in turn related to a single neutrosophic value, corresponding to the degree of relevance to truth, the degree belonging to indeterminacy and the degree of belonging to falsity is defined by [4]. The scoring function for single-valued neutrosophic sets is proposed to make the distinction between the numbers. [17]

$$\mathrm{d(A-B)} = \sqrt{\frac{1}{3}\sum_{i=1}^{n}[P_A(x_i)-P_B(x_i)]^2 + [I_A(x_i)-I_B(x_i)]^2 + [N_A(x_i)-N_B(x_i)]^2} \quad (2)$$

3 Results

The results obtained with the application of the survey in university students are reflected below. For this, each of the questions of the survey is interpreted, in correspondence with the selected neutrosophic linguistic terms.

Question 1	Excellent (5)	Very Good (4)	Good (3)	Regular (2)	Bad (1)
How do you evaluate your knowledge about	2 (6.6%)	5 (16.6%)	8 (26.6%)	10 (33.3)	5 (16.6%)

Question 1	Excellent (5)	Very Good (4)	Good (3)	Regular (2)	Bad (1)
the means of psychosomatic medicine?					

Table 2: Results of question 1 of the survey applied to university students. Source: own elaboration.

Observing the results obtained, it becomes evident that the knowledge of university students about the means of psychosomatic medicine is not the most satisfactory. Well, only 2 students indicated the linguistic terms with the highest score (E), the category of (VG) was also one of the least marked since only 5 university students indicated it. In the category of (G), although there was an increase in students, are still a minority, since only 8 selected this option. Most of the university students selected the category of (R), (10) one of the lowest of the selected scale, and 5 selected option (B). These results show the existence of insufficiencies in the knowledge of the students with this subject. [18], [19]

Question 2	Excellent (5)	Very Good (4)	Good (3)	Regular (2)	Bad (1)
How do you rate your knowledge of the techniques of psychoso-matic medicine?	3 (10%)	2 (6.6%)	4 (13.3%)	8 (26.6%)	13 (43.3%)

Table 3: Results of question 2 of the survey applied to university students. Source: own elaboration.

As shown in Table 3, which represents the results of question 2 of the survey of university students. They rated their knowledge of psychosomatic medicine techniques as follows. Only 3 students attributed the option with the highest score of the presented scale (E). Also, a minority of 2 students gave it a rating of (VG). Category (G) was marked by 4 students. While that of (R) was only chosen by 8. On the other hand, the category with the lowest score on the scale was the one selected by a majority of students (B) with 13. This denotes that the sample of this research requires actions that enhance their preparation on psychosomatic medicine.

Question 3	Excellent (5)	Very Good (4)	Good (3)	Regular (2)	Bad (1)
How do you evaluate the training you re-ceived in psy-chosomatic med-icine during your studies?	2 (6.6%)	8 (26.6%)	3 (10)	12 (40%)	5 (16.6%)

Table 4: Results of question 3 of the survey applied to university students. Source: own elaboration.

The results displayed in table 4 correspond to question 3 of the survey. Where, as in the remaining questions, a minority of university students select the categories with the highest score on the applied scale. Well, only 2 members of the sample marked the category of (E). For their part, 8 did so for (VG), and 3 for (G). While the majority of the students investigated are grouped into the categories with the lowest score on the scale. As are the cases of (R) that was selected by 12 students and that of (B) by 5. This confirms that the level of knowledge of students about psychosomatic medicine is regular and poor. Therefore, it is suggested to delve into research that enhances their training and preparation.

To validate the results of the present investigation, a correlation study was carried out, since this marks the relationships between 2 or more variables, in the case of the present investigation, the content of the three questions of the survey, that is, the degree of possibility that these have to coincide. Once the data has been processed with the SPSS 20.0 software for Windows, Table 5 is built. Where it shows, through the Pearson test, that there was a high level of significance since r, ($p<0.005$). This allows to state that there is an important correlation between the results obtained.

		Question 1	Question2	Question3
	Pearson correlation	1	.901**	.844**
Question 1	Next (2-sided)	-	,000	,000
	N	30	30	30
	Pearson correlation	.928**	1	.971**
Question 2	Next (2-sided)	,000	-	,000
	N	30	30	30
	Pearson correlation	.859**	.971**	1
Question3	Next (2-sided)	,000	,000	-
	N	30	30	30

**. The correlation is significant at the 0.01 level (bilateral).

Table 5: Correlation matrix between the responses of university students. Source: SPSS 20.0 Processing for Windows.

Conclusion

In the analysis of the theoretical references, as well as the main models of psychosomatic medicine, it is evident that they have focused research on revealing its benefits and importance, to the detriment of its impact on the medical training curricula in the universities.

The methodological logic followed was based on general methods, as well as neutrosophic techniques to know more accurately the assessment of the knowledge of university students about psychosomatic medicine.

The interpretations of the results offer important validity since they allow identifying the level of knowledge of university students about psychosomatic medicine. For this, statistical processing was carried out and it reveals a level of significance that makes the present investigation pertinent.

References

[1] R. Sokkegui. "Bosquejo de la medicina psicosomática". Revista medica hondurena, vol 12 no 29, 805-812, 2018.
[2] C. Berrocal, A. Fava y N Sonino. "Contribuciones de la Medicina Psicosomática a la Medicina Clínica y Preventiva", anales de psicología, vol. 32, nº 3, 829-835, 2016.
[3] M. Uribe. "Modelos conceptuales en medicina psicosomática"Revista Colombiana de Psiquiatría, Suplemento, vol. XXXV, 8-20, 2006.
[4] KS. Kendler. "A psychiatric dialogue on the mind: body problem". Am J Psychiatry. Jul; 158:989-1000, 2001.
[5] J. Dávila, Uribe M." Generalidades de las teorías de la mente". En: Gómez C, Hernández G, Rojas A, Santacruz H, Uribe M. Fundamentos de psiquiatría clínica: niños, adolescentes y adultos. Bogotá: CEJA; 2002
[6] R. Vidal. "Importancia de la medicina psicosomatica en la clinica de nuestros tiempos". Anales de medicina y cirucia, Vol. L - N.o 221, 362-367, 2002
[7] F. Smarandache. "Introduction to Neutrosophic Statistics". Ed. Infinite Study, 150, 2014
[8] F. Smarandache. "Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic" Over-/Under-/Off-Logic, Probability, and Statistics. 2016
[9] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018
[10] Herbas Torrico, Boris Christian, & Rocha Gonzales, Erick Ariel. "Metodología científica para la realización de investigaciones de mercado e investigaciones sociales cuantitativas". Revista Perspectivas, (42), 123-160, 2018.
[11] F. Smarandache, "of Neutrosophic Numbers". Critical Review, Vol. 13, 2016. 13: p. 103. 2016
[12] F.Smarandache, "On Multi-Criteria Decision Making problem via Bipolar Single-Valued" Neutrosophic Settings. Neutrosophic Sets & Systems, 2019. 25.
[13] M.Leyva-Vázquez, Eduardo Santos-Baquerizo, Miriam Peña-González, Lorenzo Cevallos-Torres, y Alfonso Guijarro-Rodríguez. «The Extended Hierarchical Linguistic Model in Fuzzy Cognitive Maps». En, 39-50. Springer. 2016
[14] A. Palacios, Jesús Estupiñán Ricardo, Iyo Alexis Cruz Piza, y Marcia Esther España Herrería. «Phenomenological Hermeneutical Method and Neutrosophic Cognitive Maps in the Causal Analysis of Transgressions against the Homeless». Neutrosophic Sets and Systems 44: 147-56. 2021
[15] K., M Pérez-Teruel, M. Leyva-Vázquez, y V. Estrada-Sentí. «Mental models consensus process using fuzzy cognitive maps and computing with words». Ingenieria y Universidad 19 (1): 173-88. https://doi.org/10.11144/Javeriana.iyu19-1.mmcp. 2015
[16] J. Estupiñán, Diego Fernando Coka Flores, Jorge Alfredo Eras Díaz, y Karina Pérez Teruel. «An Exploration of Wisdom of Crowds using Neutrosophic Cognitive Maps». Neutrosophic Sets and Systems 37 (1): 2, 2020.

[17] B. Sánchez Martínez, A. Rodríguez Plasencia & E. G. Vilema Vizuete. "Caracterización de las variables para la investigacion en ciencias de la salud". Universidad y Sociedad, vol. 14 no. S3, pp 455-464, 2022.
[18] M. A. López Villagrán, A. E. Gallegos Cobo & R. A. Ramos Villacís. "Análisis de la implementación de la asignatura de calidad y seguridad del paciente en la carrera de medicina". Universidad y Sociedad, vol. 14 no. S3, pp 439-454, 2022.
[19] C. M. Méndez Cabrita, C. G. Rosero Martínez & M. G. Gordón Martínez. "El logro una "cultura interpretativa" en las carreras de derecho mediante el giro hermenéutico y la argumentación jurídica". Universidad y Sociedad, vol. 14 no. S3, pp 366-375, 2022.
[20] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.
[21] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.
[22] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.
[23] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[24] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[25] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.
[26] von Feigenblatt, O. F., Pardo, P., & Cooper, M. "Sufficiency Economy Philosophy (SEP): Thailand's Emic Approach to Governance and Development as Evidence of an Asian-value Oriented Inclusive Leadership Management Philosophy". Journal of Asia Pacific Studies, vol. 6. No. 2, pp 289-300, 2021.
[27] N. F. Freire Sánchez, P. E. Del Pozo Franco & R. E. Portilla Paguay. "Ecuadorian migration policy analyzed from international causality". Universidad y Sociedad, vol. 14 no. S4, pp 172-180, 2022.
[28] J. A. Eras Diaz, C. M. Alberca Benítez, B. C. Pérez Mayorga & J. R. Limaico Mina. "Violencia física contra la mujer en el cantón Santo Domingo en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 147-157, 2022.
[29] J. X Iglesias Quintana, C. G. Rosero Martínez & M. I. Mora Verdezoto. "Procedure for the selection of a smart contracting system in the legal field". Universidad y Sociedad, vol. 14 no. S4, pp 138-146, 2022.

Received: August 27, 2022. **Accepted:** October 21, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Statistical Analysis of Self-Assessment of Rehabilitation Knowledge in University Students

Elizabeth Cristina Mayorga Aldaz[1], Rosita Elizabeth Olivo Torres[2], Silvia Tatiana Tite Andi[3] and Flor Betzabet Morocho Quinchuela[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.elizabethmayorga@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.rositaolivo@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.silviatite@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. Email: ua.flormq29l@uniandes.edu.ec

Abstract. This study arises because of the growing demand for rehabilitation in different population sectors since after the COVID-19 pandemic that the whole world experienced, this discipline is an important alternative in recovering from the sequelae caused by this disease. In accordance with the aforementioned, the objective of the present research is to carry out a neutrosophic statistical study of the self-assessment of knowledge about rehabilitation in undergraduate medical students. For this, theoretical, empirical, and mathematical-statistical methods and techniques were used. Techniques of neutrosophic statistics were used in the validation. The results obtained denote an important level of validity and allowed identifying the need to develop further studies on this topic.

Keywords: neutrosophy, neutrosophic statistics, neutrosophic model, rehabilitation.

1 Introduction

Several medical specialties are studied and applied in order to keep the different population groups as vital as possible. Within them, rehabilitation plays a leading role, since its objective is to recover patients who, because of their illness, have been affected in carrying out their daily activities.

Rehabilitation is a global and continuous process of limited duration and with defined objectives, aimed at promoting and achieving optimal levels of physical independence and functional abilities of people with disabilities, as well as their psychological, social, vocational, and economic adjustment that allow them to lead their own lives freely and independently. Rehabilitation is a complex process that results from the integrated application of many procedures to restore the individual to his optimal functional status, both at home and in the community to the extent that the appropriate use of all residual capacities allows [1].

In modern rehabilitation, comprehensive therapy is always used, since no therapeutic method, taken separately, can guarantee the recovery of the patient or the total restoration of their ability to work. The means of comprehensive therapy are therapeutic regimen, diet therapy, drug therapy, physiotherapy, balneotherapy, mechanotherapy, psychotherapy, Therapeutic Physical Culture, and others [2].

Special methods of therapy are also used selectively, such as surgical, radiotherapeutic, and diet therapy, guaranteeing the patient rational nutrition according to the particularities of his illness. Drug therapy or pharmacotherapy consists of using drugs to act on the body or, preferably, on certain systems and organs.

Physiotherapy uses both natural factors (sun rays, air, water) and artificial ones (electric currents, radiation therapy, light sources, ultrasound, and heat treatments) to cure diseases). Balneotherapy contributes to the healing and prevention of diseases with mineral waters applied externally (in the form of baths) and internally [2].

Mechanotherapy is a therapeutic method based on the execution of movements, strictly limited, with the help of special devices that are used fundamentally to avoid stiffening of the joints. Psychotherapy consists of the influence of the environment on the patient's psyche, as well as in the regimen of therapeutic institutions, positive emotions, the benevolent attitude of health personnel, and advice and conversations that contribute to the manifestation of trust in the patient reinstatement. Therapeutic Physical Culture is combined with all the elements of comprehensive rehabilitation mentioned [2] [3], [20].

That is why medical professionals must have notions of this medical specialty since they must prescribe them at certain times of their professional work. That is why the present study aims to link elements of neutrosophy and medicine to unravel the knowledge of a group of medical students from the Autonomous Regional University of the Andes in Ecuador.

That is why the objective of this research is to carry out a neutrosophic statistical study of the self-assessment of knowledge about rehabilitation in medical university students.

2 Methodology

2.1 Study subjects

When calculating a neutrosophic sample, the procedure described by authors such as [4], [5], [6], [7], [21] is followed, who agree that the order to perform this is as follows:

p = approximate proportion of the phenomenon under study in the reference population
q = proportion of the reference population that does not present the phenomenon under study (1 -p).
The desired confidence level (Z), indicates the degree of confidence that the true value of the parameter in the population is found in the calculated sample.
The absolute precision (d). It is the desired width of the confidence interval on either side of the true value of the difference between the two proportions (in percentage points).
N is population size.

To develop this research, a confidence interval between 95 and 99% was used, z= [1.645, 1.96], d= [0.05, 0.1] and p = [0.4, 0.42], N=40. The result that is called the neutrosophic sample n= [10.1, 30.6] indicates that the sample must have values between 10 and 31 individuals.

Based on the previous calculations, a sample of 28 medical students from the Autonomous Regional University of the Andes (UNIANDES) is selected. For this, a probabilistic sampling was used, where all the students had the same possibility of being chosen. To form the sample, the raffle technique was used. All students signed the informed consent.

2.2 Classical methods and techniques used

The research used methods and techniques such as those of a theoretical nature, among which the synthetic analytical and deductive inductive methods and techniques were applied to work with the bibliographic sources. They were also used for the synthesis of the results obtained.

Empirical methods were also employed, such as the student survey, which was used as the main way of obtaining the results. In addition, the measurement was applied since values were attributed to each of the categories of the elaborated Likert scale. [22]

Within the mathematical-statistical methods, descriptive statistics were used, particularly frequency analysis. Spearman's correlation coefficient was also applied. Techniques of neutrosophic statistics such as neutrosophic graphs were also employed.

This was utilized to graph the absolute neutrosophic frequencies, where different types of graphs can be used, which must contain and differentiate the determined and indeterminate part of the analyzed frequencies [7], [8], [14], [15], [16], [19].

2.3 Neutrosophic method

To develop the investigation, the following neutrosophic model is followed, as described below.

Step 1. Identification of the problem

Step 2. Study of the state of the art of the investigated problem

Step 3. Selection of the investigated sample

Step 4. Selection of instruments

Step 5. Preparation of the personnel involved in the study

Step 6. Application of the instruments

Step 7. Tabulation of the results

Step 8. Analysis and interpretation of the results

For the compilation of the information, a Likert scale was applied, and the arguments raised by Smarandache were used, [9] states that generalizing the concept of several sets such as the classic set, the fuzzy set, and the paradoxical set, and TA (x), IA(x), and FA(x) are membership functions that can be real standard or nonstandard subsets.

In this form, it was not possible to apply it to real-world problems in science and engineering. Several authors

have systematized these aspects that have enriched the study of a single value neutrosophic set (SVNS), to overcome this [10], [11], [12], [13], [17], [18].

Let X be a universe of discourse, an SVNS A over X has the following form:

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}d$$

Where

$$u_a(x): X \to [0,1], r_a(x): X \to [0,1] \text{ y } v_a(x): X \to [0,1]$$

With

$$0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \qquad \forall x \in X$$

The intervals $u_a(x), r_a(x)$ and $v_a(x)$ denote the true, indeterminate, and false memberships of x in A, respectively.

For convenience, an SVN number will be expressed as A, where a, b, c [0,1], and +b +c ≤ 3.

Linguistic term	SVN numbers
Excellent (E)	(1,0,0)
Good (G)	(0.71,0.35,0.30)
Regular (R)	(0.50,0.50,0.50)
Bad (M)	(0,1,1)

Table 1. Linguistic terms of the scale

This means that A = (T, I, F) is a single-valued neutrosophic number, a scoring function S which in turn is related to a single neutrosophic value, corresponding to the degree of relevance to truth, the degree of membership to indeterminacy and the degree of membership to falsehood is defined by: (4)

The scoring function for single-valued neutrosophic sets is proposed to make the distinction between the numbers.

3 Results

This section presents the results obtained from the application of the neutrosophic survey applied to the medical students of the Autonomous Regional University of the Andes. Which are grouped according to the option marked on the Likert scale used. [23], [24], [25]

Question 1	Excellent (5)	Good (3)	Regular (2)	Bad (1)
How do you rate your knowledge of the main rehabilitation techniques?	3 (10.7%)	5 (17.8%)	11 (39.3%)	9 (32.2%)

Table 2. Results of question 1 of the student survey

Table 2 shows the results of question 1 of the survey applied to the students. Where only a minority of students selected the option with the highest score on the elaborated Likert scale. This was reflected in 3 students for 10.7%. On the other hand, 5 students, for 17.8% selected the category of Good, while most students, 12 for 42.8%, self-assessed as Regular. While 7, for 25.1%, marked the lowest category of the indicated scale.

Question 2	Excellent (5)	Good (3)	Regular (2)	Bad (1)
How do you rate your knowledge of	5 (17.8%)	4(14.3%)	12(42.8%)	7(25.1%)

Question 2	Excellent (5)	Good (3)	Regular (2)	Bad (1)
the cardinal principles of rehabilitation?				

Table 3. Results of question 2 of the student survey

Table 3 represents the results of question 2 of the applied survey, where, like the previous one, a small group of 5 students for 17.8% indicated the category of excellent. On the other hand, 4 for 14.3% marked Good. While most of the students 12 for 42.8% self-assessed as Regular and 7 for 25.1% indicated the category of Bad.

Question 1	Excellent (5)	Good (3)	Regular (2)	Bad (1)
How do you rate your knowledge of the different forms of rehabilitation assessment?	3 (10.7%)	8(28.5%)	8(28.5%)	9 (32.2%)

Table 4. Results of question 3 of the student survey

Table 4 shows information referred to question 3 of the survey, where only a minority of 3 for 10.7% of the total number of students surveyed. On the other hand, the category of Good was marked by 8 students for 28.5%. The Regular category was the option indicated by 8 for 28.5%. While most students 9 for 32.2% self-assessed themselves as Bad.

As the results show, most of the students self-assess themselves in the categories with the lowest score on the elaborated scale. This denotes that they present a low level of knowledge about rehabilitation, its main techniques, and ways of evaluating, which makes evident the need to continue delving into this type of research topic.

Neutrosophic graph of indeterminacy of the reason for the answers

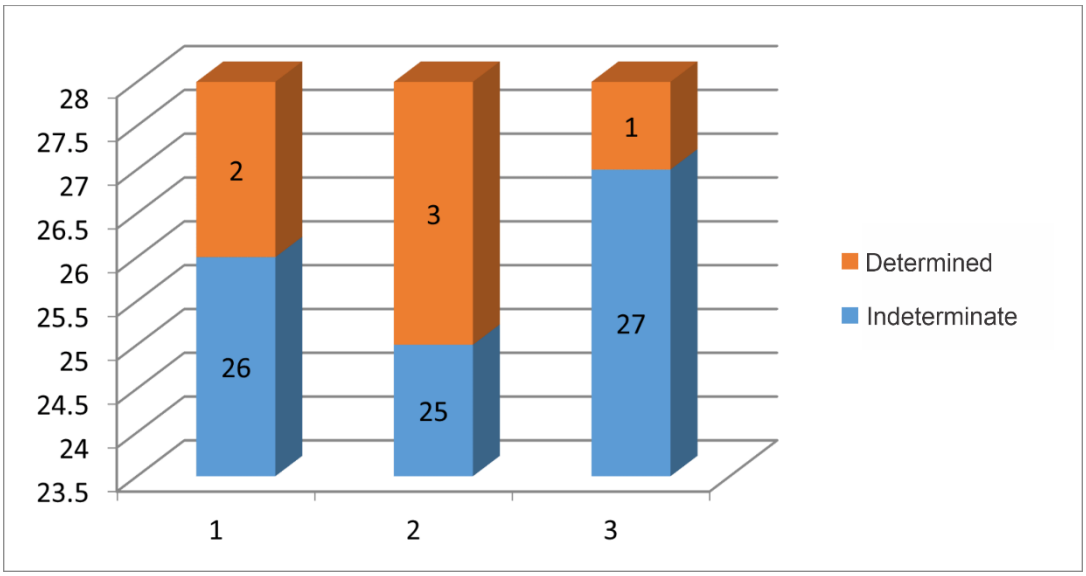


Figure 1. Neutrosophic Graph: Relation of determination indeterminacy for each of the questions of the survey

Figure 1 represents in a general way the number of students who determined the reason for their response to the question and the number who did not tell why they selected that option in said instrument. In question 1, 2

students showed indeterminacy of why their answers. While in question 2, there were 3 students who had indeterminacy. In question 3, only one student showed indetermination.

Validation of the study

Correlations					
Question content			Techniques	Principles	Evaluation
Spearman's Rho	Techniques	Correlation coefficient	1,000	.926**	.953**
		Next (2-sided)	.	,000	,000
		N	28	28	28
	Priciples	Correlation coefficient	.926**	1,000	.903**
		Next (2-sided)	,000	.	,000
		N	28	28	28
	Evaluation	Correlation coefficient	.953**	.903**	1,000
		Next (2-sided)	,000	,000	.
		N	28	28	28
**. The correlation is significant at the 0.01 level (bilateral).					

Table 5. Results of Spearman's correlation coefficient. Source: processed by SPSS for Windows v 20.

Table 5 shows the correlation between the questions of the applied survey, where after processing the data with the statistical program SPSS, version 20, it is evident that among the contents of the questions of the survey there is a high level of significance because in the three cases p0.00.

Conclusion

The study of the sources consulted in this research made it possible to justify the need to carry out a neutrosophic statistical study of the self-assessment of knowledge about rehabilitation in medical university students.

The results obtained through the application of elements of neutrosophic statistics allowed identifying that there is a low level of knowledge about rehabilitation among university medical students of the Autonomous Regional University of the Andes.

The study of the neutrosophic granted a higher level of validity to the results obtained, since it allowed an analysis of the indeterminacy of the students about the reason for their responses to the applied survey.

References

[1] YM Gordo Gómez, DM Ramírez Guerra, R Rodríguez Labrada. Estudio de la atención físico terapéutica a las alteraciones respiratorias en pacientes con Ataxia Espinocerebelosa tipo 2. Revista Olimpia, 19 (1)1-10, 2022

[2] F Horsford Hernández, A Sentmanat Belisón. Generalidades de la Cultura Física Terapéutica y la Rehabilitación, en Ejercicios físicos y reahbilitación. Editorial Deportes, La Habana Cuba, 178 p, 2007

[3] M. J Haykowsky, K. M Daniel, P. S Bhella, S Sarma & Kitzman, D. W. Heart Failure: Exercise-Based Cardiac Rehabilitation: Who, When, and How Intense? The Canadian Journal of Cardiology, 32(10. Suppl 2), S382–S387, 2016

[4] Ye, S.; Fu, J.; Ye, J. Medical diagnosis using distance-based similarity measures of single valued neutrosophic multisets. Neutrosophic Sets and Systems, 7, 47-52, 2015

[5] F Smarandache. Introduction to Neutrosophic Statistics. Infinite Study, 2014

[6] F. Smarandache. "Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic" Over-/Under-/Off-Logic, Probability, and Statistics. 2016

[7] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018

[8] A Guleria, Bajaj R.K., Technique for Reducing Dimensionality of Data in Decision-Making Utilizing Neutrosophic Soft Matrices. Neutrosophic Sets & Systems, 29, 129-141, 2019

[9] Smarandache. Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic Over-/Under-/Off-Logic, Probability, and Statistics. 2016
[10] R. G. Ortega, M. Rodríguez, M. L. Vázquez, and J. E. Ricardo, "Pestel analysis based on neutrosophic cognitive maps and neutrosophic numbers for the sinos river basin management," Neutrosophic Sets and Systems, vol. 26, no. 1, pp. 16, 2019.
[11] D. M. Ramírez Guerra, Y. M. Gordo Gómez, L. J. Cevallos Torres, F. G. Palacios Ortiz. Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment. International Journal of Neutrosophic Science (IJNS), Vol. 19, No. 01, PP. 389-402, 2022
[12] J. Estupiñán, Diego Fernando Coka Flores, Jorge Alfredo Eras Díaz, y Karina Pérez Teruel. «An Exploration of Wisdom of Crowds using Neutrosophic Cognitive Maps». Neutrosophic Sets and Systems 37 (1): 2, 2020.
[13] C. R. Sampedro Guamán, S. A. Machuca Vivar, D. P. Palma Rivera, & B. E. Villalta Jadan. "Automatizar procesos de producción repetitivos en las PYMES con robots colaborativos". Universidad y Sociedad, vol. 14 no. 2, pp 220-227, 2022.
[14] A Sánchez Garrido, & A. J. Peñafiel Salazar. (2022). La acupuntura como terapia coadyuvante en el fortalecimiento del sistema inmunológico contra el covid-19. Universidad y Sociedad, vol. 14 no. 2, pp 188-191, 2022.
[15] A Sánchez Garrido, A. J. Peñafiel Salazar & C. A. Montes de Oca Navas. "Influencia de los factores socioculturales en el estado nutricional en niños y niñas de tres a diez años, usuarios de los centros de desarrollo infantil del municipio de Ambato". Universidad y Sociedad, vol. 14 no. 2, pp 175-179, 2022.
[16] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021
[17] Rodríguez, M. D. O., León, C. A. M., Rivera, C. D. N., Cueva, C. M. B. R., & Ricardo, C. J. E. "Herramientas y buenas prácticas de apoyo a la escritura de tesis y articulos científicos". Infinite Study, 2019.
[18] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[19] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[20] Estupiñán Ricardo, J., Leyva Vázquez, M. Y., Marcial Coello, C. R., & Figueroa Colin, S. E. "Importancia de la preparación de los académicos en la implementación de la investigación científica". Conrado, vol. 17 no. 82, pp 337-343, 2021.
[21] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.
[22] von Feigenblatt, O. F. "Education, culture, and underdevelopment: Haiti's tragic failure". Universidad y Sociedad, vol. 14 no. 3, pp 604-611, 2022.
[23] M. A. Román Del Salto, S. M. Gavilanez Villamarín, J. F. Armijos Moreta & A. G. Méndez. "Caries en pacientes preescolares y sus factores de riesgo". Universidad y Sociedad, vol. 14 no. S3, pp 330-339, 2022.
[24] P. M. Moreno Arvelo, M. E. Gaspar Santos & G. A. Andrade Olvera. "Los contratos inteligentes y su incorporación en ordenamiento jurídico Smart contracts and their incorporation into the legal system". Universidad y Sociedad, vol. 14 no. S3, pp 322-329, 2022.
[25] Y. G. Calva Vega, V. P. Granja Torres, F. P. Cañizares Galarza & J. C. N. Nevárez Moncayo. "La contaminación del río Ttoachi desde su nacimiento, violación de los derechos de la naturaleza". Universidad y Sociedad, vol. 14 no. S3, pp 309-321, 2022.

Received: August 28, 2022. **Accepted:** October 22, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic study of Bullying due to Parental Sexual Identity

Marcelo Raúl Dávila Castillo[1], Cristian Fernando Benavides Salazar [2], Eugenio Javier Escobar Gonzáles[3] and Betty Cumandá Pérez Mayorga[4]

[1] Universidad Regional Autónoma de los Andes, Sede Tulcán. Ecuador. E-mail: ut.marcelodavila@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes, Sede Santo Domingo. Ecuador. E-mail: us.cristianbenavides@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes, Sede Riobamba. Ecuador. E-mail: ur.eugenioescobar@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.bettyperez@uniandes.edu.ec

Abstract. The path of making themselves visible as gay, lesbian or trans mothers or fathers is just one of the possibilities. Generally, this community has chosen to keep this situation private and not express it, as a way of avoiding possible problems with their children, such as bullying in the schools. More frequently, it occurs in cases of reconstituted families, of previous heterosexual unions, where this position becomes much simpler and more comfortable since they can present themselves to the institution as separated parents, of whom heterosexuality is presumed. In addition, the sexual orientation of the guardians is not investigated before the minors enter school. Given this uncertainty, it was decided to carry out this study to define the factors that trigger bullying due to the identity of the parents, their interrelation as a neutrosophic group, and their modeling with neutrosophic statistics. It was concluded that the state must reform existing policies for the benefit of the children of trans people.

Keywords: sexual orientation, bullying, neutrosophy, neutrosophic statistics, sexual identity.

1 Introduction

The sexual orientation of the parents is not an indicator that serves to evaluate the educational role of fathers and mothers. Parents and children of homoparental families must appropriate resilient elements that allow them to grow, in the face of any potentially negative social manifestation towards them. Many studies have shown that there are no differences in psychological, social, intellectual, personal, and effective development between children raised in these families and those from heteroparental homes. However, homoparental families are constantly challenged to demonstrate their parental aptitude.

Homoparental families, just like heteroparental ones, are capable of educating and raising their sons and daughters satisfactorily. The parental educational principles must be unalterable, given the sexual condition of the sons and daughters. Love, respect, trust, and good values are what make a family an optimal home to raise children [1].

There are social, family, personal, school, and economic causes that drive the appearance of bullying. Within the social causes, it is worth noting the value that people give to their peers according to the social or economic hierarchy that a subject or family occupies in society since under social terms the strongest abuse the weakest [2].

Schools and institutes are fundamental pieces in socialization during childhood and adolescence, as well as in performative and identity-building processes. Society is increasingly plural and this fact is also evident in the plurality of affective-sexual and gender diversity that is present in all areas of life and, therefore, also in the classroom. Even so, it is important to be aware that in educational spaces there is a problem that students suffer: bullying.

School bullying is an asymmetric relationship of power in the educational context, through aggressive or discriminatory behavior that is maintained over time. The students who are usually the object of discrimination belong to minority communities, groups stigmatized by society, or people with individual characteristics, in this case lesbian, gay, bisexual, trans, and intersex parents, for whom they are perceived as undesirable or negative.

The increase in the incidence of bullying justifies the growing need for reliable instruments for its evaluation. Bullying is an existing reality in school practices. School harassment or bullying in schools and colleges is one of the causes that influence student performance. The various types of bullying are based on aggressive and hurtful behavior [3].

School bullying produces countless consequences in various important aspects of the victims' lives, such as decreased school performance, change in habitual behavior, aggressive, disruptive, and criminal behavior, phobias, anxiety, suicide, inhibition, and withdrawal. This means that the effects of bullying can cause serious problems in

adolescents on emotional, physical, psychological, and social levels. They feel unhappy, insecure and even try to attack others who in turn consider them inferior, going from being a victim to a victimizer [4].

The present work aims to define the triggering factors of bullying due to the identity of the parents. As a specific objective, to determine the causes that affect the analyzed variable and, finally, to project potential solutions to protect school bullying victims.

2 Materials and Methods

2.1 PESTEL Method

The PESTEL analysis (Political, Economic, Social, Technological, Ecological, and Legal) is an analysis of preconditions with the main function of identifying the environment within which an organization or project operates and providing data and information to enable the organization to make predictions about new situations and circumstances. Its application consists of identifying and analyzing the environment to subsequently act strategically on it, analyzing the factors associated with the political class that influence the future activity of the organization, current, and future economic issues that influence the execution of the strategy, the sociocultural factors that help to identify the trends of today's society, the influence of new technologies and the change that may arise in the future, the possible changes referred to ecology and the changes in legal regulations related to the study (Figure. 1), that may affect it positively or negatively [5].

All aspects of this technique are crucial because, in addition to helping to understand the market, they represent the backbone of strategic management. This section includes elements such as the policies developed in the country, the levels of poverty in the environment, the inequality indices, economic development, access to resources for its inhabitants, as well as how all of this affects the activity of the company [6].

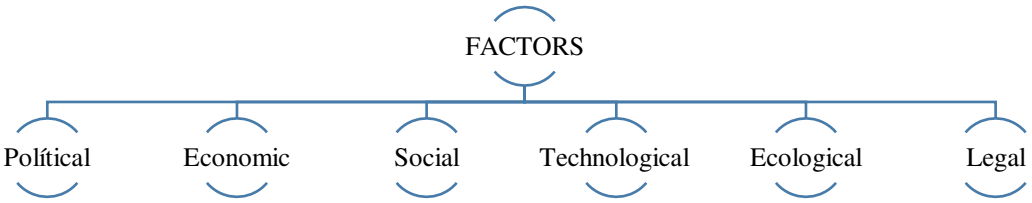


Figure 1: Dimensions of the PESTEL method.

2.2 Neutrosophic Statistics

Neutrosophic statistics is an extension of classical statistics in which neat numerical values are replaced by values in the form of intervals. This substitution can be applied to parameters, not just to random variables. The sample size can also be considered indeterminate or inexact. In this theory, the data can be ambiguous, vague, inaccurate, incomplete, or indeterminate.

Neutrosophic Statistics was founded by Prof. Florentin Smarandache who developed it in 2014 introducing Neutrosophic Descriptive Statistics (NDS). Later, Prof. Muhammad Aslam, from King Abdulaziz University, Saudi Arabia, founded Neutrosophic Inferential Statistics (NIS), Applied Neutrosophic Statistics (ANS), and Neutrosophic Statistical Quality Control (NSQC) in 2018. [24]

Neutrosophic logic, designed by Florentin Smarandache in 1995, is an addition to, or advancement of, fuzzy logic, intuitionistic logic, paraconsistent logic, and tri-valued logic that use imprecise value. In neutrosophic logic, the entire logical variable (x) is defined by the ordered triplet denoted by x= (t, i, f), (t) the degree of truth, (f) the degree of falsehood, and (i) be the degree of indeterminacy.

The Indeterminate (I) is classified as contradiction and uncertainty and obtains an addition of Belnap's four-valued logic. Also, (I) is contradictory, not true, and not known and gets the five value logic [7]. In a refined general neutrosophic logic, (T) can be divided into subcomponents (T1, T2, ..., Tp) and (I) into (I1, I2, ..., Ir) and (F) into (F1, F2,...,Fs) where [p + r + s = n ≥ 1]. Furthermore: T, I, and/or F (or any of their subcomponents Tj, Ik, and/or Fl) can be countable or uncountable infinite sets. As an example: a statement can be between [0.4, 0.6] true, {0.1} or between (0.15, 0.25) indeterminate and 0.4 or 0.6 false.

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E occurs, the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution: $NP(x) = \big(T(x), I(x), F(x)\big)$, where T(x) represents the probability that the value x occurs, F(x) represents

the probability that the value x does not occur, and I (x) represents the indeterminate or unknown probability of the value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them [9].

While Classical Statistics deals with determined data and determined inference methods, Neutrosophic Statistics deals with indeterminate data, that is, data that has some degree of indeterminacy (unclear, vague, partially unknown, contradictory, incomplete, etc.), and indeterminate inference methods that also contain degrees of indeterminacy (for example, instead of arguments and crisp values for probability distributions, graphs, diagrams, algorithms, functions, etc. can have inaccurate or ambiguous arguments and values) [25, 26, 27, 28]

Neutrosophic Statistics is also a generalization of Interval Statistics because while Interval Statistics is based on Interval Analysis, Neutrosophic Statistics is based on Set Analysis (understanding by such all types of sets, not just intervals) [10], [21]. If all the data and methods of inference are determined, then Neutrosophic Statistics coincides with Classical Statistics.

In the real world, there are more indeterminate than determined data, thus more neutrosophic than classical statistical procedures are needed [11,12, 19, 22, 23].

Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns. Finally, the Neutrosophic Logic [13], the Neutrosophic Sets, and the Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference for study in full development.

Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data [14, 20]. Neutrosophic Numbers are numbers of the form $N = a + bI$ where *a* and *b* are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\ \ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ n_N \in [n_l, n_u], \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\left[\begin{matrix}\min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{matrix}\right], I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by:

$$\boldsymbol{S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2]} \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows [15], [16], [17], [18].

$$\boldsymbol{CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U]} \tag{5}$$

3 Results

From the case study, the PESTEL method is applied to determine the negative factors of bullying.

Dimension	Factor	Possible solutions
Politics	Policy setting	• Establish a correct application of the regulations by the public officers of the entities, to guarantee that the principle of the right to equality is complied with. • Distribute school materials that address these topics. • Activate the participation of universities and thus facilitate the teaching and guidance work. • Work with the officers responsible for the various entities of the public administration so that they take the constitutional precepts seriously and therefore the constitutional norms materialize. • Comply with the provisions of the Constitution in Article 26 and be an effective guarantee of equality and social inclusion and an essential condition for good living. • Develop policies so that the different study centers provide a safe environment for the comprehensive development and well-being of trans people.
Economic	Improve economic factors.	• Assign a budget to school entities for psychological treatment derived from bullying. • Promote the study and innovation of research.
Social	Perception of equality rights.	• Give greater participation to the different agents of the educational community to have a role focused on the solution of the conflictive situation. • Prioritize the existence of professionals trained in psychology who can intervene in the detection, reduction, and eradication of peer violence. • Modify the socio-cultural patterns of behavior in society to eradicate the structural homophobia that it suffers. • Provide emotional support to students who experience bullying.
Technological	Electronic development.	• Support trans families with specialized services that help them face the challenges they face at a social and legal level. • Promote programs through social networks and outreach media that are aimed at eradicating bullying.
Legal	Rights of those involved.	• Guarantee through the courts that people from the LGBTI community who have been discriminated against are given effective protection. • Implement training programs so that those who dispense justice receive sufficient information on the human rights of the LGBTI population. • Reform the Organic Law of the Ombudsman's Office, so that it is not only an observer of due process but also has the power to sanction according to the case that arises.

Table 1: Diagnosis of variables and matrix of interrelation between dimensions, factors, and possible solutions to improve and integrate the principle of equality.

4 Development of the Neutrosophic Statistical Method

For the neutrosophic statistical modeling, the experts select five factors (Dimensions of the PESTEL) that prevail in the neutrosophic groups, that exist in bullying, and that affects the LGBTI community (Table 2). The results are presented to the group of experts to evaluate and define the main trends in bullying and its consequences.

Variable analyzed: bullying For a sample of n=60, for each factor (f)

For the development of the statistical study, the neutrosophic frequencies of the factors are analyzed to relate to the occurrence of bullying. It should be noted that the ecological factor did not apply to the variable analyzed.

Days	Neutrosophic frequencies				
	P	E	S	T	L
1	[5; 6]	[0 ; 1]	[2; 2]	[1; 6]	[1 ; 2]
2	[4 ; 6]	[4 ; 6]	[2 ; 5]	[2 ; 3]	[0 ; 6]
3	[1 ; 3]	[3; 5]	[2; 4]	[0 ; 3]	[1 ; 1]
4	[0 ; 2]	[4 ; 4]	[0 ; 4]	[2; 5]	[0 ; 2]
5	[1 ; 2]	[1 ; 1]	[2 ; 4]	[2; 6]	[1 ; 3]
6	[2 ; 3]	[3 ; 4]	[3 ; 5]	[0 ; 2]	[1 ; 3]
7	[0 ; 0]	[4 ; 4]	[3 ; 7]	[0 ; 4]	[0 ; 2]
8	[2 ; 2]	[2 ; 2]	[3 ; 3]	[0 ; 5]	[1 ; 1]

Days	Neutrosophic frequencies				
	P	**E**	**S**	**T**	**L**
9	[2 ; 3]	[4 ; 5]	[0 ; 0]	[1 ; 4]	[0 ; 0]
10	[4 ; 5]	[3 ; 6]	[3 ; 6]	[0 ; 0]	[0 ; 6]
11	[4 ; 5]	[1 ; 1]	[0 ; 2]	[0 ; 1]	[0 ; 2]
12	[3 ; 4]	[2 ; 5]	[1 ; 2]	[2 ; 2]	[0 ; 2]
13	[1 ; 2]	[0 ; 2]	[3 ; 7]	[1 ; 4]	[0 ; 5]
14	[1 ; 3]	[3 ; 4]	[1 ; 2]	[0 ; 5]	[0 ; 4]
15	[5 ; 7]	[1 ; 2]	[0 ; 1]	[0 ; 0]	[1 ; 6]
16	[4 ; 6]	[1 ; 4]	[0 ; 1]	[0 ; 3]	[1 ; 2]
17	[4 ; 4]	[1 ; 2]	[1 ; 2]	[2 ; 4]	[1 ; 7]
18	[4 ; 6]	[4 ; 4]	[0 ; 1]	[1 ; 4]	[1 ; 2]
19	[0 ; 0]	[2 ; 2]	[3 ; 3]	[2 ; 2]	[1 ; 1]
20	[5 ; 7]	[1 ; 4]	[3 ; 6]	[2 ; 7]	[0 ; 6]
0-60	[143 ; 205]	[122 ; 202]	[105 ; 237]	[62 ; 219]	[26 ; 192]

Table 2: Neutrosophic frequencies of each factor. Source: own elaboration.

Table 2 studies the factors that promote bullying for 60 days, with an occurrence level of $[0;\ 7]$ for each factor per day, with a total indeterminacy level of $f_1 = 62, f_2 = 80, f_3 = 132, f_4 = 157, f_5 = 166$, with a level of representativeness of $[30.24\%;\ 86.46\%]$, on the days that 7 occurrences per factor are recorded, with a higher incidence of 60% in the political. Because of the existing indeterminacy, the use of classical statistics is not possible, so the use of neutrosophic statistics is necessary for its greater understanding.

In the modeling, it is observed that the political factor is one of the causes that most affect the origin of bullying (Table 3). To understand which factor implies a representative mean $\bar{x}_f = \in \left[\bar{x}_{L_f}; \bar{x}_{U_f}\right]$, the values of the neutrosophic means and the variation of the variable are calculated for the study of the uncertainties in the final result, with the incorporation of the values of the neutrosophic standard deviation for each factor $S_{N_f} \in \left[S_{L_f}; S_{U_f}\right]$. To determine which factor requires more attention in the process of preventing possible acts of harassment in student centers through the values provided by the $CV_{N_f} \in \left[CV_{L_f}\ ;\ CV_{U_f}\right]$.

Factors	$\bar{x}_N$	S_N	CV_N
Political	[2,383 ; 3,417]	[1,849; 3,149]	[0.776 ; 0.922]
Economic	[2033 ; 3,367]	[1,202 ; 2,573]	[0.591 ; 0.764]
Social	[1.75 ; 3.95]	[0.877 ; 2.68]	[0.501 ; 0.678]
Technological	[1,033 ; 3.65]	[0.428 ; 2,642]	[0.414 ; 0.724]
Legal	[0.433 ; 3.2]	[0.127 ; 2,622]	[0.293 ; 0.819]

Table 3: Neutrosophic statistics of the causes of bullying. Source: own elaboration.

Each factor in the neutrosophic set has a strong interrelation with indeterminate elements among its own elements, so that representatively in this group, the economic factor has a greater incidence or repercussion, with a higher level of indeterminacy of occurrence.

While for the political factor it is on average the one that most affects the origin of bullying on a neutrosophic scale [0;1]. In affirmation, the value of $CV_{N_{f_1}}$ this factor is lower compared to the rest. This means that the political factor is more coherent and precise than the other factors.

To determine the associated referent indeterminacy measure for $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ and $CV_N \in [CV_L\ ;\ CV_U]$ to the form of neutrosophic numbers (Table 4). In the results obtained, it is observed that the values CV_N range from 0.293 to 0.776 with the measure of indeterminacy from 15.8% to 64.2%, which generates a relevant cause to be mitigated by having a lower level of indeterminacy, such as its influence on the other factors.

Factors	$\bar{x}_N$	S_N	CV_N
P	2,383 + 3,417 I;I $\in [0; 30.3]$	1,849 + 3,149 I;I $\in [0; 41.3]$	0.776 + 0.922 I;I $\in [0; 15.8]$
E	2,033 + 3,367 I,I $\in [0; 39.6]$	1,202 + 2,573 I;I $\in [0; 53.3]$	0.591 + 0.764 I;I $\in [0; 22.6]$
S	1.75 + 3.95 I; I $\in [0; 55.7]$	0.877 + 2.68 I;I $\in [0; 7.3]$	0.501 + 0.678 I;I $\in [0; 26.1]$
T	1.033 + 3.65 I; I $\in [0; 71.7]$	0.428 + 2.642 I;I $\in [0; 83.8]$	0.414 + 0.724 I;I $\in [0; 42.8]$
L	0.433 + 3.2I;I $\in [0; 86.5]$	0.127 + 2.622 I;I $\in [0; 95.2]$	0.293 + 0.819 I;I $\in [0; 64.2]$

Table 4: Neutrosophic forms with the measure of indeterminacy. Source: own elaboration

7 Preliminary Solutions

From the result obtained and the interrelation of the political factor with the rest, the following is suggested:

- ✓ Ensure that the authorities and institutions comply with the constitutional regulations whose foundations guarantee citizens equality, freedom, and the right to a dignified life and not to be discriminated against for any reason. Take all appropriate measures to prevent, investigate and punish manifestations of violence, intolerance, and discrimination that violate the human rights of the LGBTI community and their families.
- ✓ Establish the necessary judicial and administrative mechanisms to ensure that any person who is a victim of violence and discrimination has effective access to redress, compensation for the damage caused, or other fair, prompt, and effective means of compensation.
- ✓ Promote knowledge and observance of the human rights of the LGBTI population in society. This must be done at the level of colleges and schools, through sex education that emphasizes how diverse and complex human sexuality is.
- ✓ Modify the sociocultural patterns of behavior of society to eradicate the structural homophobia that it suffers. This will also be achieved with rights education that counteracts and eliminates entrenched prejudices, customs, and all kinds of practices that base their premise on the inferiority, unworthiness, or abnormality of people belonging to the LGBTI community.
- ✓ Facilitate processes of social participation with trans families with parents both in existing spaces for family care, as well as by creating specific meeting spaces between equals. Such participation makes these families visible and makes it easier for their positive parenting experiences to become known, within the trans community itself and in society as a whole.
- ✓ Define a set of actions that make the existence of transphobia visible, as a specific form of violence and discrimination, as well as define its peculiar characteristics, when it refers to a family context that requires specific preventive actions. The public powers have a very important role that enables social changes and actions to prevent violence, act against it, and generate a collective conscience that makes its mere existence impossible.

Conclusion

Education systems must play a role in improving the quality of the educational environment by preventing stigma, discrimination, and bullying, measures that would help reduce school dropouts by children of trans people. Taking into account the right to education, it is equally important to ensure that programs and curricula are gender sensitive and include a diversity of identities and the negative outcomes of intolerance and sexism, as well as homophobia and transphobia.

After the analysis of the factors from an essay perspective fused with the PESTEL technique, it can be said that the indeterminacy is incorporated into the modeling of the causal relationships between the analyzed factors, where neutrosophic science is an active part and a person who takes decisions. The neutrosophic analysis of the data determined the causes that, in the form of a chain reaction, affect the victims and their families, by determining the causes that originate bullying due to the sexual identity of their parents with the use of neutrosophic statistics. Due to the degree of indeterminacy existing in the analyzed variable, the result shows a lower value of CV to the political dimension as a key factor and trigger of school bullying.

Affective-sexual diversity must be incorporated transversally throughout the different educational cycles, subjects, and materials of formal education. An educational strategy that is attentive to affective-sexual diversity is necessary to attend to the reality of young people and train teachers and provide them with the necessary knowledge

and tools. As well as adequate protection against all forms of social exclusion and violence, including bullying and harassment within the school environment.

References

[1] F. Gil Cantero, "La educación en Derechos Humanos en el sistema educativo," *Tarbiya: Revista de investigación e innovación educativa,* vol. 35, pp. 43-56, 10/12 2022.

[2] G. Godoy-Echiburú and G. Melo-Letelier, "Análisis discursivo de Orientaciones para la Inclusión de las Personas LGBTI en el Sistema Educativo," *Arboles y Rizomas. Revista de Estudios Lingüísticos y Literarios,* vol. 1, pp. 33-50, 12/10 2019.

[3] J. Estupiñan Ricardo, M. E. Llumiguano Poma, A. M. Arguello Pazmiño, A. D. Albán Navarro, Martín stévez, L., , and N. Batista Hernandez, "Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador. ," *Neutrosophic Sets & Systems,* vol. 26, pp. 55-61, 2019.

[4] C. N. González, Leyva, C. M., Faggioni, K. M., & Álvarez, P. J. (2018)., "Comparative study of artificial intelligence techniques for the diagnosis of diseases in livestock. CISCI 2018 - Decima Septima Conferencia Iberoamericana en Sistemas, Cibernetica e Informatica. Decimo Quinto Simposium Iberoamericano en Educacion," *SIECI 2018 - Memorias,* 2018.

[5] A. R. Pupo-Kairuz, D. V. Ponce-Ruiz, G. F. Viteri-Pita, and F. S. Bustillo-Mena, "PESTEL analysis of environment state responsibility in Ecuador," *Neutrosophic Sets and Systems,* vol. 34, pp. 70-78, 2020.

[6] I. Yüksel, "Developing a multi-criteria decision-making model for PESTEL analysis.," *International Journal of Business and Management,* vol. 7, p. 52, 2012.

[7] U. G and N. Sivasubramaniam, "Impact of Neutrosophic Statistics on Acceptance Sampling Plans -A Review," *The International journal of analytical and experimental modal analysis,* vol. XIV, pp. 890-896, 07/11 2022.

[8] S. H. S. Al-Subhi, I. Pérez Pupo, R. García Vacacela, P. Y. Piñero Pérez, and M. Y. Leyva Vázquez, "A New Neutrosophic Cognitive Map with Neutrosophic Sets on Connections, Application in Project Management. ," *Neutrosophic Sets and Systems,* vol. 22. , pp. 63-75, 2018.

[9] Y. Alhasan, "The neutrosophic integrals and integration methods," *Neutrosophic Sets and Systems,* vol. 43, pp. 290-301, 2021.

[10] W. Jiang and J. Ye, "Optimal design of truss structures using a neutrosophic number optimization model under an indeterminate environment.," *Neutrosophic Sets Sys,* vol. 14, pp. 93-97., 2016.

[11] R. Refaat and I. M. El-Henawy, "Innovative method to evaluate quality management system audit results' using single value neutrosophic number," *Cognitive Systems Research,* vol. 57, pp. 197-206, 2019.

[12] J. Estupiñan Ricardo, M. E. Llumiguano Poma, A. M. Argüello Pazmiño, A. D. Albán Navarro, L. Martín Estévez, and N. B. Hernandez, "Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador," *Neutrosophic Sets & Systems,* vol. 26, 2019.

[13] Pérez-Teruel, *Neutrosophic logic for mental model elicitation and analysis.*: Neutrosophic Sets and Systems, 2012.

[14] F. Smarandache, *Neutrosophy, a new Branch of Philosophy*: Infinite Study, 2002.

[15] F. Smarandache, "A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Infinite Study.," 2005.

[16] C F. Benavides Salazar, J. C. Benavides Salazar, A. L. Santillán Molina, & S. J. Santillán Ojeda. "Efectividad del habeas corpus en defensa de los derechos a la libertad, a la vida e integridad física, en tiempos de pandemia". Universidad y Sociedad, vol. 14 no. S2, pp 432-439, 2022.

[17] F P. Cañizares Galarza, N. V. Quevedo Arnaiz, & N. García Arias. "Aproximación a indicadores de calidad en un estudio sobre la revista Mikarimin". Universidad y Sociedad, vol. 14 no. S2, pp 423-431, 2022.

[18] L. X. Cangas Oña, L. B. Salazar Andrade, E. L Hernández Ramos & J. X. Iglesias Quintana. "Vaguedad del ordenamiento jurídico ecuatoriano referente al uso progresivo de la fuerza". Universidad y Sociedad, vol. 14 no. S2, pp 415-422, 2022.

[19] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[20] García, J. M. B., Ricardo, J. E., & Villalva, I. M. "Acciones didácticas para la autorrealización física integral de los estudiantes de carreras agropecuarias". Didasc@ lia: Didáctica y Educación, vol. 7 no. 2, pp 57-66, 2016.

[21] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[22] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[23] Ricardo, J. E., & Vázquez, I. R. S. "La educación sexual para padres de niños con retraso mental, una vía para su consolidación". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 4 no. 3, pp 137-144, 2019.

[24] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.

[25] von Feigenblatt, O., Pardo, P., & Cooper, M. "The "Bad Students" Movement and Human Rights in Contemporary Thailand". Ciencias Sociales y Económicas, vol. 5 no. 1, pp 156-176, 2021.

[26] G. A. Zúñiga Cárdenas, L. K. Sailema López & I. Alfonso González. "Pacientes de COVID-19 en cuidados intensivos y sus lesiones cutáneas". Universidad y Sociedad, vol. 14 no. S3, pp 105-117, 2022.

[27] M. D. L. Llerena Cepeda, L. K. Sailema López & G. A. Zúñiga Cárdenas. "Variantes de COVID-19 predominantes en Ecuador y sus síntomas asociados". Universidad y Sociedad, vol. 14 no. S3, pp 93-104, 2022.

[28] D. R. Bonifaz Días, G. A. Zúñiga Cárdenas & L. K. Sailema López. "Artritis reumatoide y sus abordajes terapéuticos". Universidad y Sociedad, vol. 14 no. S3, pp 80-92, 2022.

Received: August 29, 2022. **Accepted:** October 22, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of Risk Factors in the Etiology of Cerebral Palsy

Piedad Elizabeth Acurio Padilla[1], Andrés Eduardo Gallegos Cobo[2] and Blanca Cristina Estrella López[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.piedadacurio@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.andresgallegos@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.blancaestrella@uniandes.edu.ec

Abstract. Cerebral Palsy is the most common form of motor disorder in childhood. The risk factors associated with this disorder are difficult to establish since its etiology is frequently multifactorial. A descriptive study was carried out, with a sample of 152 patients diagnosed with Cerebral Palsy, treated in the period from March 2020 to January 2022. To carry out the investigation, the bibliography taken from sites such as Pubmed, Dialnet, and Scielo, among others, was consulted. The medical records of these patients were also reviewed, in order to establish the risk factors associated with the etiology of this condition. They were subjected to expert consultation, which was processed through the application of Compensatory Fuzzy Logic in its neutrosophic extension. This strategic analysis allowed us to know that the highest percentage of cases is located in the Perinatal Period.

Keywords: Cerebral Palsy, Risk Facts, Etiology, Compensatory Fuzzy Logic in neutrosophic extension.

1 Introduction

Cerebral Palsy (CP) is a general term for a group of permanent developmental disorders of movement and posture. Causing activity limitation that is attributed to nonprogressive disorders that occur in fetal or infant brain development. Along with motor disabilities, children with cerebral palsy have disturbances in sensation, perception, learning, and behavior. CP places high demands on health, social, and educational services, as well as a heavy financial and emotional burden on families [1].

Cerebral Palsy is the most common cause of physical disability in childhood. The prevalence is reported to be as high as 3/1000 live births in the United States with 764,000 people living with signs of cerebral palsy. Rates increased towards the end of the 20th century and have now plateaued [2]. There are some factors contributing to this trend: a higher survival rate among premature babies, a higher incidence of cerebral palsy in full-term newborns, and greater longevity among people with cerebral palsy [3].

The vulnerability of motor pathways during brain development is a determinant factor for motor manifestation in CP. The etiology of CP varies. The most frequent causes of CP include complications of prematurity, perinatal or postnatal hypoxic-ischemia, bilirubin exposure, infection, or trauma [4]. However, in many patients with CP, an etiology cannot be determined, particularly for those born at term and/or without a clear brain lesion identifiable by neuroimaging. It is suspected that much of this unknown pathophysiology may be due to genetic or epigenetic factors. Indeed, current estimates indicate that as many as 30% of patients diagnosed with CP may be genetically determined [5].

Patients with CP are often classified clinically into spastic, hypotonic, dystonic (also called “dyskinetic”), ataxic, and mixed subgroups and by the limbs involved (diplegia, hemiplegia, or quadriplegia, and occasionally other patterns). Each of these clinical subgroups and patterns of involvement is also etiologically and genetically heterogeneous, and while certain major genetic forms of CP characteristically produce only one particular kind of involvement, the clinical presentation of other genetic forms of CP is variable [6], [7], [26].

CP presents great clinical variability due to its diverse etiology and risk factors, which can be classified as prenatal, perinatal, and postnatal [8]. Diagnosis is mainly clinical. Signs of suspicion of CP are behavioral alterations, tone (spasticity), and motor signs, as well as the exaltation or delay in the disappearance of primitive reflexes. Motor disorders are accompanied by sensory, perceptual, postural control or balance, gastrointestinal, pulmonary, urinary, and cognitive alterations related to intellectual disability and communicative alterations [9], [25].

The objective of this study is to determine the most common risk factors in the etiology of Cerebral Palsy and to propose preventive actions for this type of motor condition.

2 Method

2.1 Neutrosophy applied to Compensatory Fuzzy Logic

The theory of Neutrosophy, in this case, the inclusion of this theory enriches the possibilities of analysis by complementing the values shown in table 1 ([10,11]). This is mainly due to two reasons, firstly, the addition of the notion of indeterminacy and, secondly, the possibility of calculating using linguistic terms. That is why it was decided to opt for a fusion of both techniques and carry out the study through the use of neutrosophic Compensatory Fuzzy Logic (CFL). Firstly, let us formally expose the original definition of Neutrosophic Logic as shown in [12-18].

Definition 1. Let X be a universe of discourse. A Neutrosophic Set (NS) is characterized by three membership functions $u_A(x), r_A(x), v_A(x): X \rightarrow]$, -0.1+[, which satisfies the condition $-0 \leq inf u_A(x) + inf r_A(x) + inf v_A(x) sup u_A(x) + sup r_A(x) + \sup v_A(x) \leq 3^+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively, and their images are standard or nonstandard subsets of -0,1+[[17], [30].

Definition 2. Let X be a universe of discourse. A Single Value Neutrosophic Set (SVNS) A over X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A: X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x), r_A(x), v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)\ y\ v_A(x)$ denote the true, indeterminate, and false membership functions of x in A, respectively. For convenience, a Single Value Neutrosophic Number (SVNN) will be expressed as A = (a, b, c), where a, b, c [0,1] and satisfies 0 ≤ a + b + c ≤ 3.

The SVNSs arose with the idea of applying the neutrosophic sets for practical purposes. Some operations between SVNN are expressed below:

1. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2), two SVNNs, the sum between A1 and A2 is defined as:
$$A_1 A_2 = (a_1 + a_2 - a_1 a_2, b_1 b_2, c_1 c_2) \quad (2)$$
2. Given A1 = (a1, b1, c1) and A2 = (a2, b2, c2), two SVNNs, the multiplication between A1 and A2 is defined as:
$$A_1 A_2 = (a_1 a_2, b_1 + b_2 - b_1 b_2, c_1 + c_2 - c_1 c_2) \quad (3)$$
3. The product by a positive scalar with a SVNN, A = (a, b, c) is defined by:
$$A = (1 - (1 - a), b, c) \quad (4)$$
4. Let $\{A_1, A_2, \ldots, A_n\}$ be a set of n SVNNs, where Aj = (aj, bj, cj) (j = 1, 2, …, n), then the Single Value Neutrosophic Weighted Mean Operator (SVNWMO) over the set is calculated by the following Equation:
$$\sum_{j=1}^{n} \lambda_j A_j = \left(1 - \prod_{j=1}^{n} (1 - a_j)^{\lambda_j}, \prod_{j=1}^{n} b_j{}^{\lambda_j}, \prod_{j=1}^{n} c_j{}^{\lambda_j}, \right) \quad (5)$$

Where λ_j is the weight of Aj, $\lambda_j \in [0, 1]$ and $\sum_{j=1}^{n} = 1$.

In this paper, linguistic terms will be associated with SVNN, so that experts can carry out their evaluations in linguistic terms, which is more natural. Therefore, the scales shown in Table 2 will be taken into account.

Truth value	Category	SVNN
0	Fake	(0,1,1)
0.1	Almost fake	(0.10,0.90,0.90)
0.2	Pretty fake	(0.20,0.85,0.80)
0.3	Somewhat fake	(0.30,0.75,0.70)
0.4	More false than true	(0.40,0.65,0.60)
0.5	As true as false	(0.50,0.50,0.50)
0.6	More true than false	(0.60,0.35,0.40)
0.7	Somewhat true	(0.70,0.25,0.30)
0.8	True enough	(0.8,0,15,0.20)
0.9	Almost true	(0.9, 0.1, 0.1)
1	Real	(1,0,0)

Table 1. Evolution of the scale from fuzzy to neutrosophic linguistic variables

To convert neutrosophic numbers to neat numbers the following equation will be used:

$$s(V) = 2 + T - F - I \tag{6}$$

Compensatory Fuzzy Logic uses mathematical operators that guarantee the effective combination of intangible elements evaluated by experts, considering categorical scales of veracity, with quantitative information, which provides truth values through conveniently defined predicates based on such information:

Operators	Predicate logic
Conjunction	(and), C,⋀
Disjunction	(or), d, ⋁
Fuzzy strict order	(either)
Denial	(not)

Table 2. Presentation of the mathematical operators in the logic of predicates of the CFL.

Maps from $[0,1]^n$ to [0,1], or go from $[0,1]^2$ to [0,1] and n from [0,1][12]. Which satisfies the following axioms ([19]):

1. min{ x1, x2, ⋯, xn } ≤ d(x1, x2, ⋯, xn) ≤ max{ x1, x2, ⋯, xn } (Compensation Property).
2. d(x1, x2, ⋯, xn) = d(x1, x2, ⋯, xn) (Property of Commutativity or Symmetry).
3. If x1 = y1, x2 = y2, ⋯, xi−1 = yi−1, xi+1 = yi+1, ⋯, xn = yn, such that neither is zero, and xi >yi, then d (x1, x2, ⋯, xn) > d(y1, y2 ,⋯,yn) (Strict Growth Property)
4. If xi = 1 for some i, then d (x1, x2, ⋯, xn) = 1 (Veto Property)
5. c(x1, x2, ⋯, xn) = d(x1, x2, ⋯, xn) = x (Idempotency Property)

The coefficient of variation (Cv) of the predicates will be calculated using equation 5 applying statistical decision criteria according to the following parameters:

- If Cv ≥0.20, take the modal value (rating given by the experts that is repeated the most in the analyzed range)
- If Cv<0.20, take the value of the arithmetic mean (average rating of the experts)

$$Cv = \frac{S}{X_{med}} \tag{7}$$

Where S is the standard deviation of the data and X_{med} is the mean of the data.

3. Results

A review of the medical records of patients with a confirmed diagnosis of Cerebral Palsy was carried out, during the period from March 2020 to January 2022, with a sample of 152 cases. Of which the following were taken as data of interest for the study:

- ✓ Prenatal Period: 36
- ✓ Perinatal Period: 55
- ✓ Postnatal Period: 8
- ✓ Mixed: 51
- ✓ Not specified: 2

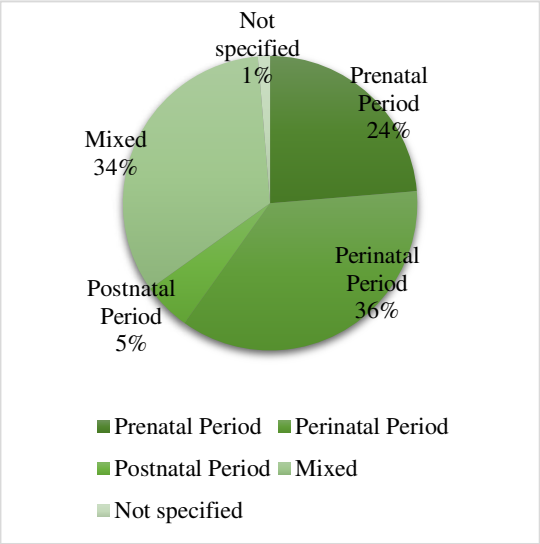


Figure 1. Period of occurrence of risk factors in LESNC. Source: review of medical records. Note: own elaboration

Figure 1 summarizes the moment in which the injury occurred in each of the patients that were considered for this study. According to the results of the analysis and the data obtained from the medical records, the period with the highest incidence was the Perinatal Period and mixed causes. It is necessary to take these values into account to establish a proposal for solutions.

Next, the dispensarization of the factors that intervene in the etiology are shown in tables, for each patient and divided by periods, for a better understanding.

Risk Factors	No.	%
Maternal Vaginal Infections	6	16.6
History of preterm labor threats	6	16.6
c/Toxaemia	5	13.8
Fetal suffering	10	27.7
Maternal Anemia	1	2.7
Maternal age under 18 years	1	2.7
Maternal age over 40 years	1	2.7
Twin pregnancy	1	2.7
Genetic Background	1	2.7
IUGR (Intrauterine Growth Retardation)	1	2.7
Obstetric History of Preterm Labor	1	2.7
Fever during labor	2	5.5

Table 3. Distribution of patients with CP according to risk factors manifested in the Prenatal Period. Source: medical records. Note: own elaboration

Risk Factors	No.	%
Severe hypoxia at birth	13	23.6
Neonatal convulsions	9	16.36
Low Birth Weight	5	9
Cesarean section	4	7.2
Mechanic ventilation	1	1.8
Instrumented delivery	6	11
Sepsis of the Newborn	8	14.54
Preterm labor	5	9

Risk Factors	No.	%
Metabolic disorders	1	1.8
Post-term delivery	1	1.8
Obstetric trauma	1	1.8
CNS infections	1	1.8

Table 4. Distribution of patients with CP according to risk factors present in the Perinatal Period. Source: medical records. Note: own elaboration

Risk Factors	No.	%
Head trauma	2	25
CNS infections	2	25
Convulsive status	3	37.5
Intoxications	1	12.5

Table 5. Distribution of patients with CP according to risk factors present in the Postnatal Period. Source: medical records. Note: own elaboration

- ✓ In the Prenatal period, the factors with the highest incidence were: Maternal Vaginal Infections, History of Preterm Labor Threats, AHT, and Fetal Suffering, representing among them 74.4% of the total 36 cases located in this period.
- ✓ In the Perinatal period, which was the most frequent, with 55% of the total sample, the factors that appear higher were: severe hypoxia at birth, neonatal convulsions, low birth weight, instrumented delivery, sepsis of the NB and preterm labor, the sum of them represents 83.5% of the total.
- ✓ From the postnatal period, 3 factors were selected: cranioencephalic trauma, CNS infections, and convulsive status, which accounted for 87.5% of the total.

Of the factors that were mentioned in tables 3, 4, and 5, those with the highest incidence were selected according to what was found in this study. These factors were analyzed using Compensatory Fuzzy Logic in its neutrosophic extension to determine, through the experience of the experts consulted, which of these provide the most significant values in medical practice to make it possible to guide preventive work. [31, 32, 33]

3.1 Application of Compensatory Fuzzy Logic in its neutrosophic extension

For the analysis of the risk factors involved in the etiology of Cerebral Palsy (CP), the following procedures were performed:

1. Review of the medical records of these patients, taking as a reference the data provided regarding the etiology of the diagnosis, from which the factors with the highest incidence were selected, according to Tables 3, 4, and 5.
2. Interviews and consultations with the selected experts, consisting of specialists in the care of children with Cerebral Palsy, such as Pediatricians, Neurologists, Specialists in Physical Medicine and Rehabilitation, Nurses, and Obstetricians.
3. Analysis of the previously selected risk factors, applying compensatory fuzzy logic in its neutrosophic extension according to the following methodology:

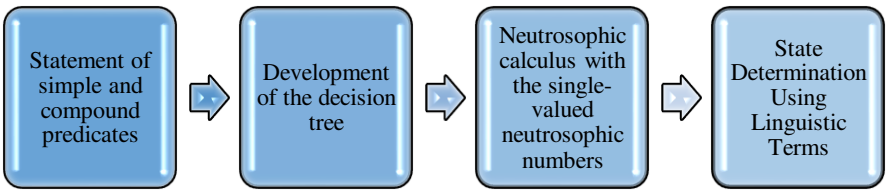


Figure 2. Working algorithm. Note: own elaboration

The results are shown below:
Simple and compound predicates and their calculation expressions:

- ✓ Risk factors $RF(X)$
- ✓ Prenatal Period $PreNP(X)$

- ✓ Perinatal Period $PeriNP(X)$
- ✓ Postnatal Period $PostNP(X)$
- ✓ Maternal Vaginal Infections $MVI(X)$
- ✓ Preterm Labor Threats $PLT(X)$
- ✓ Arterial hypertension $AH(X)$
- ✓ Fetal Suffering $FS(X)$
- ✓ Severe Hypoxia at Birth $SHB(X)$
- ✓ Neonatal Convulsions $NC(X)$
- ✓ Low Birth Weight $LBW(X)$
- ✓ Instrumented Delivery $ID(X)$
- ✓ Sepsis of the Newborn $SNB(X)$
- ✓ Preterm Delivery $PD(X)$
- ✓ Cranioencephalic Trauma $CET(X)$
- ✓ Central Nervous System infections $SNSI(X)$
- ✓ Convulsive Status $CS(X)$

Calculation Expressions:

$$RF(X) = PreNP(X) \wedge PeriNP(X) \wedge PostNP(X)$$
$$PreNP(x) = MVI(X) \wedge PLT(X) \wedge AH(X) \wedge FS$$
$$PeriNP(X) = SHB(X) \wedge NS(X) \wedge LBW(X) \wedge ID(X) \wedge SNB(X) \wedge PTD(X)$$
$$PostNP(X) = CET(X) \wedge CNSI(X) \wedge SC(X)$$

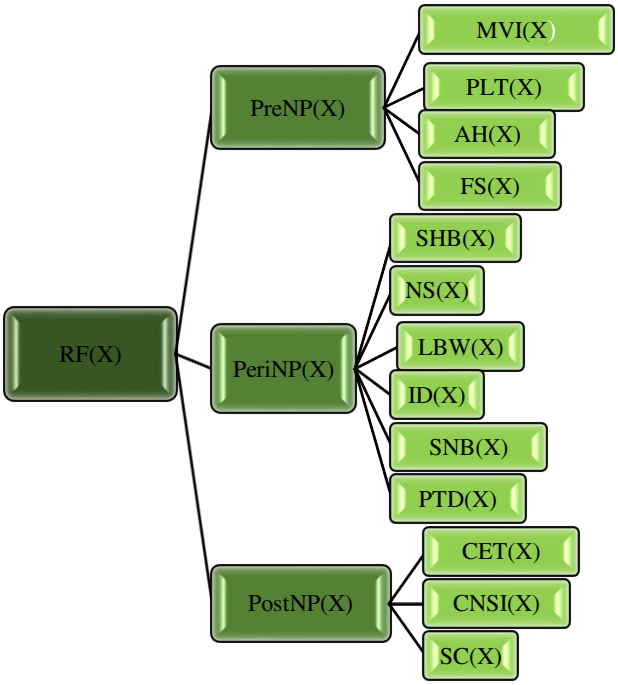


Figure 3: Predicate tree. Own elaboration

The following tables show the calculation of the predicates by groups of experts using the neutrosophic scales in Table 1 and the mathematical operators in Table 2:

Simple Predicates	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
$MVI(X)$	(1;0;0)	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.5;0.5;0.5)	(0.9;0.1;0.1)
$PLT(X)$	(0.5;0.5;0.5)	(1;0;0)	(0.8;0.15;0.2)	(0.9;0.1;0.1)	(1;0;0)
$AH(X)$	(1;0;0)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(1;0;0)	(0.8;0.15;0.2)
$FS(X)$	(0.9;0.1;0.1)	(0.8;0.15;0.2)	(1;0;0)	(0.9;0.1;0.1)	(1;0;0)

Simple Predicates	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
$SHB(X)$	(0.8;0.15;0.2)	(1;0;0)	(1;0;0)	(1;0;0)	(1;0;0)
$NC(X)$	(1;0;0)	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(1;0;0)
$LBW(X)$	(0.5;0.5;0.5)	(1;0;0)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.5;0.5;0.5)
$ID(X)$	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.7;0.25;0.3)	(0.4;0.65;0.6)
$SNB(X)$	(1;0;0)	(0.7;0.25;0.3)	(1;0;0)	(0.4;0.65;0.6)	(1;0;0)
$PD(X)$	(0.5;0.5;0.5)	(1;0;0)	(0.6;0.35;0.4)	(1;0;0)	(0.6;0.35;0.4)
$CET(X)$	(0.8;0.15;0.2)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.6;0.35;0.4)	(0.7;0.25;0.3)
$SNSI(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.8;0.15;0.2)	(1;0;0)	(1;0;0)
$CS(X)$	(0.5;0.5;0.5)	(0.5;0.5;0.5)	(0.5;0.5;0.5)	(0.2;0.85;0.8)	(0.5;0.5;0.5)

Table 3. Calculation of the truth value of the simple predicates of experts 1 to 5. Source: evaluation of experts. Own elaboration

Simple Predicates	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
$MVI(X)$	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.7;0.25;0.3)	(0.6;0.35;0.4)	(0.4;0.65;0.6)
$PLT(X)$	(0.8;0.15;0.2)	(1;0;0)	(1;0;0)	(0.8;0.15;0.2)	(0.9;0.1;0.1)
$AH(X)$	(0.4;0.65;0.6)	(0.9;0.1;0.1)	(0.8;0.15;0.2)	(0.9;0.1;0.1)	(0.7;0.25;0.3)
$FS(X)$	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(1;0;0)	(0.8;0.15;0.2)
$SHB(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)
$NC(X)$	(0.7;0.25;0.3)	(0.5;0.5;0.5)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)
$LBW(X)$	(0.7;0.25;0.3)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.7;0.25;0.3)	(0.9;0.1;0.1)
$ID(X)$	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	(0.9;0.1;0.1)
$SNB(X)$	(1;0;0)	(1;0;0)	(0.7;0.25;0.3)	(0.7;0.25;0.3)	(1;0;0)
$PD(X)$	(0.6;0.35;0.4)	(0.5;0.5;0.5)	(0.9;0.1;0.1)	(0.6;0.35;0.4)	(0.5;0.5;0.5)
$CET(X)$	(1;0;0)	(1;0;0)	(0.9;0.1;0.1)	(0.7;0.25;0.3)	(1;0;0)
$SNSI(X)$	(1;0;0)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(1;0;0)
$CS(X)$	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.8;0.15;0.2)	(0.5;0.5;0.5)	(0.4;0.65;0.6)

Table 4: Calculation of the truth value of the simple predicates of the experts 6 to 10. Source: evaluation of experts. Own elaboration

Simple Predicates	Mode	Mean	Truth Value	Category
$MVI(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$PLT(X)$	(0.8;0.15;0.2)	(1;0;0)	(0.8;0.15;0.2)	True enough
$AH(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	Almost true
$FS(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$SHB(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$NC(X)$	(0.9;0.1;0.1)	(1;0;0)	(0.9;0.1;0.1)	Almost true
$LBW(X)$	(0.8;0.15;0.2)	(1;0;0)	(0.8;0.15;0.2)	True enough
$ID(X)$	(0.9;0.1;0.1)	(1,0.001,0.002)	(0.9;0.1;0.1)	Almost true
$SNB(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$PD(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$CET(X)$	(0.7;0.25;0.3)	(1,0,0.001)	(0.7;0.25;0.3)	Somewhat true
$SNSI(X)$	(1;0;0)	(1;0;0)	(1;0;0)	True
$CS(X)$	(0.5;0.5;0.5)	(1,0.044,0.042)	(0.5;0.5;0.5)	As true as false

Table 5: Calculation of the Truth Values of simple predicates. Source: expert evaluation. Own elaboration

The calculation of the truth values of the simple predicates showed that there is a high incidence of the factors related to the Perinatal Period, followed by those related to the Prenatal Period. This indicates that the Static Injury of the Central Nervous System (SICNS) derives fundamentally from the combination of these factors, according to the experts mentioned above. Fundamentally, those related to Maternal Vaginal Infections, Fetal Suffering,

Severe Hypoxia at Birth, Sepsis of the Newborn, Preterm Delivery, and Central Nervous System Infections. These aspects must be taken into account to guide possible solutions.

Computation of Compound Predicates

Predicates	Truth Value	Category
$RF(X)$	(0.70,0.25,0.30)	Somewhat true
$PreNP(X)$	(0.8,0,15,0.20)	True enough
$PeriNP(X)$	(0.9;0.1;0.1)	Almost true
$PostNP(X)$	(0.70,0.25,0.30)	Somewhat true

Table 6: Calculation of truth values of compound predicates. Source: expert evaluation. Own elaboration

From the previous exercise, it was possible to obtain that the most significant value in the compound predicates was obtained by the one related to the Perinatal Period, giving greater significance to the causes mentioned in the simple predicates related to this period. Followed by the Prenatal Period, which is where the conditions are met for gestation to occur properly. It is important to focus on all the factors, bearing in mind that this type of injury can be caused by one or a combination of several of them. In some patients, the moment in which it could occur is not specified. Therefore, taking measures aimed at preventing Cerebral Palsy can contribute to the good development of minors and their families.

4 Discussion

The prevalence of Cerebral Palsy is 1.5-3 per 1,000 live births, being higher in preterm infants <28 weeks (111.8/1,000 live births) and newborns <1,500 g (59.2 /1,000 live births). Children with CP have complex medical care needs and often require the participation of a multidisciplinary team since, in addition to neurological problems, they are associated with other disorders that will be more frequent with a greater degree of involvement of CP and that will be key in estimating life expectancy [2], [28]. These results show the need to take preventive actions to prevent the injury from occurring.

Cerebral Palsy is the most common motor disability in childhood. Its early identification is an important priority for parents and is critical for access to early intervention resources, which may optimize function [1], [27]. Early diagnosis can lead to better stimulation and treatment of minors who suffer from it.

Recognizing the specific cause of CP in an affected individual is essential to providing optimal clinical management. The structural and/or functional abnormalities of the central nervous system that underlie CP may have their origin at conception, during embryonic or fetal development, during the perinatal period, or in early childhood. Nongenetic factors, such as teratogenic exposures, hypoxia, hemorrhage, or infections, cause PC in some patients.[6]. The study mentioned above showed similar results to those found in the current research. [29]

In a study carried out in full-term infants, a significant correlation was found between admission to the Intensive Care Unit (ICU), and neonatal encephalopathy, in children who developed CP; An association of CP with infections, malformations of the central nervous system, perinatal adverse events and multiple gestations has also been found; as well as with placental infarcts and pre-eclampsia. According to the results of this study, the most frequent risk factors associated with CP in a Mexican community are perinatal ones [20]. This research applied in Mexico coincides with the results of this study applied in Ecuador.

In an investigation entitled: "Pediatric cerebral palsy in Botswana: etiology, outcomes, and comorbidities", reference is made to how Cerebral Palsy in Botswana has different etiologies and is associated with poorer outcomes and higher prevalence of comorbidities than what has been reported in high-resource settings. Further studies are necessary to determine optimal preventative and treatment strategies in this population [21, [22], [24].

Therefore, the validity of the study carried out is highlighted and it is recommended to establish a series of actions to reduce the incidence of SICNS, such as:

1. Educate pregnant women about the possible risk factors in this important period for the proper gestation of the fetus. In order to raise awareness of the possible consequences that could lead to alterations for the future baby and his family. [23]
2. Execute actions in hospital centers on the importance of maintaining special care at the time of delivery and the prevention of risk factors.
3. Carry out community actions that prepare postpartum women and their families on the importance of caring for the newborn baby, avoiding the risk factors that have been mentioned in the research.

Conclusions

In patients with Static Injury of the Central Nervous System, the risk factors occurred fundamentally in two periods: Perinatal, which was the one with the highest incidence, and Mixed, marked by the combination of two or more periods. According to the expert consultation, processed by the Application of Compensatory Fuzzy Logic in its neutrosophic extension, the factors with the highest incidence in the etiology of Cerebral Palsy are those related to Maternal Vaginal Infections, Fetal Suffering, Severe Hypoxia at Birth, Sepsis of the Newborn, Preterm Delivery and Central Nervous System Infections. These aspects must be taken into account to guide possible solutions. Through the compensatory fuzzy logic method applied with single-value neutrosophic numbers, it was possible to carry out the strategic analysis, with which the criteria of the experts consulted were taken into account to propose solutions to prevent the occurrence of this type of diagnosis (CP).

Extend the proposal of preventive actions, resulting from the investigation, to other Maternal-child care centers. In order to reduce the incidence of Cerebral Palsy, taking into account that it affects the proper development of the infant, its inclusion in society, and family dynamics. In addition to the high costs that this type of condition implies for the health system and the family economy.

References

[1] H. C. Glass, Y. Li, M. Gardner, A. J. Barkovich, I. Novak, C. E. McCulloch*, et al.*, "Early identification of cerebral palsy using neonatal MRI and General Movements Assessment in a cohort of high-risk term neonates," *Pediatric Neurology,* vol. 118, pp. 20-25, 2021.

[2] M. J. P. Cantero, E. E. M. Medinilla, A. C. Martínez, and S. G. Gutiérrez, "Comprehensive approach to children with cerebral palsy," *Anales de Pediatría (English Edition),* vol. 95, pp. 276. e1-276. e11, 2021.

[3] J. F. Bennett, M. Andrews, and J. Omura, "Cerebral Palsy: Etiology, Evaluation, and Management of the Most Common Cause for Pediatric Disability," *Physician Assistant Clinics,* vol. 5, pp. 525-538, 2020.

[4] A. M. Elliott and C. Guimond, "Genetic counseling considerations in cerebral palsy," *Molecular Genetics and Metabolism,* 2021.

[5] V. Zouvelou, D. Yubero, L. Apostolakopoulou, E. Kokkinou, M. Bilanakis, Z. Dalivigka*, et al.*, "The genetic etiology in cerebral palsy mimics: the results from a Greek tertiary care center," *European Journal of Paediatric Neurology,* vol. 23, pp. 427-437, 2019.

[6] J. M. Friedman, P. van Essen, and C. D. van Karnebeek, "Cerebral palsy and related neuromotor disorders: Overview of genetic and genomic studies," *Molecular Genetics and Metabolism,* 2021.

[7] C. Gómez-Pérez, J. C. Martori, A. P. Diví, J. M. Casanovas, J. V. Samsó, and J. M. Font-Llagunes, "Gait event detection using kinematic data in children with bilateral spastic cerebral palsy," *Clinical Biomechanics,* vol. 90, p. 105492, 2021.

[8] M. McInerney, C. Imms, P. N. Carding, and D. S. Reddihough, "Evaluation of an intensive voice treatment to reduce anterior drooling in children with cerebral palsy: Protocol for a concurrent multiple-baseline, single case experimental design study," *Contemporary Clinical Trials Communications,* vol. 24, p. 100872, 2021.

[9] M. Moriwaki, H. Yuasa, M. Kakehashi, H. Suzuki, and Y. Kobayashi, "Impact of social support for mothers as caregivers of cerebral palsy children in Japan," *Journal of Pediatric Nursing,* vol. 63, pp. e64-e71, 2022.

[10] P. Y. Jadán-Solís, B. A. Auria-Burgos, M. L. Triana-Palma, C. Y. Mackencie-Álvarez, and F. d. R. Carriel-Paredes, "Compensatory fuzzy logic model for impact assessment when implementing ICT in pedagogical scenarios," *Neutrosophic Sets and Systems,,* vol. 26, pp. 41-48, 2019.

[11] E. L. Hernández-Ramos, L. R. Ayala-Ayala, D. F. Tixi-Torres, and R. Gonzalez, "Method for Treatment and its Incidence in the Change of Social Rehabilitation Regime using Neutrosophic Compensatory Logic," *Neutrosophic Sets and Systems,,* vol. 37, pp. 377-384, 2020.

[12] J. R. Viteri-Moya, G. A. Álvarez-Gómez, C. Viteri-Sánchez, and M. Y. Leyva-Vázquez, "El liderazgo sincrónico en la transformación de la educación superior," *Universidad y Sociedad,,* vol. 13, pp. 139-146, 2021.

[13] F. Smarandache, J. E. Ricardo, E. G. Caballero, M. Y. L. Vázquez, and N. B. Hernández, "Delphi method for evaluating scientific research proposals in a neutrosophic environment," *Neutrosophic Sets and Systems,,* vol. 34, pp. 204-213, 2020.

[14] F. Smarandache, M. Abdel-Basset, and S. Broumi, Eds., *Neutrosophic Sets and Systems*. Infinite Study, 2021, p.^pp. Pages.

[15] F. Smarandache, M. A. Quiroz-Martínez, J. E. Ricardo, N. B. Hernández, and M. Y. L. Vázquez, "Application of neutrosophic offsets for digital image processing," *Investigacion Operacional,,* vol. 41, pp. 603-611, 2020.

[16] Y. R. Pena, J. R. Hechavarria-Hernandez, and M. L. Vazquez, "Problem-based learning. An experience on the inclusion of quality problems in Educational Software Engineering," in *2018 World Engineering Education Forum - Global Engineering Deans Council, WEEF-GEDC*, 2019.

[17] R. Cabezas, J. G. Ruiz, and M. Leyva, "A Knowledge-based Recommendation Framework using SVN," *Neutrosophic Sets and Systems,,* vol. 16, pp. 24-27, 2017.

[18] M. Leyva-Vázquez, K. Pérez-Teruel, and R. I. John, "A model for enterprise architecture scenario analysis based on fuzzy cognitive maps and OWA operators," in *CONIELECOMP 2014 - 24th International Conference on Electronics, Communications and Computers*, 2014, pp. 243-247.

[19] R. A. Espín-Andrade, E. González-Caballero, W. Pedrycz, and E. Fernández, "An Interpretable Logical Theory: The case of Compensatory Fuzzy Logic," *International Journal of Computational Intelligence Systems,,* vol. 9, pp. 612–626, 2016.

[20] F. Barrón-Garza, M. Coronado-Garza, H. Riquelme-Heras, F. Guzmán-de la Garza, C. Ibarra-Rodríguez, and L. Covarrubias-Contreras, "Factores De Riesgo Asociados A Parálisis Cerebral En Una Poblacion De Niños Y Jovenes Mexicanos," *Revista Ecuatoriana de Neurología,* vol. 27, pp. 34-40, 2018.

[21] D. R. Bearden, B. Monokwane, E. Khurana, J. Baier, E. Baranov, K. Westmoreland*, et al.*, "Pediatric cerebral palsy in Botswana: etiology, outcomes, and comorbidities," *Pediatric neurology,* vol. 59, pp. 23-29, 2016.

[22] J. A. Viteri Rodríguez, G. C. Romero Paredes & E. S. Cocha Chicaiza. "Uso de ordenadores electrónicos como factor predisponente para el desarrollo de astenopia". Universidad y Sociedad, vol. 14 no. S2, pp 259-267, 2022.

[23] Y. Rodriguez Cuéllar & L. N. Espinoza Pire. "Las manifestaciones bucales en pacientes adultos con asma y su manejo odontológico". Universidad y Sociedad, vol. 14 no. S2, pp 252-258, 2022.

[24] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[25] Ricardo, J. E., Vázquez, M. Y. L., Palacios, A. J. P., & Ojeda, Y. E. A. "Inteligencia artificial y propiedad intelectual". Universidad y Sociedad, vol. 13 no. S3, pp 362-368, 2021.

[26] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[27] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[28] Álvarez Gómez, G. A., Viteri Moya, J. R., Viteri Intriago, D. A., & Estupiñán Ricardo, J. "Integración de los procesos sustantivos para la mejora de la calidad del aprendizaje". Conrado, vol. 17 no. 80, pp 21-27, 2021.

[29] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.

[30] von Feigenblatt, O. "Mediation for management: Dealing with Conflict in the Workplace". Innovaciones de Negocios, vol. 18 no. 35, pp 113-119, 2021.

[31] M. E. Machado Maliza, C. M. Rosero Morán & A. J. Peñafiel Palacios. "Main types of computer crimes existing in Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 611-619, 2022.

[32] J. L. Robalino Villafuerte, E. A. Guerrero Bernal, G. V. Jordán Naranjo & J. I. Cruz Arboleda. "Acoso laboral. Prohibición al empleador en el Código de Trabajo del Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 591-599, 2022.

[33] M. L. Merizalde Avilés, E. L. Palacios Campoverde, D. F. Granja Zurita & C. J. Lizcano Charpeta. "Declaraciones de testigos por streaming: libertad para declarar y el contenido del testimonio. estudio de caso Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 582-590, 2022.

Received: August 30, 2022. **Accepted:** October 23, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Cognitive Maps for the Analysis of the Factors in the proper Diagnosis of Conversion Disorder

Jenny Olivia Caicedo Rodríguez[1], Álvaro Paúl Moina Veloz[2] and Silvia Tatiana Tite Andi[3]

[1] Universidad Regional Autónoma de Los Andes. Sede Santo Domingo. Ecuador. E-mail: us.jennycaicedo@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.alvaromoina@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.silviatite@uniandes.edu.ec

Abstract. Somatoform disorders encompass a variety of entities and symptoms, including Conversion Disorder. This type of disorder is characterized by a variety of symptoms, which often confuse specialists when establishing a diagnosis, due to its similarity to functional neurological disorders. The variety of manifestations is often interpreted as epileptic seizures. To promote adequate management of these patients, the present investigation carried out a bibliographic review on the subject, in reference sites such as PubMed, Scielo, Elsevier, and Research Gate. In addition, neutrosophic methods that favor decision-making were used, such as the Neutrosophic Cognitive Maps, to determine the factors that will facilitate decision-making to establish an accurate diagnosis. What will contribute to an economy in medical resources such as tests and others. From the results obtained, the need for the integration of a multidisciplinary team in the care of these patients is highlighted, involving the figure of the psychologist and psychiatrist from the beginning of the evaluation.

Keywords: conversion disorder, somatoform disorders, epileptic seizures, neutrosophic cognitive map.

1 Introduction

Functional neurological disorders are a common clinical problem in neurology and psychiatry services. In the new diagnostic categories, emphasis is placed on the positive characteristics necessary for the diagnosis of this disorder [1]. The Diagnostic and Statistical Manual (DSM-5) has included a new classification called "somatic symptom disorders and related disorders" that replaces the old somatoform disorders that included somatization disorder, pain disorder, hypochondriasis, and conversion disorder. People with this type of disorder seek help in primary care and other medical settings and, less frequently, in the field of mental health, generating a high consumption of resources for the public system.

The origin of these disorders is not well defined, although both biological and psychological causes have been found, taking into account the patient's biographical experience and personality traits [2]. In the diagnosis, it is necessary to rule out the presence of an underlying medical pathology through a thorough examination and the performance of complementary tests [3]. The treatment combines strategies for patient management with specific therapeutic interventions (pharmacological and psychotherapeutic measures) [4].

Specialists are prone to confuse this diagnosis with that of organic epileptic disorders. Thus, it can be stated that there is indeterminacy involved; therefore, it is necessary to apply neutrosophic methods that provide better support for decision-making. Based on this, the objective of this research is to analyze the factors that will facilitate the proper diagnosis of Conversion Disorder.

2 Methodology

2.2 Neutrosophic Cognitive Maps

Starting from the previous elements, in this particular work, the use of Neutrosophic Cognitive Maps (NCMs) is proposed considering the advantages that this technique offers compared to other soft-computing techniques, in terms of interpretability, scalability, aggregation of knowledge, dynamism, and its ability to represent feedback and indeterminacy relationships [5]. NCMs are an integration of the Fuzzy Cognitive Maps (FCMs) introduced by Kosko in 1986 and the Neutrosophic Sets (NSs) introduced by Smarandache in 1995.

This technique overcomes the inability of traditional FCMs to represent indeterminacy. The inclusion of indeterminacy establishes that neutrality and ignorance are also forms of uncertainty. NCMs constitute a technique that has received increasing attention due to their possibilities for representing causality. The following is a set of definitions necessary for working with NCMs [6].

Definition 1. Let $N = \{(T, I, F): T, I, F \in [0,1]\}$ be a neutrosophic set of evaluation v: is a mapping of a group of propositional formulas into N, i.e., each sentence p is associated with a value in N, meaning that P is T% true,

I% indeterminate, and F% false, v (p) = (T, I, F). Hence, neutrosophic logic is a generalization of fuzzy logic, based on the concept of neutrosophy according to [7].

Definition 2. (See [8]) Let K be the ring of real numbers. The ring generated by $K \cup I$ is called a neutrosophic ring if it involves the indeterminacy factor in it, where I satisfies $I2 = I, I + I = 2I$ and in general, $I + I + \ldots + I = nI$, if $k \in$, then $k.I = kI, 0I = 0$. The neutrosophic ring is denoted by $K(I)$, which is generated by $K \cup I, i.e., K(I) = < K \cup I >$, where $<$ K$\cup$I $>$ denotes the ring generated by K and I.

Definition 3. A neutrosophic matrix is a matrix $A = [c]_{ij} = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n;\ m, n \geq 1$, such that each $a_{ij} \in K(I)$, where $K(I)$ is a neutrosophic ring.

The elements of the matrix can have the form $a + bI$, where "a" and "b" are real numbers, whereas I is the indeterminacy factor. The usual operations of neutrosophic matrices can be extended from the classical matrix operations.

For example, $\begin{pmatrix} -1 & I & 5I \\ I & 4 & 7 \end{pmatrix} \begin{pmatrix} I & 9I & 6 \\ 0 & I & 0 \\ -4 & 7 & 5 \end{pmatrix} = \begin{pmatrix} -21I & 27I & -6 + 25I \\ -28 + I & 49 + 13I & 35 + 6I \end{pmatrix}$

Additionally, a neutrosophic graph is a graph that has at least one indeterminate edge or one indeterminate node. The neutrosophic adjacency matrix is an extension of the adjacency matrix in classical graph theory. $a_{ij} = 0$ means nodes i and j are not connected, $a_{ij} = 1$ means that these nodes are connected and $a_{ij} = I$, which means the connection is indeterminate (unknown whether it is or not) [8]. Fuzzy set theory does not use such notions. On the other hand, if the indetermination is introduced in a cognitive map, as it is referred to, then this cognitive map is called a neutrosophic cognitive map, which is especially useful in the representation of causal knowledge. It is formally described in Definition 4.

Definition 4. A Neutrosophic Cognitive Map (NCM) is a neutrosophic directed graph with concepts like policies, and events, among others, as nodes and causalities or indeterminates as edges. It represents the causal relationship between concepts. The measures described below are used in the proposed model, they are based on the absolute values of the adjacency matrix [9]:

Outdegree (v_i) is the sum of the row elements in the neutrosophic adjacency matrix. It reflects the strength of outgoing relationships (c_{ij}) of the variable:

$$od(v_i) = \sum^{n} c_{ij} \tag{1}$$

Indegree (v_i) is the sum of the column elements. It reflects the strength of relations relationships (c_{ij}) outgoing from the variable.

$$id(v_i) = \sum_{i=1}^{n} c_{ji} \tag{2}$$

Total centrality (total degree (v_i)), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \tag{3}$$

The variables are classified according to the following criteria:

- Transmitting variables are those with $od(v_j) > 0\ e\ id(v_i) = 0$
- The receiving variables are those with $od(v_j) = 0\ e\ id(v_i) > 0$
- Ordinary variables satisfy both $od(v_j) \neq 0\ e\ id(v_i) \neq 0$

The static analysis is applied using the adjacency matrix, taking into consideration the absolute value of the weights. Static analysis in Neutrosophic Cognitive Maps (NCMs), initially contains the neutrosophic number of the form $(a + bI)$, where I = indetermination.

It requires a process of deneutrosophication as proposed in [8], where $I \in [0, 1]$ and it is replaced by their values maximum and minimum. Finally, we work with the average of the extreme values, which is useful to obtain a single value. This value contributes to the identification of the characteristics to be attended, according to the factors obtained, for our case study [10-12-35].

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{4}$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \tag{5}$$

3 Results

3.1 Results of the bibliographic review

A bibliographic search was made on sites such as PubMed, Scielo, Elseivier, and Research Gate, where it was found that there is a little approach to Conversion Disorders, due to their difficult diagnosis. It was possible to verify the little presence of published papers, regarding this topic set in Ecuador. Considering this, the search spectrum was expanded, resulting in the following: [1-3, 13-31] from which could be known that:

- ✓ Somatoform disorders (SD) and conversion disorders (CD) involve a set of entities, phenomena, and symptoms that nosology has classified and conceptualized multiple times throughout history. These are ubiquitous disorders in medicine since their forms of presentation involve practically all systems, but they contain a common denominator, that is, the relevance of somatic symptoms linked to psychic discomfort, apparent or not. [32], [35], [36], [38]
- ✓ The Diagnostic and Statistical Manual of Mental Disorders in its current edition (DSM-5) places them in the category of somatic symptom disorders and related disorders, grouping them into the following entities, each with clinical specifiers: somatic symptom disorder, anxiety disorder due to disease, conversion disorder or functional neurological symptom disorder, factitious disorder (Münchhausen syndrome, applied to oneself or a third party).
- ✓ This type of disorder (previously known as hysteria) is defined as the real loss or alteration of motor or sensory functioning that leads to suspicion of the existence of an underlying somatic disorder or disease. Generally, there is usually a temporal relationship between the stressful event and the onset of conversion symptoms; therefore, a thorough medical examination is essential to reach the diagnosis. [33], [34], [37]
- ✓ The somatoform is closely related to the conversion; in both the phenomenon is unconscious, however, CDs are alterations associated with a more specific dysfunction of the nervous system.
- ✓ CDs are often difficult to diagnose and treat, even by mental health professionals. They are prevalent conditions that are often misdiagnosed as somatic diseases and that require a multidisciplinary approach in all its phases.
- ✓ They constitute entities that must be known by all medical specialties because as was pointed out, the presentation is polymorphous.
- ✓ It is often not easy to diagnose conversion disorder, even more so when the presence of a neurological disorder does not exclude its diagnosis.
- ✓ There may be cases in which a somatic disease is previously present; in this situation, the symptoms and signs do not correlate, and the severity, duration, and dysfunction produced by the signs and symptoms is proportional to that previous disease.
- ✓ Basically, 4 groups of conversion disorders are distinguished:
    a) **With motor symptoms or deficits**. In this case, among the main clinical manifestations are alterations in psychomotor coordination and balance, paralysis or localized muscle weakness, difficulty swallowing, the sensation of a "lump in the throat", aphonia, and urinary retention. They do not follow the neurological patterns resulting from injury to the peripheral nervous system.
    b) **With crises or convulsions.** It is clinically characterized by the presence of crises or convulsions, with a voluntary or sensory motor component. Generally, no expected injuries appear (such as tongue biting, paroxysmal activity in the encephalogram, or lack of sphincter control). The crises can last minutes, with an apparent lack of response to stimuli; after the crisis, the patient can remember what has happened.
    c) **With symptoms or sensory deficits.** In this case, the appearance of the pathology is distant from what is expected by the existing dermatomes and there may be a uniform loss of all sensory modalities. Pain, specific and idiosyncratic pictures related to personal experiences, and pseudohallucinations are frequent. [39]
    d) **Mixed presentation.** Symptoms from more than one category are identified. Although they are not specific to the disease, there are a series of characteristics and mental disorders that can be associated in some way with the existence of conversion disorders. Among the associated characteristics, histrionic personality traits stand out, the existence of primary benefits (somatic conflict resolution) and/or secondary benefits (sick role), the existence of family patterns, sexual alterations, stress before the onset of symptom and symbolism (the affected organ is not random)
- ✓ The onset of conversion disorder is usually sudden. The clinical course is also characterized by the short duration of most symptoms. Its onset usually occurs in late adolescence and early adulthood (although it can appear at any stage of life); when it begins in mid to late adult life, an underlying neurological or organic disorder is more likely.
- ✓ Within the clinical semiology of conversion disorders, other clinical signs are also indicative: tremors that change in frequency or disappear with distraction maneuvers; fixed and painful dystonia after minimal

trauma; a sensory disorder that reaches exactly to the midline; hypoesthesia of an arm that disappears at the shoulder; to the order to say "yes" when perceiving with eyes closed the touch of cotton, the patient says "no" in the hemi-body with functional hemi-anesthesia; the patient only perceives the vibratory sensitivity in the middle forehead in functional hemi-anesthesias; a totally normal examination in decubitus and astasia-abasia in standing position; a strange gait (dragging a leg, posture with very flexed knees, very notable variations of the disorder throughout the day). [40, 41, 42, 43]

- ✓ Clinical differences based on sex have been described, with falls due to muscle atony being more frequent in women together with higher rates of major depression, while tonic-clonic movements of the extremities are more frequent in men and higher rates of Deficit Disorder. of attention and hyperactivity.
- ✓ For its evaluation in primary care centers, the diagnosis of Somatoform Disorder is developed along a route with 3 simultaneous parts:
  a) ruling out a general medical condition as the cause of the symptoms.
  b) identifying psychosocial dysfunction and recognizing and relieving stressors. A biopsychosocial evaluation is therapeutic and is often followed by improvement, even resolution of symptoms.
- ✓ Findings that are highly suggestive of a somatization disorder include a history of multiple somatic complaints, multiple visits to doctors and different specialists, as well as the presence of a family member of chronic and recurrent symptoms and dysfunction in the main areas of life. (family, peers, and school).
- ✓ In the evaluation process, unnecessary or repetitive complementary tests should be avoided as an attempt to demonstrate to the family the psychosomatic origin of the condition. A cost-effective method of determination in an appropriate manner with the appropriate analytical and imaging tests is the basis of the diagnostic plan and always follows the signs or symptoms that suggest organicity.

3.2 Application of the Neutrosophic Cognitive Map

According to the bibliography consulted in section 3.1, several factors or diagnostic guidelines were established for the comprehensive approach of patients with somatization disorder in a conversion form, which was used for the elaboration of the map shown in Figure 1.

1) Environmental factors
2) Intellectual capacity
3) Patient Age
4) Underlying psychological symptoms
5) Personality elements
6) Associated genetic predisposition

A group of experts composed of Neurologists, Pediatricians, Psychiatrists, and Psychologists was selected. As an inclusion criterion, it was taken into account that the experts had a professional experience of at least five years, both teaching and assisting. Associated with the Autonomous University of the Andes.

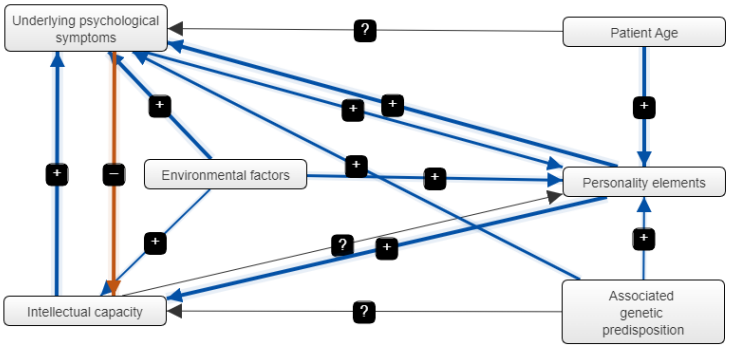


Figure 1: Neutrosophic Cognitive Map. Source: own elaboration.

	Environmental Factors	Intellectual Capacity	Patient Age	Underlying psychological symptoms	Personality Elements	Associated Genetic Predisposition
Environmental Factors	0	0.31	0	1	0.73	0
Intellectual Capacity	0	0	0	1	I	0
Patient Age	0	0	0	I	1	0
Underlying Psychological Symptoms	0	-0.12	0	0	0.63	0
Personality	0	0.14	0	1	0	0

Elements						
Associated Genetic Predisposition	0	I	0	0.72	0.36	0

Table 1: Adjacency matrix. Source: own elaboration.

Component	Indegree	Outdegree	Centrality
Associated genetic predisposition	0	1.58	1.58
Personality elements	3.2199999999999998	1.1400000000000001	4.359999999999999
Underlying psychological symptoms	4.22	0.75	4.97
Patient Age	0	1.5	1.5
Intellectual capacity	1.07	1.5	2.5700000000000003
Environmental factors	0	2.04	2.04

Figure 2: Static Analysis. Source: own elaboration.

4 Discussion

The order of the variables according to their level of centrality is as follows:

1. Underlying psychological symptoms
2. Personality elements
3. Intellectual capacity
4. Environmental factors
5. Associated genetic predisposition
6. Patient Age

Among these six components, 14 connections were established for a map density of 0.46, with approximately 2.3 connections for each component. Of the 14 connections, three of them are indeterminate, three are transmitters and three are ordinary.

- ✓ Of the three transmitter variables: Associated genetic predisposition, Patient Age, and Environmental factors, the latter is the one with the highest level of centrality (2.04). Therefore, it is the variable with the highest level of importance within the neutrosophic cognitive map modeled for this analysis. This variable provides the greatest amount of information that directly affects the patient's behavior. This indicates that, on this variable, specialists should pay special attention to establish a timely diagnosis of the nosological entity. This will make it possible to reduce costs in terms of medical examinations performed unnecessarily. The Personality elements variable takes second place in importance because certain personality patterns predispose to the disease.
- ✓ Of the three connections of indeterminacy, it can be said that the specialists present a contrast of criteria with respect to the nodes Associated genetic predisposition-Intellectual capacity, Intellectual capacity- Personality elements, and Patient Age- Personality elements.

Taking into consideration the previous interrelationships, future prediction scenarios were established for variables of interest for the study.

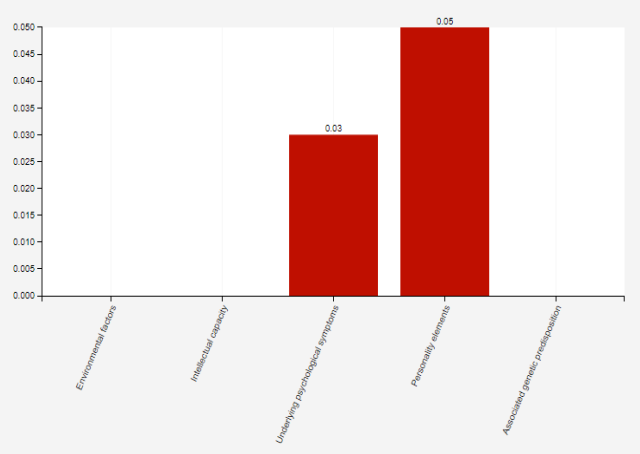


Figure 3: Scenario 1. Source: own elaboration.

If age is increased, then personality elements and underlying psychological symptoms increase in turn. Because the assessment of the situation depends in this case on the level of perception acquired by the patient as he increases in age. In this case, the patient, as he grows, acquires the possibility of establishing judgments and comparisons about reality.

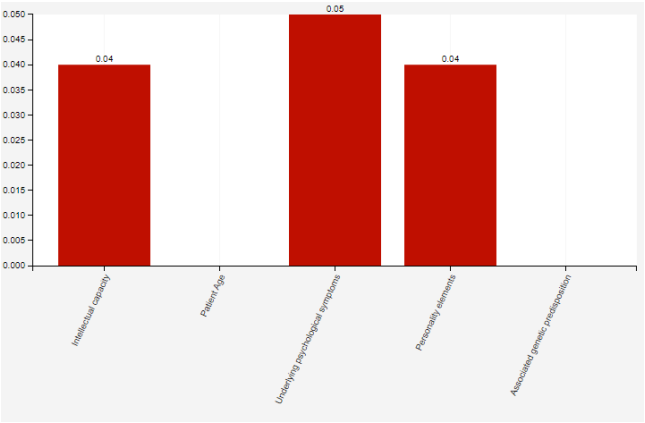


Figure 4: Scenario 2. Source: own elaboration

If environmental factors are modified, either by deterioration or improvement, then the intellectual capacity, the symptoms, and the elements of the personality are exacerbated or mitigated, due to the magnitude of the interrelationship between these variables. Therefore, an exhaustive exploration of the environment and society where the subject develops must be carried out, in order to enrich the diagnosis.

5 Recommendations

Considering the high costs for the health system implied by the use of diagnostic means for somatoform disorders, including conversion disorders, it is recommended for their comprehensive care, to highlight the importance of a multidisciplinary assessment, since said entity is suspected. Involving the figure of the psychologist and psychiatrist from the beginning in the approach to the patient. In this way, the evaluation will be facilitated more deeply, rapport will be established and proper therapeutic adherence will be facilitated.

Providing specialists with knowledge for adequate evaluation and clinical management will be essential, avoiding, in addition to unnecessary medical evaluations, the iatrogenesis produced by them, which can contribute to a better prognosis for patients.

Conclusion

The factors that will provide an adequate diagnosis of Conversion Disorder were analyzed, it is important to highlight that, in the case of this type of disorder, it is necessary to focus on the predisposing environmental and personality factors, as well as the underlying psychological symptoms.

Multidisciplinary evaluation of this type of patient is necessary, where a team made up of neurologists, pediatricians, psychologists and psychiatrists intervene and evaluate together.

Somatoform disorders make up a heterogeneous group of disorders with a broad symptom spectrum that ranges from transient functional somatic symptoms to serious somatoform disorders themselves.

References

[1] A. Feinstein, "Conversion disorder," *CONTINUUM: Lifelong Learning In Neurology,* vol. 24, pp. 861-872, 2018.

[2] A. Samuels, T. Tuvia, D. Patterson, O. Briklin, S. Shaffer, and A. Walker, "Characteristics of conversion disorder in an urban academic children's medical center," *Clinical Pediatrics,* vol. 58, pp. 1250-1254, 2019.

[3] M.-A. Kate, T. Hopwood, and G. Jamieson, "The prevalence of dissociative disorders and dissociative experiences in college populations: A meta-analysis of 98 studies," *Journal of Trauma & Dissociation,* vol. 21, pp. 16-61, 2020.

[4] M. V. Morán, L. S. García, and I. G. Cabeza, "Trastornos somatomorfos y facticios," *Medicine-Programa de Formación Médica Continuada Acreditado,* vol. 12, pp. 4929-4937, 2019.

[5] R. G. Ortega, M. L. Vázquez, J. A. S. Figueiredo, and A. Guijarro-Rodriguez, "Sinos river basin social-environmental prospective assessment of water quality management using fuzzy cognitive maps and neutrosophic AHP-TOPSIS," *Neutrosophic Sets and Systems,* vol. 23, pp. 160-171, 2018.

[6] A. J. P. Palacios, J. E. Ricardo, I. A. C. Piza, and M. E. E. Herrería, "Phenomenological Hermeneutical Method and Neutrosophic Cognitive Maps in the Causal Analysis of Transgressions against the Homeless," *Neutrosophic Sets and Systems,* vol. 44, pp. 147-156, 2021.

[7] S. H. Al-subhi, E. I. Papageorgiou, P. P. Pérez, G. S. S. Mahdi, and L. A. Acuña, "Triangular neutrosophic cognitive map for multistage sequential decision-making problems," *International Journal of Fuzzy Systems,* vol. 23, pp. 657-679, 2021.

[8] N. Martin, A. Aleeswari, and W. Lilly Merline, "Risk Factors of Lifestyle Diseases – Analysis by Decagonal Linguistic Neutrosophic Fuzzy Cognitive Map," *Materials Today: Proceedings,* vol. 24, pp. 1939-1943, 2020/01/01/ 2020.

[9] M. D. L. L. Cepeda, J. V. P. Quilambaque, A. M. N. Quispe, E. T. M. Álvarez, and J. F. R. Pérez, "Hermeneutical Analysis of the Determinants of Obesity using Neutrosophic Cognitive Maps," *Neutrosophic Sets and Systems,* vol. 44, pp. 90-99, 2021.

[10] M. Leyva-Vázquez, M. A. Quiroz-Martínez, Y. Portilla-Castell, J. R. Hechavarría-Hernández, and E. González-Caballero, "A New Model for the Selection of Information Technology Project in a Neutrosophic Environment," *Neutrosophic Sets and Systems,* vol. 32, pp. 344-346, 2020.

[11] F. Smarandache, J. E. Ricardo, E. G. Caballero, M. Y. L. Vázquez, and N. B. Hernández, "Delphi method for evaluating scientific research proposals in a neutrosophic environment," *Neutrosophic Sets and Systems,* vol. 34, pp. 204-213, 2020.

[12] R. M. Zulqarnain, X. L. Xin, M. Saqlain, F. Smarandache, and M. I. Ahamad, "An integrated model of Neutrosophic TOPSIS with application in Multi-Criteria Decision-Making Problem," *Neutrosophic Sets and Systems,,* vol. 40, pp. 253-269, 2021.

[13] H. Schrader, T. Bøhmer, and J. Aasly, "The incidence of diagnosis of Munchausen syndrome, other factitious disorders, and malingering," *Behavioural neurology,* vol. 2019, 2019.

[14] M. B. Mikkelsen and M. Rosholm, "Systematic review and meta-analysis of interventions aimed at enhancing return to work for sick-listed workers with common mental disorders, stress-related disorders, somatoform disorders and personality disorders," *Occupational and environmental medicine,* vol. 75, pp. 675-686, 2018.

[15] J. Liu, N. S. Gill, A. Teodorczuk, Z.-j. Li, and J. Sun, "The efficacy of cognitive behavioural therapy in somatoform disorders and medically unexplained physical symptoms: A meta-analysis of randomized controlled trials," *Journal of affective disorders,* vol. 245, pp. 98-112, 2019.

[16] B. Bursch, N. D. Emerson, and M. J. Sanders, "Evaluation and management of factitious disorder imposed on another," *Journal of Clinical Psychology in Medical Settings,* vol. 28, pp. 67-77, 2021.

[17] B. L. Brand, H. J. Schielke, K. T. Putnam, F. W. Putnam, R. J. Loewenstein, A. Myrick*, et al.*, "An online educational program for individuals with dissociative disorders and their clinicians: 1-year and 2-year follow-up," *Journal of Traumatic Stress,* vol. 32, pp. 156-166, 2019.

[18] M. P. Mychailyszyn, B. L. Brand, A. R. Webermann, V. Şar, and N. Draijer, "Differentiating Dissociative from Non-Dissociative Disorders: A Meta-Analysis of the Structured Clinical Interview for DSM Dissociative Disorders (SCID-D) Journal of Trauma and Dissociation," *Journal of Trauma & Dissociation,* vol. 22, pp. 19-34, 2021.

[19] C. A. Ganslev, O. J. Storebø, H. E. Callesen, R. Ruddy, and U. Søgaard, "Psychosocial interventions for conversion and dissociative disorders in adults," *Cochrane Database of Systematic Reviews,* 2020.

[20] M. A. O'Neal and G. Baslet, "Treatment for patients with a functional neurological disorder (conversion disorder): an integrated approach," *American Journal of Psychiatry,* vol. 175, pp. 307-314, 2018.

[21] I. Conejero, E. Thouvenot, M. Abbar, S. Mouchabac, P. Courtet, and E. Olie, "Neuroanatomy of conversion disorder: towards a network approach," *Reviews in the Neurosciences,* vol. 29, pp. 355-368, 2018.

[22] F. A. McFarlane, H. Allcott-Watson, M. Hadji-Michael, E. McAllister, D. Stark, C. Reilly*, et al.*, "Cognitive-behavioural treatment of functional neurological symptoms (conversion disorder) in children and adolescents: a case series," *European Journal of Paediatric Neurology,* vol. 23, pp. 317-328, 2019.

[23] L. K. Dar and S. Hasan, "Traumatic experiences and dissociation in patients with conversion disorder," *J Pak Med Assoc,* vol. 68, pp. 1776-1781, 2018.

[24] L. Del Río-Casanova, A. I. González-Vázquez, A. Justo, V. Andrade, M. Páramo, J. Brenlla*, et al.*, "The role of emotion dysregulation in Conversion Disorder," *Actas espanolas de psiquiatria,* vol. 46, pp. 92-103, 2018.

[25] S. K. Morsy, S. Aybek, A. Carson, T. R. Nicholson, J. Stone, A. M. Kamal*, et al.*, "The relationship between types of life events and the onset of functional neurological (conversion) disorder in adults: a systematic review and meta-analysis," *Psychological medicine,* pp. 1-18, 2021.

[26] L. de Vroege, I. Koppenol, W. J. Kop, M. M. Riem, and C. M. van der Feltz-Cornelis, "Neurocognitive functioning in patients with conversion disorder/functional neurological disorder," *Journal of Neuropsychology,* vol. 15, pp. 69-87, 2021.

[27] K. R. Edwards, C. M. McMurtry, B. Dick, R. Lewinson, A. Dhariwal, and J. Katz, "Somatic symptom disorder, conversion disorder, and chronic pain: Pediatric clinician perspectives," *Clinical Practice in Pediatric Psychology,* 2021.

[28] C. M. Van der Feltz-Cornelis, S. F. Allen, and J. F. Van Eck van der Sluijs, "Childhood sexual abuse predicts treatment outcome in conversion disorder/functional neurological disorder. An observational longitudinal study," *Brain and Behavior,* vol. 10, p. e01558, 2020.

[29] A. Sammartino-Arbour, A. Dufour, V. Frenette, M.-F. Forget, M.-A. Bruneau, S. Ducharme*, et al.*, "The association between somatic symptom disorders and neurocognitive disorders: A systematic review," *The American Journal of Geriatric Psychiatry,* 2022.

[30] N. L. Papadopoulos and F. Röhricht, "A single case report of Body Oriented Psychological Therapy for a patient with Chronic Conversion Disorder," *The Arts in Psychotherapy,* vol. 61, pp. 38-43, 2018.

[31] S. Sánchez Oller, "Conferencia Magistral:" Los trastornos somatomorfos en la niñez"," 2019.

[32] D. Peña Suárez, N.D. Silva Álvarez & G. R. Navas Espín. "Análisis de la cartera vencida y su incidencia en la liquidez del Banco Pichincha en Puyo". Universidad y Sociedad, vol. 14 no. S2, pp 244-251, 2022.

[33] D. Peña Suárez, N.D. Silva Álvarez & G. R. Navas Espín. "La auditoría y su incidencia en la gestión de la calidad en los procesos de elaboración de confites y snacks". Universidad y Sociedad, vol. 14 no. S2, pp 237-243, 2022.

[34] A R. Soria Acosta & Y. C. Hernández Zambrano. "Intervenciones de enfermería en la encefalopatía hipóxica isquémica aguda por asfixia neonatal". Universidad y Sociedad, vol. 14 no. S2, pp 230-236, 2022.

[35] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[35] de Mora-Litardo, K., & Estupiñan-Ricardo, J. "La influencia de la programación neurolingüística en estudiantes universitarios en la República de Ecuador". Luz, vol. 16 no. 1, pp 104-112, 2017.

[36] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[37] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[38] Vega Falcón, V., Alarcón Quinapanta, M., Yancha Villacís, M., & Estupiñán Ricardo, J. Medición del capital intelectual: Caso hotelero. Dilemas Contemporáneos: Educación, Política y Valores, no. 96, pp 1-19, 2019.

[39] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.

[40] von Feigenblatt, O. F. "Un estudio de caso sobre la competencia diplomática entre la República Popular China y la República de China (Taiwán): La experiencia de la República de Costa Rica de 1995 a 2010". Dilemas contemporáneos: Educación, Política y Valores. Vol. 9no. (Edición especial), pp 1-19, 2021.

[41] M. G. González Vallejo, J. L. Rueda Buste, L. X. Cangas Oña & J. J. Cellán Palacios. "Prescripción extraordinaria adquisitiva de dominio frente al derecho a la propiedad privada de los adultos mayores en el cantón Ambato, Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 576-581, 2022.

[42] M. R. Rivilla Requelme, J. D. Bósquez Remache, M. I. Mora Verdezoto & L. M. Guaño Morillo. "Retos y perspectivas del consultorio jurídico de uniandes en el cantón Santo Domingo en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 560-569, 2022.

[43] J. L. Rueda Buste, R. R. Naranjo Cedeño, F. J. Caicedo Banderas & N. V. Vinueza Ocho. "Valoración del perjuicio ocasionado al estado ecuatoriano por las empresas inexistentes o fantasmas". Universidad y Sociedad, vol. 14 no. S4, pp 551-559, 2022.

Received: August 31, 2022. **Accepted:** October 24, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Treatment Alternatives to Gingival Hyperpigmentation using Neutrosophic Correlation Coefficients (revisited)

Fernando Marcelo Armijos Briones[1], José Israel Castillo González[2], Jaime Fernando Armijos Moreta[3], and Catalina Del Rosario Boada Zurita[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.fernandoarmijos@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador. E-mail: uq.josecastillo@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Santo Domingo. Ecuador. E-mail: us.jaimearmijos@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.catalinaboada@uniandes.edu.ec

Abstract. Among the main techniques described in the literature for the treatment of gingival melanosis are the use of chemical agents, free gingival grafts, abrasion with rotary or manual instruments (scalpel), cryosurgery with liquid nitrogen, gingivectomy and gingivoplasty, and the use of lasers. The present study aims to perform a selective evaluation of therapeutic alternatives for gingival hyperpigmentation using neutrosophic correlation coefficients. For this purpose, a bibliographic review of the specialized documentary base was carried out to determine the main treatments for the object of study. Neutrosophic sets logic and expert evaluation were applied. The use of correlation coefficients between two single-valued neutrosophic numbers allowed the selection of a therapeutic alternative according to the experts' evaluations. The present study made it possible to verify the usefulness of neutrosophy as a means for the solution of complex real-life problems by incorporating indeterminacies.

Keywords: correlation coefficient, single value neutrosophic number, gingival hyperpigmentation.

1 Introduction

Melanin is one of the most common and widely distributed pigments in nature. It is a black or blackish-brown endogenous pigment present in the cytoplasm of certain cells. This pigment is responsible for the coloration of plants and animals. In humans, this pigment creates the characteristic coloration of the skin, hair, choroid, gingival tissues, etc. The process of melanin formation in the body is called melanogenesis and occurs in the basal layer (deep layer) of the epidermis, as well as in the matrix cells of the hair follicles of the follicle [1].

It has been suggested that physiological pigmentation is probably genetically determined. Usually, all individuals maintain the same concentration of melanocytes in the skin per unit area. Although the degree of pigmentation is due to the activation and increased activity of the melanocytes and not to their number [2], [3].

The coloration present in the oral mucosa depends on the degree and extent of epithelial keratinization, the increase or decrease of blood vessels, the thickness of the epithelium, and the amount of exogenous or endogenous non-hemoglobin pigments such as melanin [4]. Hyper-pigmentation in this area is usually relatively frequent and, in general, can be a cause of low self-esteem in patients with gummy smiles [5].

One of the main factors in over coloration of the oral mucosa refers to the amount and melanogenic activity produced by melanocytes [6]. Likewise, the differences in the number, size and distribution of melanosomes, the type of melanin, and the masking of the keratinized epithelium are determining factors [7].

In accordance with [8], gingival pigmentation may be associated with endogenous causes due to the melanoblastic activity of each individual and even exogenous. According to Tal et al. (2003), this pathology has a higher prevalence in men and women, blacks, French, Filipinos, Arabs, Chinese, Indians, and Germans. It is important to note that although there is some prevalence in these individuals, it can be present in all races and ethnicities [10] [11].

On the other hand, associations have been reported with the consumption of certain medications [12], smoking, and metallic deposits [13]. The suffering of underlying pathologies such as Kaposi's sarcoma or Addison's disease has also been associated with hyperpigmentation in the oral area [14]. The uncontrolled production of melanin is also caused by DNA damage caused by ultraviolet radiation [15].

Although gingival melanin pigmentation is a benign condition and not a medical problem, it is a major cosmetic concern for many patients [16]. In this sense, there are different procedures used to remove melanocytic pigmentation from the gingival area. Among the main techniques described in the literature, the most common are: the

use of chemical agents (90% phenol with 95% alcohol), free gingival grafts, abrasion with rotary or manual instruments (scalpel), cryosurgery with liquid nitrogen, gingivectomy and gingivoplasty and the use of laser [9].

Most of these techniques are capable of providing the patient with an effective treatment to mitigate or eliminate the effects of gingival hyperpigmentation. However, making an effective selection between them is a cumbersome process, since it depends on many factors that are often not mutually comparable or even quantifiable. In this environment of uncertainty, it is where neutrosophic logic and its contributions to the decision-making process are developed.

Neutrosophy is the branch of philosophy that studies the origin, nature, and scope of neutralities [17]. The incorporation of neutrosophic sets during decision-making guarantees that the uncertainty of the decision-making process, including indeterminacies, is considered during the process [18].

In this sense, correlation coefficients are an important tool to judge the relationship between two objects. These coefficients have been widely applied to data analysis and classification, decision-making, pattern recognition, etc. [19], [20]. The present study aims to carry out a selective evaluation of therapeutic alternatives for gingival hyperpigmentation using neutrosophic correlation coefficients. [28, 29, 30]

2 Preliminaries

Definition 1. Let X be a space of points (objects), with a generic element in X denoted by x. A neutrosophic set A in X is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. The functions $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or nonstandard subsets of] −0, 1+ [, i.e., $TA(x)$: $X \rightarrow]-0, 1+[$, IA(x): $X \rightarrow]-0, 1+[$, and FA(x): $X \rightarrow]-0, 1+[$. There is no restriction on the sum of $T_A(x)$, $I_A(x)$, and $F_A(x)$, so there is $-0 \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3+$.

Obviously, it is difficult to apply the neutrosophic set to practical problems. Therefore, [22] introduced the concept of a single-valued neutrosophic set (SVNS), which is an instance of a neutrosophic set, to be used in real scientific and engineering applications. Next, the definition of a SVNS is introduced [22, 31, 32].

Definition 2. [22] Let X be a space of points (objects) with generic elements in X denoted by x. A SVNS A in X is characterized by a truth-membership function TA(x), an indeterminacy-membership function IA(x), and a falsehood-membership function FA(x) for each point x in X, TA(x), IA(x), FA(x) ∈ [0, 1]. Thus, A SVNS A can be expressed as

$$A = \{x, T_A(x), I_A(x), F_A(x) \mid x \in X\}$$

Then, the sum of $T_A(x)$, $I_A(x)$, and $F_A(x)$ satisfies the condition $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

Definition 3. [22] The complement of a SVNS A is denoted by Ac and is defined as

$$Ac = \{x, FA(x), 1 - IA(x), TA(x) \mid x \in X\}$$

Definition 4. [22] A SVNS A is contained in the other SVNS B, $A \subseteq B$ if and only if $TA(x) \leq TB(x)$, $IA(x) \geq IB(x)$, and $FA(x) \geq FB(x)$ for every x in X.

Definition 5. [22] Two SVNSs A and B are equal, written as A = B, if and only if $A \subseteq B$ and $B \subseteq A$

2.1 Correlation coefficient of SVNSs

Definition 6. [23] For any two SVNSs A and B in the universe of discourse X = {x1, x2, . . . , xn}, the correlation coefficient between two SVNSs A and B is defined as follows:

$$M(A,B) = \frac{1}{3n}\sum_{i=1}^{n}[\phi_i(1-\Delta T_i) + \varphi_i(1-\Delta I_i) + \psi_i(1-\Delta F_i)] \quad (1)$$

where

$$\phi_i = \frac{3-\Delta T_i - \Delta T_{max}}{3-\Delta T_{min} - \Delta T_{max}},$$

$$\varphi_i = \frac{3-\Delta I_i - \Delta I_{max}}{3-\Delta I_{min} - \Delta I_{max}},$$

$$\psi_i = \frac{3-\Delta F_i - \Delta F_{max}}{3-\Delta F_{min} - \Delta F_{max}},$$

$$\Delta T_i = |T_A(x_i) - T_B(x_i)|,$$

$$\Delta I_i = |I_A(x_i) - I_B(x_i)|,$$

$$\Delta T_i = |T_A(x_i) - T_B(x_i)|,$$

$$\Delta T_{min} = min_i|T_A(x_i) - T_B(x_i)|,$$

$$\Delta I_{min} = min_i|I_A(x_i) - I_B(x_i)|,$$

$\Delta F_{min} = min_i|F_A(x_i) - F_B(x_i)|$,

$\Delta T_{max} = max_i|T_A(x_i) - T_B(x_i)|$,

$\Delta I_{max} = max_i|I_A(x_i) - I_B(x_i)|$,

$\Delta F_{max} = max_i|F_A(x_i) - F_B(x_i)|$,

for any $x_i \in X$ and i = 1, 2, . . ., n

However, the differences of importance are considered in the elements in the universe. Therefore, the weight of the element x_i (i=1, 2, ..., n) must be considered. Next, a weighted correlation coefficient between SVNSs is introduced.

Definition 7. [23] Let w_i be the weight for each element x_i (i = 1, 2, . . . , n), $w_i \in [0, 1]$, and $\sum_{i=1}^{n} w_i = 1$, then the following weighted correlation coefficient between the SVNSs A and B:

$$M_w(A,B) = \frac{1}{3}\sum_{i=1}^{n} w_i[\phi_i(1 - \Delta T_i) + \varphi_i(1 - \Delta I_i) + \psi_i(1 - \Delta F_i)] \quad (2)$$

2.2 Decision-making method using the correlation coefficient of SVNSs

In the multiple attribute decision-making problem with single-valued neutrosophic information, the characteristic of an alternative Ai (i = 1, 2,..., m) on an attribute Cj (j = 1, 2,..., n) is represented by the following SVNS:

$A_i = \{C_j, T_{Ai}(C_j), I_{Ai}(C_j), F_{Ai}(C_j) | C_j \in C, j = 1, 2, \ldots, n\}$

where $T_{Ai}(C_j), I_{Ai}(C_j), F_{Ai}(C_j) \in [0, 1]$ and $0 \leq T_{Ai}(C_j) + I_{Ai}(C_j) + F_{Ai}(C_j) \leq 3$ for $C_j \in C$, j =1, 2, . . ., n, and i = 1, 2, . . ., m.

For convenience, the values of the three functions $T_{Ai}(C_j)$, $I_{Ai}(C_j)$, $F_{Ai}(C_j)$ are denoted by a single-valued neutrosophic value (SVNV) $d_{ij} = \langle t_{ij}, i_{ij}, f_{ij} \rangle$ (i = 1, 2, . . ., m; j = 1, 2, . . ., n), which is usually derived from the evaluation of an alternative A_i with respect to a criterion C_j by the expert or decision maker. Thus, a single-valued neutrosophic decision matrix $D = (d_{ij})_{m \times n}$.

In multiple attribute decision-making problems, the concept of the ideal point has been used to help identify the best alternative in the decision set. Although the ideal alternative does not exist in the real world, it does provide a useful theoretical construct against which to evaluate alternatives [24].

In the decision-making method, an ideal SVNV can be defined by $d_j^* = \langle t_j^*, i_j^*, f_j^* \rangle = \langle 1, 0, 0 \rangle$ (j = 1, 2,..., n) in the ideal alternative A*. Hence, by applying Equation (2) the weighted correlation coefficient between an alternative Ai (i =1, 2, . . ., m) and the ideal alternative A* is given by

$$M_w(A_i, A^*) = \frac{1}{3}\sum_{j=1}^{n} w_j\left[\phi_{ij}\left(1 - \Delta t_{ij}\right) + \varphi_{ij}\left(1 - \Delta i_{ij}\right) + \psi_{ij}\left(1 - \Delta f_{ij}\right)\right] \quad (3)$$

where

$$\phi_{ij} = \frac{3 - \Delta t_{ij} - \Delta t_{i\,max}}{3 - \Delta t_{i\,min} - \Delta t_{i\,max}},$$

$$\varphi_i = \frac{3 - \Delta i_{ij} - \Delta i_{i\,max}}{3 - \Delta i_{i\,min} - \Delta i_{i\,max}},$$

$$\psi_i = \frac{3 - \Delta f_{ij} - \Delta f_{i\,max}}{3 - \Delta f_{i\,min} - \Delta f_{i\,max}},$$

$$\Delta t_{ij} = \left|t_{ij} - t_j^*)\right|,$$

$$\Delta i_{ij} = \left|i_{ij} - i_j^*)\right|,$$

$$\Delta f_{ij} = \left|f_{ij} - f_j^*)\right|,$$

$$\Delta t_{i\,min} = min_j\left|t_{ij} - t_j^*\right|,$$

$$\Delta i_{i\,min} = min_j\left|i_{ij} - i_j^*\right|,$$

$$\Delta f_{i\,min} = min_j \left| f_{ij} - f_j^* \right| ,$$

$$\Delta t_{i\,max} = max_j \left| t_{ij} - t_j^* \right| ,$$

$$\Delta i_{i\,max} = max_j \left| i_{ij} - i_j^* \right| ,$$

$$\Delta f_{i\,max} = max_j \left| f_{ij} - f_j^* \right| ,$$

for i = 1, 2, . . ., m and j = 1, 2, . . ., n. By the correlation coefficient M_w (Ai, A*) (i =1, 2,..., m), the ranking order of all alternatives and the best one(s) can be obtained.

2.2 Methodology

A bibliographic review was carried out by analyzing original articles and systematic reviews obtained from the last 5 years that include information related to the topic. The search was made by consulting specialized databases and using the Google Scholar search engine. Scientific articles were searched using the words: gingival; treatment; gingival melanosis; pigmentation; gingival depigmentation techniques. [37, 38]

The scientific data obtained were listed and submitted to scientific review by the work team, within which there were 3 specialists in the field with a minimum of 8 years of experience each. Nearly a dozen alternative methods for treating the disease were found; however, to facilitate the work and the processing of the data, it was decided to synthesize the information obtained. In this way, Table 1 shows a summary of the main treatments to be considered in the development of the study.

Surgical treatment alternatives	Characteristic
A1. Electrosurgery	It works according to the principle of electrosurgical fulguration or fulguration (arcing between the tip of the electrode and the conductive tissue that induces coagulation in the tissue). The result is the formation of a clot or carbonization instead of actual cellular vaporization. The resulting thermal effects and collateral damage (coagulative necrosis edema) could cause a measure of postoperative pain and discomfort for the patient proportional to the voltage used and the time of tissue exposure, which in turn prolongs healing [26, 33].
A2. Surgical technique with a scalpel	It consists of the removal of the pigmented gingival epithelium together with a layer of the underlying connective tissue, using the scalpel. The scalpel method is one of the most economical techniques and does not require extensive instrumentation. In addition, the healing period of scalpel wounds is relatively fast compared to other techniques [25].
A3. Laser	It is an effective, comfortable, and reliable technique with good aesthetic results. Various lasers have been used for gingival depigmentation including carbon dioxide (CO2), diode lasers, neodymium: yttrium aluminum garnet (Nd: YAG), erbium: yttrium aluminum garnet (Er: YAG), and erbium, yttrium doped. with chromium, scandium, gallium, and garnet (Er, Cr: YSGG) [25, 34].
A4. Cryosurgery or cryotherapy	It consists of the use of freezing substances (tetrafluoroethane, liquid nitrogen, nitrous oxide, etc.) to cause protein denaturation, mitochondria destruction, and cell death by freezing the cell cytoplasm. It is an effective, easy treatment, and does not require anesthesia, suture, or surgical dressing. It implies an absence of bleeding during or after treatment and minimal scar formation; it does not harm adjacent tissues, there is no risk of infection, and it does not require expensive equipment [25, 35, 36].
A5. Radiosurgery	It is the removal of soft tissue with the help of radiofrequency energy, from 3.0 MHz to 4.0 MHz. This technique consists of the removal of soft tissue with the help of radiofrequency energy [27]
A6. Abrasion method	It consists of the elimination of the epithelium that contains melanin deposits. It is done using rotary abrasive instruments. Fine-

Surgical treatment alternatives	Characteristic
	grain diamond burs in the form of flame, round diamonds, polishing discs, and even ceramic bur are generally used for sectioning soft tissues. It is a non-aggressive, simple, economical method, with reduced surgical time, produces little bleeding, provides comfort to the patient, and provides satisfactory results [25].

Table 1. Treatment alternatives to be evaluated. Source: own elaboration.

As analysis criteria, cost (C1), effectiveness (C2), and availability of treatment (C3) are selected. Each of the experts is asked to fill in a small form in which a weighting of importance must be included for each of the criteria with respect to the rest. Likewise, they are asked to submit each of the therapeutic alternatives for evaluation based on the selected criteria. For this, the evaluations to be given must specify to what extent the expert considers that the alternative Ai is good (Tx), bad (Fx), or is not entirely sure (Ix) with respect to the criterion Cj. it is considered that the evaluated criteria have the same weight wj=0.33.

3 Results

The results obtained from the evaluations of all the experts are considered of equal importance and the average of the results is determined for the processing and obtaining of the information. In this way, the resulting decision matrix D is shown below.

$$D = \begin{matrix} \langle 0.5;\ 0.3;\ 0.2\rangle & \langle 0.4;\ 0.2;\ 0.3\rangle & \langle 0.2;\ 0.2;\ 0.5\rangle \\ \langle 0.6;\ 0.1;\ 0.2\rangle & \langle 0.6;\ 0.1;\ 0.2\rangle & \langle 0.4;\ 0.2;\ 0.3\rangle \\ \langle 0.5;\ 0.3;\ 0.2\rangle & \langle 0.5;\ 0.2;\ 0.3\rangle & \langle 0.6;\ 0.1;\ 0.2\rangle \\ \langle 0.7;\ 0.1;\ 0.1\rangle & \langle 0.2;\ 0.2;\ 0.5\rangle & \langle 0.4;\ 0.2;\ 0.2\rangle \\ \langle 0.3;\ 0.2;\ 0.3\rangle & \langle 0.6;\ 0.1;\ 0.2\rangle & \langle 0.3;\ 0.2;\ 0.3\rangle \\ \langle 0.6;\ 0.1;\ 0.2\rangle & \langle 0.5;\ 0.2;\ 0.3\rangle & \langle 0.6;\ 0.1;\ 0.2\rangle \end{matrix}$$

Following the logic of the method used, the values of the operators necessary for the determination of each correlation coefficient are determined, as shown in Tables 2 and 3.

	$\varphi C1$	$\varphi C2$	$\varphi C3$	$\mu C1$	$\mu C2$	$\mu C3$	$\psi C1$	$\psi C2$	$\psi C3$
A1	1	0.94	0.82	1	0.96	0.87	0.96	1	1
A2	1	1	0.9	1	1	0.96	1	1	1
A3	0.95	0.95	1	1	0.96	1	0.92	0.96	1
A4	1	0.74	0.84	1	0.83	0.96	1	0.96	1
A5	0.84	1	0.84	0.96	1	0.96	0.96	1	1
A6	1	0.95	1	1	0.96	1	1	0.96	1

Table 2. Values of φ, μ, and ψ for each alternative. Source: own elaboration.

	A1	A2	A3	A4	A5	A6
ΔTmin	0.5	0.4	0.4	0.3	0.4	0.4
ΔImin	0.2	0.2	0.2	0.1	0.2	0.2
ΔFmin	0.2	0.1	0.1	0.1	0.1	0.1
ΔTmax	0.8	0.6	0.5	0.8	0.7	0.5
ΔImax	0.5	0.3	0.3	0.5	0.3	0.3
ΔFmax	0.3	0.2	0.3	0.2	0.2	0.2

Table 3. Minimum and maximum values of variation in the functions of belonging to truth, falsehood, and indeterminacy. Source: own elaboration.

In this way, by using equation (3), the values of the correlation coefficients are obtained. Table 4 shows the values obtained and their ranking accordingly.$M_w(A_i, A^*)$

	A6	A2	A3	A4	A5	A1
MW	0.7243	0.7147	0.6862	0.6338	0.6318	0.5797

Table 4. Weighted correlation coefficients. Source: own elaboration.

In this way, it is valid to point out that, according to the analysis carried out, alternative 6 (abrasion method) is the most preferred among the 6 alternatives evaluated, closely followed by the surgical method with a scalpel. It is estimated that the results achieved may vary depending on the criteria to be evaluated and the panel of experts, since the data obtained have a certain degree of imprecision, variable from one person to another.

Conclusion

Gingival melanosis is a condition that can affect all strata of society and affects the aesthetic appearance of patients to a greater extent. There are several surgical treatments to mitigate or eliminate its effects, although the selection between them is sometimes cumbersome. The present study allowed the evaluation of surgical therapeutic alternatives for hyperpigmentation of the gums through expert criteria. A bibliographic review was carried out on the specialized documentary base to determine the main treatments regarding the object of study. Neutrosophic logic was used to achieve the selection of a therapeutic alternative by using correlation coefficients between two single-valued neutrosophic numbers.

References

[1] M. E. Urán and L. E. Cano, "Melanina: implicaciones en la patogénesis de algunas enfermedades y su capacidad de evadir la respuesta inmune del hospedero," Infectio, vol. 12, no. 2, 2011.
[2] S. K. Kasagani, R. Nutalapati, and R. B. Mutthineni, "Esthetic depigmentation of anterior gingiva. A case series.," N. Y. State Dent. J., vol. 78, no. 3, pp. 26–31, 2012.
[3] Y. Castro-Rodríguez, "Melanosis gingival, una revisión de los criterios para el diagnóstico y tratamiento," Odontoestomatologia, vol. 21, no. 33, pp. 54–61, 2019.
[4] V. Singh, S. B. Giliyar, S. Kumar, and M. Bhat, "Comparative Evaluation of Gingival Depigmentation by Diode Laser and Cryosurgery Using Tetrafluoroethane: 18-Month Follow-Up," Clin. Adv. periodontics, vol. 2, no. 3, pp. 129–134, 2012.
[5] S. Malhotra, N. Sharma, and P. Basavaraj, "Gingival esthetics by depigmentation," J Periodontal Med Clin Pr., vol. 1, no. 1, pp. 79–84, 2014.
[6] H. Montaudié, C. Bertolotto, R. Ballotti, and T. Passeron, "Fisiología del sistema pigmentario. Melanogénesis," EMC-Dermatología, vol. 48, no. 1, pp. 1–11, 2014.
[7] E. Faúndez L, V. Villalba M, Y. Valenzuela V, and M. C. Ramírez R, "Lesiones pigmentadas de la mucosa oral," Rev. chil. dermatol, pp. 203–211, 2011.
[8] S. D. Narayankar, N. C. Deshpande, D. H. Dave, and D. J. Thakkar, "Comparative evaluation of gingival depigmentation by tetrafluroethane cryosurgery and surgical scalpel technique. A randomized clinical study," Contemp. Clin. Dent., vol. 8, no. 1, p. 90, 2017.
[9] H. Tal, D. Oegiesser, and M. Tal, "Gingival depigmentation by erbium: YAG laser: clinical observations and patient responses," J. Periodontol., vol. 74, no. 11, pp. 1660–1667, 2003.
[10] S. Raposo and E. Pérez, "Melasnosis gingival en un paciente pediátrico: caso clínico y revisión de la literatura," Rev Eur Odontoestomatol [Internet], vol. 21, no. 1, pp. 1–9, 2015.
[11] M. A. Trelles, W. Verkruysse, J. M. Segui, and A. Udaeta, "Treatment of melanotic spots in the gingiva by argon laser," J. oral Maxillofac. Surg., vol. 51, no. 7, pp. 759–761, 1993.
[12] A. A. Cerman, "Training SE Atlas of Pigmentary Disorders," J Pigment Disord, vol. 3, no. 1, pp. 1–4, 2016.
[13] P. E. M. Valencia, J. F. Q. Eguizábal, and B. I. Y. Ramírez, "Despigmentación gingival y cirugía de alargamiento coronal en erupción pasiva alterada tipo IA e IB en el mismo tiempo quirúrgico," Univ. Odontológica, vol. 34, no. 72, pp. 19–28, 2015.
[14] A. S. Shirazi, A. Moeintaghavi, F. Khorakian, and M. Talebi, "Treatment of gingival physiologic pigmentation in adolescents by liquid nitrogen cryosurgery: 24-month follow-up.," Int. J. Periodontics Restorative Dent., vol. 32, no. 4, 2012.
[15] C. Morales and M. A. López-Nevot, "Efectos de la radiación ultravioleta (UV) en la inducción de mutaciones de p53 en tumores de piel," Oncol., vol. 29, no. 7, pp. 25–32, 2006.
[16] M.-F. Liébart et al., "Smile line and periodontium visibility.," Periodontal Pract. today, vol. 1, no. 1, 2004.
[17] M. L. Vázquez and F. Smarandache, Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre. Infinite Study, 2018.
[18] W. B. Vasantha, I. Kandasamy, and F. Smarandache, "Algebraic Structure of Neutrosophic Duplets in Neutrosophic Rings < Z U I>,< Q U I> and < R U I.>," Neutrosophic Sets Syst., vol. 23, pp. 85–95, 2018.
[19] E. Szmidt and J. Kacprzyk, "Correlation of intuitionistic fuzzy sets," in International conference on information processing and management of uncertainty in knowledge-based systems, 2010, pp. 169–177.
[20] J. Ye, "Multicriteria fuzzy decision-making method using entropy weights-based correlation coefficients of interval-valued intuitionistic fuzzy sets," Appl. Math. Model., vol. 34, no. 12, pp. 3864–3870, 2010.

[21] F. Smarandache, A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Infinite Study. 2005.
[22] H. Wang, F. Smarandache, Y. Zhang, and R. Sunderraman, Single valued neutrosophic sets. Infinite study, 2010.
[23] J. Ye, "Improved correlation coefficients of single valued neutrosophic sets and interval neutrosophic sets for multiple attribute decision making," J. Intell. Fuzzy Syst., vol. 27, no. 5, pp. 2453–2462, 2014.
[24] J. Ye, "Multicriteria decision-making method using the correlation coefficient under single-valued neutrosophic environment," Int. J. Gen. Syst., vol. 42, no. 4, pp. 386–394, 2013.
[25] L. D. Osorio-Ayala, P. M. Cantos-Tello, and A. S. Carvajal-Endara, "Melanosis gingival: diagnóstico y terapéutica de su implicación estética. Revisión de la literatura," Odovtos Int. J. Dent. Sci., vol. 23, no. 2, pp. 39–51, 2021.
[26] Y. Castro-Rodríguez, F. Bravo-Castagnola, and S. Grados-Pomarino, "Repigmentación melánica de la melanosis gingival. Revisión sistemática," Rev. clínica periodoncia, Implantol. y Rehabil. oral, vol. 9, no. 3, pp. 238–243, 2016.
[27] H. S. Rosa, H. Josephine, I. Wijayanti, and R. A. Putranto, "Penatalaksanaan Depigmentasi Gingiva Fisiologis dengan Teknik Sederhana (Laporan Kasus)," *J. Kedokt. Gigi Terpadu*, vol. 2, no. 2, 2020.
[28] D. F. Granja Zurita, M. H. Abad Tandazo, J. A. Paredes López & C. F. Rey Siquilanda. "La ausencia del error en el código orgánico integral penal en la conducta delictiva del procesado en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 59-69, 2022.
[29] D. E. Huera Castro, A. E. Paucar Bombón, B. C. Pérez Mayorga & L. R. Miranda Chávez. "La eutanasia en personas adultas mayores". Universidad y Sociedad, vol. 14 no. S4, 48-58, 2022.
[30] W. A. Zorrilla Baque, H. Paronyan, K. E. Carrión León & L. X. Cangas Oña. "Diligencias preparatorias y providencias preventivas según el código orgánico general de procesos". Universidad y Sociedad, vol. 14 no. S4, pp 39-47, 2022.
[31 S. F. Fiallos Bonilla, J. P. Rodriguez Murillo, E. D. P. Araujo Escobar & M. F. Pineda Rivera. "Ausencia de regulación de las acciones de proveedores de servicios de comunicación telemática y plataformas de internet". Universidad y Sociedad, vol. 14 no. S4, pp 28-38, 2022.
[32] A. D. Mendoza Vera, N. V. Quevedo Arnaiz, R. Meléndez Carballido & D. F. Tixi Torres. "Análisis jurídico al límite de velocidad del transporte público en las carreteras del Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 10-19, 2022.
[33] C. A. Pérez Padilla, Z. Herrera Lazo, D. Cañizares Vásquez, J. García Conrado, F. Nieto Núñez. "Incidencia de Síndrome de Down en la sala de neonatología". Universidad y Sociedad, Vol. 14 num 2, pp- 328-335, 2022.
[34] S. A. Machuca Vivar, N. V. Vinueza Ochoa, C. R. Sampedro Guamán & A. L. Santillán Molina. "Habeas data y protección de datos personales en la gestión de las bases de datos". Universidad y Sociedad, Vol. 14 num 2, pp- 244-251, 2022
[35] de Mora-Litardo, K., & Estupiñan-Ricardo, J. "La influencia de la programación neurolingüística en estudiantes universitarios en la República de Ecuador". Luz, vol. 16 no. 1, pp 104-112, 2017.
[36] Ricardo, J. E., Vázquez, M. Y. L., Palacios, A. J. P., & Ojeda, Y. E. A. "Inteligencia artificial y propiedad intelectual". Universidad y Sociedad, vol. 13 no. S3, pp 362-368, 2021.
[37] von Feigenblatt, O. F., Pardo, P., & Cooper, M. "Sufficiency Economy Philosophy (SEP): Thailand's Emic Approach to Governance and Development as Evidence of an Asian-value Oriented Inclusive Leadership Management Philosophy". Journal of Asia Pacific Studies, vol. 6. No. 2, pp 289-300, 2021.
[38] von Feigenblatt, O., Pardo, P., & Cooper, M. "The "Bad Students" Movement and Human Rights in Contemporary Thailand". Ciencias Sociales y Económicas, vol. 5 no. 1, pp 156-176, 2021.

Received: September 01, 2022. **Accepted:** October 24, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Linguistic Scale for the Assessment of Knowledge of Natural and Traditional Medicine in Dental Students

Rolando Manuel Benites[1], Jorge David Morales Cobos[2] and Javier Estuardo Sánchez Sánchez[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.rolandobenites@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.jorgemc52@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.javiersanchez@uniandes.edu.ec

Abstract. It is more and more frequent to carry out research in the field of natural and traditional Chinese medicine in dental treatments and for this reason, it is necessary to identify the knowledge of university students in this matter while in connection with neutrosophic philosophy. Based on these arguments, this paper aims to apply a linguistic neutrosophic scale for the assessment of knowledge of natural and traditional medicine in dental university students. During the study, theoretical, empirical, and mathematical-statistical methods were used. When applying these methods, the knowledge of the students on this subject was identified. The results obtained show the need to deepen other investigations that link Neutrosophy, natural and traditional medicine, and dentistry.

Keywords: neutrosophic linguistic scale, neutrosophic sample, natural medicine, dentistry.

1 Introduction

Medicine is the product of man's activity, his social development, and originates when his instinct to preserve life and relieve pain drives him to influence nature. Throughout history, man has raised the problem of the balance between health and disease [1].

Natural and Traditional Medicine (NTM), conceived as the unique heritage of the Eastern Hemisphere, over time has expanded its use to other territories of the planet, where it has reached great significance [1].

The NTM includes 10 modalities: herbal medicine, apitherapy, traditional Chinese medicine, and all its variants, homeopathy, floral therapy, medical hydrology, traditional exercises: taiji, tiangong, ozone therapy, heliothalassotherapy, and nutritional guidance, so that the methods and procedures that encompass its use enrich its actions on man and that, over time, it occupies an important place in the patient's therapy [2], [3].

The NTM is also known by the international scientific community as energetic, alternative, naturalistic, or complementary. It is part of the heritage of universal culture, that is, of concepts and practices that have been inherited from generation to generation. It has contributed since ancient times to the treatment of various diseases and ailments [1].

The clinical-therapeutic model of natural and traditional medicine has its own theoretical and philosophical foundations, supported by scientific knowledge and medical science, whose approach to the health-disease process is based on principles such as similarity, the individuality of the patient and the use of minimum drug dose [4].

Among the trends in NTM, its growing incorporation into professional practice stands out, not as an alternative method motivated by economic reasons or to solve shortage problems, but as a true scientific discipline that needs to be studied, perfected, and permanently develop its skills due to its proven ethical and scientific advantages [3].

As shown by the theoretical references, research on NTM has been addressed by the international scientific community from various approaches and perspectives. However, in these cases, the use of neutrosophic techniques for the evaluation of the results has been insufficient.

The NTM has several applications in different medical specialties where dentistry is increasingly acquiring greater connotation. The use of herbalism has already been demonstrated in various treatments for gum diseases and as a means of coagulation once jaw extractions have been carried out, just to mention two examples. That is why every day it is used more and more is included in the arsenal of dentists to indicate to their patients.

That is why this medical specialty is increasingly included in the different curricula for the training of dental professionals at different universities in Latin America. On these arguments, the need to carry out research on the knowledge of university students on this subject is demanded. [19], [20], [22]

Based on the arguments presented above, this research has the objective of applying a linguistic neutrosophic scale for the assessment of knowledge of natural and traditional medicine in dental students from the Autonomous Regional University of the Andes in Ecuador.

2 Methodology

2.1 Study subjects

A neutrosophic sample is a chosen subset of a population, a subset that contains some indeterminacy: either with respect to several of its individuals (which may not belong to the population under study or may only partially belong to it) or with respect to the subset as a whole. While classical samples provide accurate information, neutrosophic samples provide vague or incomplete information, as researchers have suggested [5], [6], [7], [21], [23].

Following the aforementioned, the following aspects are established:

q = proportion of the reference population that does not present the subject under study (1 -p).

The desired confidence level (Z). Indicates the degree of confidence that the true value of the parameter in the population will be found in the calculated sample. The absolute precision (d).

With a confidence level of 95 to 99%, then z= [1.895, 1.96], d= [0.05, 0.1] and p = [0.3,0.33], N=30. On the results obtained before, the sample has 10 and 29 subjects.

That is why a total of 25 students of the Dentistry course of the Autonomous Regional University of the Andes (UNIANDES) are selected for the study. The sample was randomly chosen, particularly through the raffle procedure, where all the dental students had the same selection possibilities. [24]

2.2 Classical methods and techniques used

For the investigation, a group of methods and techniques of a theoretical, empirical, and mathematical statistical nature were taken into account. Which will be explained below, in correspondence with the type to which it corresponds.

Theoretical methods

Analytical-synthetic: it allowed to carry out a study about the theoretical and methodological foundations that support the neutrosophic linguistic scale to identify the knowledge about natural and traditional medicine in dental students. It was used for the and specification of the processed information. It was helpful in interpreting the data obtained in this study.

Inductive-deductive: it made it possible to make a deep analysis of the bibliographic sources consulted and from them to make inferences and generalizations that were useful for the justification and foundation and interpretation of the data obtained, from which new logical conclusions are deduced.

Empirical methods

A *neutrosophic survey* will be used to identify the knowledge about natural and traditional medicine in dental students from the Autonomous Regional University of the Andes in Ecuador.

Statistical-mathematical methods

Descriptive statistics are used, within it the percentage calculation, which allows identifying the level of knowledge of the students who are part of the study sample.

2.3 Neutrosophic method

The flow of activities followed during the investigation is presented from a neutrosophic approach. Which has been structured in the ten fundamental methodological steps described below:

Step 1. Selection of the study sample

Step 2. Selection of methods and instruments

Step 3. Preparation of personnel involved in the investigation

Step 4. Selection of the implementation schedule

Step 5. Preparation of the implementation plan

Step 6. Implementation of methods and techniques

Step 7. Data collection

Step 8. Tabulation of the data

Step 9. Analysis and interpretation of the results

Step 10. Writing the final report

For the investigation, the so-called "Likert scales" are used. These are psychometric instruments where the respondent must indicate his agreement or disagreement on a statement or item, which is done through an ordered and one-dimensional scale. These instruments are usually recognized among the most used for measurement in Social and medical sciences, particularly in this case medical education [5], [8], [9].

In agreement with several authors knowledgeable about Neutrosophy [8], [9], these scales are used to represent inconsistent, imprecise and uncertain information from the real world, the membership of indeterminacy is represented independently, along with the membership of truth and falsity in the set of Neutrosophy as explained by Smarandache, [10] generalizing the concept of various sets such as the classical set, the fuzzy set and the paradoxical set, TA (x), IA (x) and FA (x) are functions of membership that can be real standard or nonstandard subsets.

In this way, it was not possible to apply it to real-world problems in science and engineering. Authors like [11], [12], [13], [14], proposed a single value neutrosophic set (SVNS), to overcome this. [25, 26, 27]

Let X be a universe of discourse, an SVNS A over X has the following form:

$$A = \{\langle x, u_a(x), r_a(x), v_a(x)\rangle : x \in X\}d$$

Where

$$u_a(x): X \to [0,1], r_a(x): X \to [0,1] \text{ and } v_a(x): X \to [0,1]$$

With

$$0 \leq u_a(x), r_a(x), v_a(x) \leq 3, \qquad \forall\, x \in X$$

The intervals $u_a(x), r_a(x)$ and $v_a(x)$ denote the true, indeterminate, and false memberships of x in A, respectively. In correspondence with the application of the aforementioned, the results are shown in Table 1.

Linguistic term	SVN numbers
Excellent (E)	(1,0,1)
Very good (VG)	(0.71,0.34,0.29)
Good (G)	(0.50,0.49,0.49)
Regular (R)	(0.40,0.75,0.85)
Bad (B)	(0,1,1)

Table 1. Linguistic terms of the Likert scale applied in the research.

Let A = (T, I, F) be a single-valued neutrosophic number, a score function S related to a single-valued neutrosophic value, based on the degree of truth membership, the degree of indeterminacy membership and the degree of falsehood membership is defined by: [15], [16], [18]

3 Results

This section shows the results of the three questions of the neutrosophic survey. The number of students who expressed indeterminacy in the response to each of the survey questions are also presented. The results obtained are explained below.

Question 1	Excellent	Very good	Good	Regular	Bad
How do you assess your	4 (16%)	3 (12%)	3 (12%)	6 (24%)	9 (36%)

knowledge about Natural and Traditional Medicine?					

Table 2. Results of question 1 of the student survey

When analyzing the results of question 1 of the survey, the terms with the highest values were the least indicated by the students. This shows that E was only marked by 4, for 16%, while VG was only marked by 3, for 12%, that of G coincided with the previous value. While most of the students are located in the values of R, 6 for 24% and B, 9 for 36%. Which denotes that most of the students of this research have a poor knowledge about natural and traditional medicine in dentistry.

Question 2	Excellent	Very good	Good	Regular	Wrong
How do you evaluate the use of natural and traditional medicine in dentistry?	9(36%)	7(28%)	3(12%)	3(12%)	3(12%)

Table 3. Results of question 2 of the student survey

Table 3 reflect the results of question 2 of the survey, where the majority of the students 9 of them for 36% selected the scale with the highest score, that is, E, while the other term most indicated by the students was VG with 7 for 28%. On the other hand, G was selected by 3, for 12%, equal to this value were the remaining terms (R and B), respectively.

Question 2	Excellent	Very good	Good	Regular	Wrong
How do you value natural and traditional medicine treatments in dentistry?	12 (48%)	8 (32%)	3(12%)	1(4%)	1(4%)

Table 4. Results of question 3 of the student survey

Table 4 shows the results of question 3 of the survey to university dental students. Where, the majority, 12 for 48%, determined that the treatments with natural and traditional medicine were E, on the other hand, 8 for 32% stated that it was VG. While, 3 for 12% said it was G, while only 1 for 4% selected R and the same amount selected B.

These results show that university students, despite having little knowledge about natural and traditional medicine, do value its use in different dental treatments very positively. Which denotes that actions must be carried out in order to enhance and knowledge of these in this subject. [17]

The survey applied to the students had a subsection that referred to arguing why they selected one of the two options. However, there was a group of students in each of the questions and linguistic terms that left that section blank and marked one of the options, this gave rise to the indeterminacy of why they marked that option.

Table 5 shows a summary of each of the students who showed indeterminacy in their arguments. Where in question 1 there were 8, distributed as shown in Table 5. On the other hand, in question 2 there were 9, while in question 3 there were only 5. This denotes the importance of Neutrosophy in the explanation of the results obtained in this studio.

Linguistic terms	Question 1	Question 2	Question 3
Excellent	1	-	1
Very good	-	-	1
Good	-	5	-
Regular	4	2	2
Bad	3	2	1
Total	8	9	5

Table 5. Number of students who showed indeterminacy as to why they selected one of the two options for each question according to the linguistic terms.

Conclusion

In accordance with the results of the study of the bibliographic sources, it was identified that there are few investigations that use a neutrosophic approach in the evaluation of the use of natural and traditional medicine in dentistry.

The results obtained in the research are valid because they are obtained with the use of scientific methods and show that university students have little knowledge about natural and traditional medicine. However, they recognize the importance that this has for an adequate treatment.

References

[1] B Zúñiga Monier, Caballero Orduño A. La medicina tradicional y natural y los ensayos clínicos: un reto de las ciencias médicas en el siglo XXI. MEDISAN [Internet]. Abr [citado 29/10/2018]; 20(4), 2016.

[2] E Quintana Mayet, Pantoja Fornés I, Pérez Tauriaux O, Rego Columbie I, Calunga
Calderón M. Efectividad del tratamiento acupuntural en pacientes con hipertensión arterial leve. MEDISAN 19(6) 2015.

[3] R González Rodríguez, Cardentey García J. Conocimiento sobre Medicina Natural y
Tradicional por residentes de Medicina General Integral. Rev Med Electrón, 38(5), 2016

[4] R Manchanda, Kau H, Singh D, Bhatia M. Scientific Framework of Homeopathy Evidence Based Homeopathy. Germany: Liga Medicorum Homoeopathica Internationalis; 2017.

[5] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018.

[6] F. Smarandache, M. A. Quiroz-Martínez, J. E. Ricardo, N. B. Hernández, y M. Y. Leyva Vázquez. «Application of neutrosophic offsets for digital image processing». Investigacion Operacional 41, no 5 603-11, 2020.

[7] M. Leyva, P. E. Del Pozo Franco, y A. J. P. Palacio. «Neutrosophic DEMATEL in the Analysis of the Causal Factors of Youth Violence». International Journal of Neutrosophic Science 18, no3, 199-207. https://doi.org/10.54216/IJNS.1803017, 2022.

[8] YM. Gordo Gómez, D M Ramírez Guerra, LA Zaldívar Castellanos, R. González Piña. Análisis del emprendimiento comunitario en las actividades físico-terapéuticas desde la Universidad. Empleo de una escala lingüística neutrosófica. Neutrosophic Computing and Machine Learning, Vol. 8, 2019.

[9] R. G. Ortega, M. Rodríguez, M. L. Vázquez, and J. E. Ricardo, "Pestel analysis based on neutrosophic cognitive maps and neutrosophic numbers for the sinos river basin management," Neutrosophic Sets and Systems, vol. 26, no. 1, pp. 16, 2019.

[10] F Smarandache, Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly, for Neutrosophic Over-/Under-/Off-Logic, Probability, and Statistics, 2016.

[11] R. M Carballo, Paronyan, H., Matos, M. A., & Santillán Molina, A. L. Neutrosofic statistics applied to demonstrate the importance of humanistic and higher education components in students of legal careers. Neutrosophic Sets and Systems, 26(1), 26, 2019.

[12] J. Estupiñán, Diego Fernando Coka Flores, Jorge Alfredo Eras Díaz, y Karina Pérez Teruel. «An Exploration of Wisdom of Crowds using Neutrosophic Cognitive Maps». Neutrosophic Sets and Systems 37 (1): 2, 2020.

[13] R Jansi, Mohana, K., & Smarandache, F. Correlation Measure for Pythagorean Neutrosophic Fuzzy Sets with T and F as Dependent Neutrosophic Components. Neutrosophic Sets and Systems, 30(1), 16, 2019.

[14] D. M. Ramírez Guerra, Y. M. Gordo Gómez, L. J. Cevallos Torres, F. G. Palacios Ortiz. Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment. International Journal of Neutrosophic Science (IJNS), Vol. 19, No. 01, PP. 389-402, 2022.

[15] F. Smarandache, A Unifying Field in Logics: Neutrosophic Logic. Philosophy, 1999.

[16] F. X. Poveda Paredes, K. J. Toctaquiza Cumbicos, & M. J. Goyes Baca. "Efectos adversos de la ivermectina en pacientes con Sars-Cov-2". Universidad y Sociedad, Vol. 14 Num. S2, pp- 479-487, 2022.

[17] S. A. Montecé Giler, & L. A. Montecé Giler. "Tipos de normas que regulan la sociedad". Universidad y Sociedad, Vol. 14 Num.S2, pp- 471-478, 2022.

[18] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación

superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021
[19] García, J. M. B., Ricardo, J. E., & Villalva, I. M. "Acciones didácticas para la autorrealización física integral de los estudiantes de carreras agropecuarias". Didasc@ lia: Didáctica y Educación, vol. 7 no. 2, pp 57-66, 2016.
[20] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[21] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[22] Ricardo, J. E., & Vázquez, I. R. S. "La educación sexual para padres de niños con retraso mental, una vía para su consolidación". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 4 no. 3, pp 137-144, 2019.
[23] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.
[24] von Feigenblatt, O. "Mediation for management: Dealing with Conflict in the Workplace". Innovaciones de Negocios, vol. 18 no. 35, pp 113-119, 2021.
[25] R. A. Vásquez Díaz, J. L. Acosta Espinoza & M. A. Checa Cabrera. "Power bi como herramienta de apoyo a la toma de decisiones". Universidad y Sociedad, vol. 14 no. S3, pp 195-207, 2022.
[26] O. X. Torres Merlo, M. S. Cuarán Guerrero & A. Y. Quintero Vivero. "La producción biodegradable como alternativa para reducir la contaminación por plástico en el cantón San Lorenzo". Universidad y Sociedad, vol. 14 no. S3, pp 188-194, 2022.
[27] W. M. Arias Collaguazo, C. W. Maldonado Gudiño, O. G. Arciniegas Paspuel & L. G. Castro Morales. "Factores de crecimiento en los depósitos bancarios del Ecuador y su análisis". Universidad y Sociedad, vol. 14 no. S3, pp 179-187, 2022.

Received: September 02, 2022. **Accepted:** October 25, 2022

NSS
Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Relevance of the Obstacles to the Achievement of Food Sovereignty in Ecuador, Analysis through the Neutrosophic Soft Set

Tannia Cristina Poveda Morales[1], Silvia Elizabeth Bonilla Veloz[2] and Diego Armando Freire Muñoz[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.tanniapoveda@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.silviabonilla@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.diegofreire@uniandes.edu.ec

Abstract. One of the elements addressed in the Sustainable Development Goals until 2030, is the achievement of food sovereignty. This important issue takes relevance in the debates at the level of states, among which is Ecuador, which recognizes it as a right to its citizens from its Magna Carta. Despite being a widely addressed topic and to which substantial resources are destined, obstacles persist in its implementation. Therefore, it is proposed as the objective of this investigation: the analysis of the relevance of obstacles to the achievement of food sovereignty in Ecuador through Neutrosophic Soft Sets. To meet the proposed objective, empirical methods such as the interview and a neutrosophic soft set model were used. As a result, it was obtained that from the four initial statements, only three were true and that their relevance in the subject addressed was given by the following hierarchy: first of all the need to guarantee vulnerable groups the right to healthy eating, second, the fact that the allocations of resources to peasant producers are scarce in order to increase food production in the area and finally, the insufficient legal framework to guarantee the right to food sovereignty of Ecuadorians, in correspondence with the international pronouncements and The Constitution.

Keywords: food sovereignty, neutrosophic soft set.

1 Introduction

Food sovereignty is the right of peoples, countries, or unions of states to define their agricultural and food policy, without dumping (too cheap agricultural and food imports) against third countries. In addition, it prioritizes a reform and participation of agrarian policies that support local agricultural production to feed the population; the right and access of peasants to use the soil to sow, access to credit, water, non-genetically modified seeds; the right of consumers to be able to decide what they want to eat; recognize farmers because they have a fundamental role in agricultural production and food [1].

With food security, not only access to food is required, but also the right to the means necessary for its production (mainly land, water, and seeds). Such redistribution of the means of production towards the peasantry is justified by its preponderant role in guaranteeing the right to food for all. It implies an ambiguous definition of the privileged productive subjects and how and where food should be produced and distributed.

The food sovereignty approach explicitly favors agroecological production, on a small and medium scale, through diversified and healthy agriculture, rooted in the territories, that offer quality and culturally appropriate food to local food systems, at the expense of long chains. This approach opposes, therefore, agro-industrial monocultures and the intensive use of chemical inputs, as well as, in general, the homologous logic of the corporate regime that subjects the production and consumption of food to the processes of accumulation of capital. The intention is to reduce the gap between producers and consumers and guarantee food quality linked not only to nutritional properties but also to the social and environmental impacts of production processes [2].

The production and export of food in Latin America contribute significantly to national economies, but it also creates dependency and brings economic, environmental, and social problems. Negative impacts on public health, the integrity of ecosystems, food quality, and in many cases, disrupt traditional rural livelihoods, by accelerating the indebtedness of thousands of farmers [3]. Despite innovations and technologies in a globalized economy, the current system of agriculture has failed to prevent widespread hunger and boost the well-being of some communities.

This is why Ecuador incorporates food sovereignty in its Constitutional Magna Carta as a fundamental right

of Ecuadorians in 2008 [4]. The government's efforts to comply with legal regulations and monitor all the established dimensions that took advantage of the international concept have become a challenge within its public policies [5]. However, they are not exempt from difficulties and obstacles to guarantee this right. Like any phenomenon that occurs in practical life, its analysis cannot be rigid, but must also consider the uncertainty in each fact.

In reality, there are many more situations that for various reasons introduce indeterminacy and uncertainty to the information, making it uncertain and not unique, but hesitant or alternative. Disciplines such as image processing, artificial intelligence, applied physics, social sciences, and topology also suffer from the same problems [6]. Numerous applications can be made from neutrosophy to real life and specifically, the soft set, among which are the legal and social sciences.

The classic soft set is based on a certain function (whose values are certain and unique), they were heard of in the investigations carried out by Professor Molodtsov in 1999 [7], then the studies were extended, giving way to the Neutrosophic Soft Set of 2013. The first are deterministic since the set of parameters on which the evaluations are based are deterministic, although they generalize the definition of fuzzy sets. These investigations arise because there is not always total certainty in the evidence that is handled, there may be several points of view that sometimes may even be contrary, lack of information or that is incomplete due to various causes, the lack of witnesses, the hesitant opinion of one of the factors involved in the process, among other reasons [8], [19].

Neutrosophy arises to deal with decision-making problems that involve human knowledge, which frequently has uncertainty, indeterminacy, and inconsistency in information, this is a tool to represent those inconsistencies and contradictions that undoubtedly exist in the processing of evidence within the social sciences and everyday life [9]. Neutrosophic sets are characterized by a truth membership function (t), an indeterminacy membership function (i), and a falsehood membership function (f) independently, which lie within the real unit interval [−0, 1+] standard or not standard. Neutrosophic Sets (NS) proposed by Smarandache are a powerful mathematical tool to handle incomplete, indeterminate, and inconsistent information in the real world [10].

When triads of truth values are assigned to the possible values of the obtained sets, meaning membership, non-membership, and indeterminacy, soft set theory is combined with that of neutrosophic sets to obtain greater precision in the results [11], [17]. This situation can be modeled by operators that have some degree of indeterminacy due to the imprecision that exists in the world. They are a generalization of fuzzy set theory, intuitionistic fuzzy sets, and interval-valued intuitionistic fuzzy sets.

Due to the above, the objective of this research is to analyze the relevance of the obstacles to the achievement of food sovereignty in Ecuador through the neutrosophic soft set.

2 Materials and methods

2.1 Empirical methods

Interviews: will be applied to the sample made up of selected experts. Structured interviews were prepared aimed at obtaining information on the real problem, to obtain valid conclusions and support the results.

Observation: to check how the phenomenon under investigation behaves.

Selection of experts: the competencies of potential experts are checked. For this, a competency validation survey is applied where the degree of knowledge that said potential expert has about the subject and its degree of influence on each of the sources of argumentation is carried out through self-assessments, on an ascending scale of 1 to 10 [12]. The processing of the form was based on the calculation of the rating factor of the experts through the following mathematical expression:

$$K = ((FA + GC)) /= [((SI + EP + IR + FB)) / 4 + GC]/2 \quad (1)$$

Where:

Si= intuition

PS=Practical Experience	IR= Research conducted	FB=Consultation of bibliography	CG: degree of knowledge (1-10)

K value	Classification
8-10	Tall
5-7	Medium
1-4	Bass

2.2 Neutrosophic Soft Set

Let U, be a universe of situations, H a non-empty subset of U, and $P(H)$ the power function of H. Let a be an attribute and A a set of these attribute values.

A function $F: A \to P(H)$ is called an indeterminate or soft function if:$F: A \to P(H)$

i. The set A has some indeterminacy;

ii. or $P(H)$ has some indeterminacy;

iii. or there exists at least one attribute value $v \in A$, such that F(v) = indeterminate (unclear, uncertain, or not unique);

iv. or two or the three previous situations.

The neutrosophic soft set is defined as the soft set where F (perhaps) or F (indeterminate), etc, is roughly equivalent to F (yes), F (no), F (true), or F (false), associated with a triad of values (α, β, γ), where $(\alpha, \beta, \gamma) \in [0,1]^3$ are the degrees of truth, indeterminacy, and falsehood, respectively [13, 14].

From the previously discussed, the following neutrosophic triplet can be formed [13], [18]:

i. (Classical) function, which is a well-defined (inner-defined) function for all elements in its domain of definition, or (T, I, F) = (1,0,0).

ii. Neutrofunction (or neutrosophic function), is a function that is partially well defined (degree of truth T), partially indeterminate (degree of indeterminacy I), and partially externally defined (degree of falsehood F) in its domain of definition, where (T, I, F)$\in$ {(1,0,0), (0,0,1)}.

Definition 1 [13]: let U be a universe of situations, H is a non-empty subset of U, with P (H) the power set of H, and an attribute, with its set of attribute values, is denoted by A. Then the pair (F, H), where f $F: A \to P(H)$, is called classic soft set on H.

Definition 2 [13]: If the function $F: A \to P(H)$, where for each $x \in A, f(x) \in P(H)$ and $f(x)$ is true and unique, it is called a determinate (classical) function.

2.3 Model based on Neutrosophic Sof Sets

Starting from a group of statements or sentences that will be denoted by $A = \{a_1, a_2, \cdots, a_k\}$, which must be classified or evaluated by the specialists that belong to the group of experts chosen for the study $E = \{e_1, e, \cdots, e_l\}$. The set of parameters to be measured is given by C={Yes, No}, where "yes" means that for the expert, the statement is positive, while "no" means the opposite. [15], [20], [21], [22], [23]

The algorithm to follow is:

1. A group of statements is compiled whose veracity and relevance in the legal context are to be determined. These will be denoted by $A = \{a_1, a_2, \cdots, a_k\}$.

A group of experts or specialists are convened, who must issue a criterion regarding the veracity or relevance of the statements described. This is known as $E = \{e_1, e, \cdots, e_l\}$ set.

2. The expert (e_j) is asked to give his opinion on the statement a_i about truthfulness and relevance Expert (e_j) is asked to rate the truth of the statement and its relevance on a scale of 0 to 100. This value is called.α_{ij}

2.2. Expert (e_j) is asked to give an evaluation of the falsehood and irrelevance of the statement on a scale of 0 to 100. This value is called γ_{ij}

2.3. Expert (e_j) is asked to assess the uncertainty and irrelevance of the situation on a scale of 0 to 100. This value is called β_{ij}

As a result, you get the following triad:

$$R\_ij = \langle \alpha\_ij/100, \beta\_ij/100, \gamma\_ij/100 \rangle \quad (2)$$

This is the triad of truth values between 0 and 1, to evaluate the degrees of truth, indeterminacy, and falsehood, respectively, of the relevance of the i-th test according to the j-th expert.

3. The Soft Set is formed by $F: A \to P(H)$, where $A = \{yes, no\}$, as follows:

$$F(yes) = \{(a_i, e_j, R_{ij}), where\ R_{ij} \neq \langle 0, \tau, 1\rangle, \tau \geq 0\}, \quad (3)$$

while:

$$F(no) = \{(a_i, e_j, R_{ij}), where\ R_{ij} \neq \langle 1,0,0\rangle\} \quad (4)$$

4. The final results for tests or evidence are obtained from:

$$G(yes) = \{(a_i, \wedge_j R_{ij}): j \in \{1,2,\cdots,l\}\ such\ that\ (a_i, e_j, R_{ij}) \in F(yes)\} \quad (5)$$

Where, (6) $[\![\wedge_j R]\!]_{ij} = \langle \min_j \{\alpha_{ij}/100\}, \max_j \{\beta_{ij}/100\}, \max_j \{\gamma_{ij}/100\}\rangle$

$$G(no) = \{(a_i, \wedge_j NOT(R_{ij})): j \in \{1,2,\cdots,l\}\ such\ that\ (a_i, e_j, R_{ij}) \in F(no)\} \quad (7)$$

Where, $[\![NOT(R)]\!]_{ij} = \langle \gamma_{ij}/100, \beta_{ij}/100, \alpha_{ij}/100\rangle$

5. For each proof or evidence s_i, select between $G(yes)$ and $G(no)$ the triad that meets the following requirements.

   5.1 If a_i is in $G(yes)$ and is not in $G(no)$, then this statement is determined to be true or relevant, with a truth value determined by $\bar{R}_i = \wedge_j R_{ij}$.

   5.2 If a_i is in $G(no)$ and is not in $G(yes)$, then this statement is determined to be true or relevant, with a truth value determined by $\tilde{R}_i = \wedge_j NOT(R_{ij})$.

   5.3 If it is in both sets, the following criteria are followed: a_i

A single value $\bar{V}_i = (2 + \bar{R}_{i1} - \bar{R}_{i2} - \bar{R}_{i3})/3$ is calculated, where $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3}\rangle$, while $\bar{F}_i = (2 + \bar{R}_{i1} - \bar{R}_{i2} - \bar{R}_{i3})/3$, where $\tilde{R}_i = \langle \tilde{R}_{i1}, \tilde{R}_{i2}, \tilde{R}_{i3}\rangle$.

   5.3.1 If $\bar{V}_i > \bar{F}_i$ then the i-th statement is relevant with a truth value of $\bar{R}_i$.

   5.3.2 If $\bar{V}_i < \bar{F}_i$ then the i-th test is not relevant with a value of truth $\tilde{R}_i$.

   5.3.4 If $\bar{V}_i = \bar{F}_i$ then it is determined that the i-th test is not relevant enough with a truth value of $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3}\rangle$.

6. The statements that were classified as relevant are issued, sorted from highest to lowest, where $e_m \succ e_n$ if and only if $\bar{V}_m > \bar{V}_n$.

3 Application

To identify the main problems in relation to compliance with the legal framework that supports food sovereignty policies in Ecuador and its influence on its scope, interviews were applied to 25 jurists from the canton of Santo Domingo, province Santo Domingo de Los Tsáchilas. To carry out the study, 5 experts on the subject were chosen, who obtained K scores between 8 and 10, which is considered high.

An interview guide was designed as shown below:

Taking into account what you know about food sovereignty, analyze the following statements and issue a score concerning their veracity, in triads of values from 0 to 100, where the first value represents the veracity of the statement, the second the indeterminacy, and the last denial.

1. There is a need to guarantee vulnerable groups the right to healthy food.
2. Insufficient legal framework to guarantee the right to food sovereignty of Ecuadorians, in correspondence with international pronouncements and the Constitution of the nation.
3. Intermediaries are the main ones responsible for price inflation
4. Few resource allocations to peasant producers in order to increase food production in the area.

The 5 experts consulted $(e_1, e_2, e_3, e_4, e_5)$ issue their criteria regarding the statements (a_1, a_2, a_3, a_4), in triads of values from 0 to 100, to standardize truthfulness, negative and indeterminate responses, where the first score represents the certainty or relevance of the statement, the second value indicates doubt or indeterminacy regarding the statement described and the third value indicates the falsehood of that statement. This algorithm will be applied twice to determine the veracity and the degree of relevance. [16, 24, 25, 26]

Application to determine the veracity of statements.

The results regarding veracity are shown in Table 1.

Expert/Assertion	a_1	a_2	a_3	a_4
e_1	⟨64,15,21⟩	⟨89,10,10⟩	⟨35,10,60⟩	⟨56,10,13⟩
e_2	⟨76,10,20⟩	⟨58,20,30⟩	⟨38,0,52⟩	⟨72,8,20⟩
e_3	⟨85,0,20⟩	⟨79,0,20⟩	⟨36,0,45⟩	⟨82,12,15⟩
e_4	⟨68,4,18⟩	⟨72,15,18⟩	⟨45,0,58⟩	⟨54,15,22⟩
e_5	⟨81,8,16⟩	⟨90,12,26⟩	⟨42,0,36⟩	⟨57,9,18⟩

Table 1: Result of the evaluation of the veracity of the statement according to the selected experts.

The above results are divided by 100 to bring them to a [0, 1] scale which is more common in neutrosophic theories.

Expert/Assertion	a_1	a_2	a_3	a_4
e_1	⟨0.64,0.15,0.21⟩	⟨0.89,0.1,0.1⟩	⟨0.35,0.1,0.6⟩	⟨0.56,0.1,0.13⟩
e_2	⟨0.76,0.1,0.2⟩	⟨0.58,0.2,0.3⟩	⟨0.38,0,0.52⟩	⟨0.72,0.08,0.2⟩
e_3	⟨0.85,0,0.2⟩	⟨0.79,0,0.2⟩	⟨0.36,0,0.45⟩	⟨0.82,0.12,0.15⟩
e_4	⟨0.68,0.04,0.18⟩	⟨0.72,0.2,0.18⟩	⟨0.45,0,0.58⟩	⟨0.54,0.15,0.22⟩
e_5	⟨0.81,0.08,0.16⟩	⟨0.9,0.1,0.26⟩	⟨0.42,0,0.36⟩	⟨0.57,0.09,0.18⟩

Table 2: Result of the evaluation of the veracity of the statement according to the experts, expressed in the form of neutrosophic numbers.

Soft sets are defined as:

$$F(yes) = \left\{ \begin{array}{c} (e_1, a_1, \langle 0.64,0.15,0.21\rangle), (e_1, a_2, \langle 0.89,0.1,0.1\rangle), (e_1, a_3, \langle 0.35,0.1,0.6\rangle), (e_1, a_4, \langle 0.56,0.1,0.13\rangle), \\ (e_2, a_1, \langle 0.76,0.1,0.2\rangle), (e_2, a_2, \langle 0.58,0.2,0.3\rangle), (e_2, a_3, \langle 0.38,0,0.52\rangle), \\ (e_2, a_4, \langle 0.72,0.08,0.2\rangle), (e_3, a_1, \langle 0.85,0,0.2\rangle), (e_3, a_2, \langle 0.79,0,0.2\rangle), \\ (e_3, a_3, \langle 0.36,0,0.45\rangle), (e_3, a_4, \langle 0.82,0.12,0.15\rangle), (e_4, a_1, \langle 0.68,0.04,0.18\rangle), \\ (e_4, a_2, \langle 0.72,0.2,0.18\rangle), (e_4, a_3, \langle 0.45,0,0.58\rangle), (e_4, a_4, \langle 0.54,0.15,0.22\rangle) \\ (e_5, a_1, \langle 0.81,0.08,0.16\rangle), (e_5, a_2, \langle 0.9,0.1,0.26\rangle), (e_5, a_3, \langle 0.42,0,0.36\rangle), (e_5, a_4, \langle 0.57,0.09,0.18\rangle) \end{array} \right\}$$

$$\mathrm{F}(no) = \left\{ \begin{array}{c} (e_1, a_1, \langle 0.64,0.15,0.21\rangle), (e_1, a_2, \langle 0.89,0.1,0.1\rangle), (e_1, a_3, \langle 0.35,0.1,0.6\rangle), (e_1, a_4, \langle 0.56,0.1,0.13\rangle), \\ (e_2, a_1, \langle 0.76,0.1,0.2\rangle), (e_2, a_2, \langle 0.58,0.2,0.3\rangle), (e_2, a_3, \langle 0.38,0,0.52\rangle), \\ (e_2, a_4, \langle 0.72,0.08,0.2\rangle), (e_3, a_1, \langle 0.85,0,0.2\rangle), (e_3, a_2, \langle 0.79,0,0.2\rangle), \\ (e_3, a_3, \langle 0.36,0,0.45\rangle), (e_3, a_4, \langle 0.82,0.12,0.15\rangle), (e_4, a_1, \langle 0.68,0.04,0.18\rangle), \\ (e_4, a_2, \langle 0.72,0.2,0.18\rangle), (e_4, a_3, \langle 0.45,0,0.58\rangle), (e_4, a_4, \langle 0.54,0.15,0.22\rangle) \\ (e_5, a_1, \langle 0.81,0.08,0.16\rangle), (e_5, a_2, \langle 0.9,0.1,0.26\rangle), (e_5, a_3, \langle 0.42,0,0.36\rangle), (e_5, a_4, \langle 0.57,0.09,0.18\rangle) \end{array} \right\}$$

$$G(yes) = \{(a_1, \langle 0.64,0.15,0.21\rangle), (a_2, \langle 0.58,0.20,0.30\rangle), (a_3, \langle 0.35,0.10,0.60\rangle), (a_4, \langle 0.54,0.15,0.22\rangle)\}$$

$$G(no) = \{(a_1, \langle 0.21,0.15,0.64\rangle), (a_2, \langle 0.30,0.20,0.58\rangle), (a_3, \langle 0.60,0.10,0.35\rangle), (a_4, \langle 0.22,0.15,0.54\rangle)\}$$

From $G(yes)$ and $G(no)$ it is concluded that a_1 is true with a truth value of $\langle 0.64,0.15,0.21\rangle$, a_2 is true with a truth value of $\langle 0.58,0.20,0.30\rangle$, the applied model yields that a_3 is not true, with a denial value of $\langle 0.60,0.10,0.35\rangle$ of and finally a_4 is also true with a truth value of $\langle 0.22,0.15,0.54\rangle$.

This decision is made since, $\bar{V}_1 = 0.8 > \bar{F}_1 = 0.5$; $\bar{V}_2 = 0.7 > \bar{F}_2 = 0.5$; $\bar{V}_3 = 0.6 < \bar{F}_3 = 0.7$; $\bar{V}_4 = 0.7 > \bar{F}_4 = 0.5$.

From the above, it is inferred that the statements a_1, a_2 and a_4 are true, while statement 3 is not.

Therefore, the relevance of the 3 statements that were identified as true by the experts will be analyzed:

1. There is a need to guarantee vulnerable groups the right to healthy food.
2. Insufficient legal framework to guarantee the right to food sovereignty of Ecuadorians, in correspondence with international pronouncements and the Constitution of the nation.
4. Few resource allocations to peasant producers in order to increase food production in the area.

Application to determine the relevance of claims.

The results regarding relevance are shown in Table 3.

Expert/Assertion	a_1	a_2	a_4
e_1	⟨84,10,12⟩	⟨56,13,15⟩	⟨68,24,16⟩
e_2	⟨72,12,20⟩	⟨60,11,17⟩	⟨76,10,19⟩
e_3	⟨87,6,18⟩	⟨61,15,10⟩	⟨72,3,15⟩
e_4	⟨85,10,16⟩	⟨57,12,16⟩	⟨70,23,21⟩
e_5	⟨77,9,19⟩	⟨55,22,25⟩	⟨69,12,18⟩

Table 3: Result of the evaluation of the relevance of the statements according to the experts.

The above results are divided by 100 to bring them to a [0, 1] scale which is more common in neutrosophic theories.

Expert/Assertion	a_1	a_2	a_4
e_1	⟨0.84,0.10,0.12⟩	⟨0.56,0.13,0.15⟩	⟨0.68,0.24,0.16⟩
e_2	⟨0.72,0.12,0.20⟩	⟨0.60,0.11,0.17⟩	⟨0.76,0.10,0.19⟩
e_3	⟨0.87,0.06,0.18⟩	⟨0.61,0.15,0.10⟩	⟨0.72,0.03,0.15⟩
e_4	⟨0.85,0.10,0.16⟩	⟨0.57,0.12,0.16⟩	⟨0.70,0.23,0.21⟩
e_5	⟨0.77,0.09,0.19⟩	⟨0.55,0.22,0.25⟩	⟨0.69,0.12,0.18⟩

Table 4: Result of the evaluation of the relevance of the statements according to the experts, expressed in the form of neutrosophic numbers.

Soft sets are defined as:

$$F(yes) = \left\{ \begin{array}{c} (e_1, a_1, \langle 0.84,0.10,0.12\rangle), (e_1, a_2, \langle 0.56,0.13,0.15\rangle), (e_1, a_4, \langle 0.68,0.24,0.16\rangle), \\ (e_2, a_1, \langle 0.72,0.12,0.20\rangle), (e_2, a_2, \langle 0.60,0.11,0.17\rangle), , \\ (e_2, a_4, \langle 0.76,0.10,0.19\rangle), (e_3, a_1, \langle 0.87,0.06,0.18\rangle), (e_3, a_2, \langle 0.61,0.15,0.10\rangle), \\ (e_3, a_4, \langle 0.72,0.03,0.15\rangle), (e_4, a_1, \langle 0.85,0.10,0.16\rangle), \\ (e_4, a_2, \langle 0.57,0.12,0.16\rangle), (e_4, a_4, \langle 0.70,0.23,0.21\rangle) \\ (e_5, a_1, \langle 0.77,0.09,0.19\rangle), (e_5, a_2, \langle 0.55,0.22,0.25\rangle), (e_5, a_4, \langle 0.69,0.12,0.18\rangle) \end{array} \right\}$$

$$F(No) = \left\{ \begin{array}{c} (e_1, a_1, \langle 0.84,0.10,0.12\rangle), (e_1, a_2, \langle 0.56,0.13,0.15\rangle), (e_1, a_4, \langle 0.68,0.24,0.16\rangle), \\ (e_2, a_1, \langle 0.72,0.12,0.20\rangle), (e_2, a_2, \langle 0.60,0.11,0.17\rangle), , \\ (e_2, a_4, \langle 0.76,0.10,0.19\rangle), (e_3, a_1, \langle 0.87,0.06,0.18\rangle), (e_3, a_2, \langle 0.61,0.15,0.10\rangle), \\ (e_3, a_4, \langle 0.72,0.03,0.15\rangle), (e_4, a_1, \langle 0.85,0.10,0.16\rangle), \\ (e_4, a_2, \langle 0.57,0.12,0.16\rangle), (e_4, a_4, \langle 0.70,0.23,0.21\rangle) \\ (e_5, a_1, \langle 0.77,0.09,0.19\rangle), (e_5, a_2, \langle 0.55,0.22,0.25\rangle), (e_5, a_4, \langle 0.69,0.12,0.18\rangle) \end{array} \right\}$$

$G(yes) = \{(a_1, \langle 0.72,0.12,0.20\rangle), (a_2, \langle 0.55,0.22,0.25\rangle), (a_3, \langle 0.68,0.24,0.16\rangle)\}$

$G(no) = \{(a_1, \langle 0.20,0.12,0.72\rangle), (a_2, \langle 0.25,0.22,0.55\rangle), (a_3, \langle 0.16,0.24,0.68\rangle)\}$

From $G(yes)$ and $G(no)$ it is concluded that a_1 is relevant with a truth value of ⟨0.72,0.12,0.20⟩, a_2 is relevant with a truth value of ⟨0.55,0.22,0.25⟩, and finally, a_3 is also relevant with a truth value of $\langle 0.16,0.24,0.68\rangle$.

This decision is made since, $\bar{V}_1 = 0.80 > \bar{F}_1 = 0.45$; $\bar{V}_2 = 0.69 > \bar{F}_2 = 0.49$; $\bar{V}_3 = 0.76 > \bar{F}_3 = 0.41$.

The order of relevance of the statements described is as follows: $a_1 \succ a_3 \succ a_2$, where all are relevant or important according to the results obtained.

Finally, the order of relevance of the statements described is as follows:

1. a_1: There is a need to guarantee vulnerable groups the right to healthy food.

2. a_4: Few resource allocations to peasant producers in order to increase food production in the area.
3. a_2: Insufficient legal framework that guarantees the right to food sovereignty of Ecuadorians, in correspondence with international pronouncements and the Constitution of the nation.

Conclusions

The processing of the information through a Neutrosophic Soft Set model allowed knowing which of the statements analyzed were true and which should be left out of the study. In this way, one of the statements analyzed was discarded and the rest were prioritized, leaving in the first place the need to guarantee vulnerable groups the right to healthy food, in second place, the fact that resource allocations to peasant producers are scarce in order to increase food production in the area and lastly the insufficient legal framework that guarantees the right to food sovereignty of Ecuadorians, in correspondence with international pronouncements and the Constitution of the nation.

References

[1] O. V. Cordero-Ahiman. (2022) Ley Orgánica del Régimen de la Soberanía Alimentaria de Ecuador. *Revista chilena de nutrición*. 34-38.

[2] M. Tilzey, "Capitalism, imperialism, nationalism: agrarian dynamics and resistance as radical food sovereignty," *Canadian Journal of Development Studies/Revue canadienne d'études du développement,* vol. 41, no. 3, pp. 381-398, 2020.

[3] I. Giunta and J. D. González, "Crecimiento económico inclusivo y sostenible en la Agenda 2030: un análisis crítico desde la perspectiva de la soberanía alimentaria y los derechos de la naturaleza," *Revista Iberoamericana de Estudios de Desarrollo= Iberoamerican Journal of Development Studies,* vol. 9, no. 1, pp. 146-176, 2020.

[4] A. Vergara-Romero, A. Menor Campos, O. Arencibia Montero, and J. A. Jimber del Río. (2022) Soberanía alimentaria en Ecuador: descripción y análisis bibliométrico. *Revista Venezolana de Gerencia*. 498-510.

[5] R. Merino, "The Geopolitics of Food Security and Food Sovereignty in Latin America: Harmonizing Competing Visions or Reinforcing Extractive Agriculture?," *Geopolitics,* vol. 27, no. 3, pp. 898-920, 2022.

[6] M. Khan, L. H. Son, M. Ali, H. T. M. Chau, N. T. N. Na, and F. Smarandache, "Systematic review of decision making algorithms in extended neutrosophic sets," *Symmetry,* vol. 10, no. 8, p. 314, 2018.

[7] D. Molodtsov, "Soft set theory—first results," *Computers & mathematics with applications,* vol. 37, no. 4-5, pp. 19-31, 1999.

[8] M. Abu Qamar and N. Hassan, "An approach toward a Q-neutrosophic soft set and its application in decision making," *Symmetry,* vol. 11, no. 2, p. 139, 2019.

[9] N. El-Hefenawy, M. A. Metwally, Z. M. Ahmed, and I. M. El-Henawy, "A review on the applications of neutrosophic sets," *Journal of Computational and Theoretical Nanoscience,* vol. 13, no. 1, pp. 936-944, 2016.

[10] I. Deli, "Interval-valued neutrosophic soft sets and its decision making," *International Journal of Machine Learning and Cybernetics,* vol. 8, no. 2, pp. 665-676, 2017.

[11] M. I. Ali, F. Feng, X. Liu, W. K. Min, and M. Shabir, "On some new operations in soft set theory," *Computers & Mathematics with Applications,* vol. 57, no. 9, pp. 1547-1553, 2009.

[12] S. Mauksch, A. Heiko, and T. J. Gordon, "Who is an expert for foresight? A review of identification methods," *Technological Forecasting and Social Change,* vol. 154, p. 119982, 2020.

[13] F. Smarandache, "Introduction to the IndetermSoft Set and IndetermHyperSoft Set," *Neutrosophic Sets and Systems,* vol. 50, no. 1, p. 38, 2022.

[14] F. G. Naranjo Armijo, L. H. Carrión Hurtado, & F. G. Bosmediano Andrade. "Gestión administrativa en las pymes del sector comercial en la ciudad de Santo Domingo en Ecuador". Universidad y Sociedad, vol. 14 no.3, pp 504-513, 2022.

[15] B. R. Pinda Guanolema. "Análisis de aporte a reactivación económica pot-covid-19 del sector agropecuario en provincia de Chimborazo, Ecuador". Universidad y Sociedad, vol. 14 no.3, pp 493-503, 2022.

[16] W. V. Culque Toapanta, J. D. R. Gavilanes Palacios, A. M. Tiban Chito, & L. A. De la Torre. "Aplicación web–móvil para la gestión de productores agropecuarios del gobierno autónomo descentralizado del cantón mocha". Universidad y Sociedad, vol. 14 no.3, pp 487-492, 2022.

[17] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.

[18] González, I. A., Fernández, A. J. R., & Ricardo, J. E. "Violación del derecho a la salud: caso Albán Cornejo Vs Ecuador". Universidad Y Sociedad, vol. 13 no. S2, pp 60-65, 2021.

[19] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.

[20] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.

[21] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[22] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[23] von Feigenblatt, O. F. "Education, culture, and underdevelopment: Haiti's tragic failure". Universidad y Sociedad, vol. 14 no. 3, pp 604-611, 2022.

[24] K. E. Carrión León, M. A. Torres Villamarín, J. C. Arandia Zambrano & E. E. Pino Andrade. "Los derechos laborales de la clase obrera al someterlos a las regulaciones de la LOSEP en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 350-358, 2022.

[25] G. N. Solis Ana Luisa, J. R. Santillán Andrade, P. A. Centeno Maldonado & R. E. Chuga Quemac. "El trabajo infantil frente al interés superior del niño. Caso de estudio Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 342-349, 2022.

[26] I. E. Albuja Lalangui, L. V. Rosillo Abarca, L. R. Ayala Ayala & I. F. Barcos Arias. "Estudio de la violencia intrafamiliar psicológica contra el hombre en el cantón de Santo Domingo, Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 333-341, 2022.

Received: September 03, 2022. **Accepted:** October 25, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of Nutritional Orientation in University Students

María Gabriela Balarezo García[1], Andrés Eduardo Gallegos Cobo[2] and Miguel Eduardo Ramos Argilagos[3]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.mariabalarezo@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.andresgallegos@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.miguelramos@uniandes.edu.ec

Abstract. In the present study, Neutrosophy is used for the analysis of the nutritional orientation of university students. Since this approach is the least treated in the specialized scientific literature, the research arises because of the potential of Neutrosophy in the evaluation of this topic is little used. The objective of the research is to carry out a neutrosophic analysis of nutritional orientation in university students. For this purpose, methods, and techniques from sciences in general, and Neutrosophy, in particular, were used. Theoretical, empirical, and mathematical-statistical methods and techniques were also used. After applying these instruments, the results obtained denote little knowledge of the students about nutritional orientation. Which is the reason that leaves open future lines of research on this topic.

Keywords: neutrosophic analysis, neutrosophic statistics, neutrosophic chart, nutritional orientation.

1 Introduction

Nutrition is a key factor in maintaining and promoting human health and, therefore, malnutrition is both a cause and a consequence of health problems, so its identification and treatment can prevent complications or relapses in underlying pathologies, as well as accelerate recovery. In addition, to maintain an adequate quality of life [1], [2].

Since the 1990s, the School of Nutrition of the University of Costa Rica (UCR) has been designing nutrition education methods that have been evolving. In 1996, Anne Chinnock and Indira deBeausset, based on the principles of constructivist education, proposed an educational methodology for nutritionists; this evolved and began to be called Interactive Nutrition Education because it is based on participation and dialogue with people collaborating in groups to learn.

Enteral nutrition (EN) is understood as that nutrition support care in which a liquid feeding formula is administered directly into the gastrointestinal (GI) tract to supplement or provide all caloric requirements to the individual [3], [4], [18].

In correspondence with the postulates stated above, it is evident that an adequate nutritional orientation is in favor of a healthy lifestyle in different population groups. However, it is also important for young people, since this age group is mostly attending university. A reason that demands a significant energy expenditure, so it is required that university students know this subject.

Based on the above criteria and in order to corroborate them, a diagnosis was made on students of the medical school of the Regional Autonomous University of the Andes (UNIANDES), in Ecuador, with the application of scientific observation. A group of limitations were identified and are summarized as follows:

- ✓ Little use of the potential of Neutrosophy in the evaluation of knowledge about nutritional orientation in undergraduate medical students.
- ✓ Limited use of neutrosophic models for the assessment of nutritional counseling knowledge in undergraduate medical students

Based on the above arguments, the following research problem is identified: insufficient use of neutrosophic methods and techniques limits the evaluation of knowledge on nutritional orientation in university students of medicine at UNIANDES Ecuador.

Therefore, the following research objective is formulated: to carry out a neutrosophic analysis of the nutritional

orientation of university students in the medical school at UNIANDES Ecuador.

2 Methodology

2.1 Subjects under study

A neutrosophic sample is a chosen subset of a population, a subset that contains some indeterminacy: either with respect to several of its individuals (who may not belong to the population we are studying or may only partially belong to it) or with respect to the subset as a whole. While classical samples provide precise information, neutrosophic samples provide vague or incomplete information [5].

Following this postulate of the creator of Neutrosophy, the calculation of the sample under study is carried out. For this purpose, we follow the suggestions of authors such as [6, 19, 20, 23], who propose to do it as it was done in the present research.

The starting point is to identify that p = approximate proportion of the phenomenon under study in the reference population, q = proportion of the reference population that does not present the phenomenon under study (1 -p). The desired confidence level (Z), indicates the degree of confidence that the true value of the parameter in the population will be found in the calculated sample. The absolute precision (d). It is the desired width of the confidence interval on both sides of the true value of the difference between the two proportions (in percentage points). N is the size of the population. Criteria shared from [7], [8].

In this case a confidence level between 90 and 95% is desired, z= [1.645, 1.96], d= [0.05, 0.0] and p = [0.4, 0.41], N=41. The result we call the neutrosophic sample n= [10.1, 30.6] indicates that the sample should be between 10 and 31 individuals.

For this reason, 18 university students from the medical school of the Regional Autonomous University of the Andes, in Ecuador, were chosen for this research. They were randomly selected, using the token procedure as indicated by authors such as [9], [10], [11], [17], [21].

The sample has an average age of 25.8 years, of which 10 are female and 8 are male. All of them have already completed and passed the third year of their degree and signed the informed consent form to participate in the study.

2.2 Instruments used

During the research process, methods and techniques from both general and neutrosophic sciences were used. Among the former are the theoretical ones such as the analytical-synthetic and the inductive-deductive. Both were useful for the work with the bibliographic sources and to make inferences from these with the results of the present research. Among the empirical ones, there is the survey and observation, the former was used to collect data from the students regarding the research topic, and the latter to identify the research problem in a facto-perceptual way.

On the other hand, statistical and mathematical methods were used, particularly descriptive statistics and within this the frequency distribution. Within these, the neutrosophic measures of central tendency were used, such as the mean. In addition, neutrosophic graphs were used to illustrate the results obtained. [24], [25], [26]

2.3 Neutrosophic method

For the research, the following neutrosophic model is followed, which serves as a guide for the realization of the scientific research:

Step 1. Identification of the problem to be investigated

Step 2. Selection of the main data collection technique

Step 3. Preparation of the personnel who will implement the methods and techniques.

Step 4. Selection of the study sample

Step 5. Selection of application schedule

Step 5. Application of the instruments

Step 6. Neutrosophication of the data

Step 7. Analysis and interpretation of results.

3 Results

In this section, the results obtained in the research are presented, where a frequency distribution analysis is carried out first, and then descriptive neutrosophic statistics are applied to determine the mean number of students who stated that they knew about adequate nutritional orientation.

Table 1 shows the results of the four questions of the survey applied to the students. These will be analyzed individually below for a better understanding of the analysis.

Questions	"Yes" Answers	Percentage of "Yes" Answers	"No" Answers	Percentage of "No" Answers
1	5	27,7	13	72,3
2	7	38,8	11	61,2
3	4	22,3	14	77,7
4	3	16,6	15	83,4

Table 1: Results of the student survey.

Results of question 1. General nutrition knowledge for young students.

As shown in Table 1, there is a minority group of students who stated that they had general knowledge about nutrition for young students. This was reflected in the fact that 5 of them (27.7%) selected this option. However, it is noteworthy that the majority of them, 13 (72.3%), stated that they did not. This shows that the sample under study has little knowledge about this question.

Results of question 2. Do you know the number of nutrients that a university student of your specialty should consume?

Only 7 students (38.8%) stated that they knew the number of nutrients that a university student of their specialty should consume. Most of these students reported the opposite (11 for 61.2%), which shows that the students do not have much knowledge about this, which makes them a risk factor group for obesity.

Results of question 3. Have you received any type of nutritional orientation?

Same as with the previous questions, only a minority of students are aware of the content of the question. This is shown by the fact that only 4 students (38.8%). While the option was not the most indicated by the students, as 14 for 61.2% indicated so. This leaves the line open for future research on the preparation of students in this content.

Results of question 4. Do you know some of the ways to calculate the energy expenditure of a university student?

Similarly, only a minority of students stated that they were familiar with some of the ways of calculating the energy expenditure of a university student, in this case, this was reflected in the fact that 3 (16.6%) indicated this option. On the other hand, the majority of students stated that they did not know them, with 15 (83.4%). This shows, as in the previous questions, that students have a low level of nutritional orientation.

To each of the questions in the survey, an item was added referring to the fact that if your answer is positive, argue why you selected this option. This gave rise to the suggestion of a group of students who showed indeterminacy as to the reason for their answers. This is represented in a neutrosophic graph (Figure 1), according to the criteria of [12], [13], [14], [22]. The one that shows the relationship between students who said yes and the indeterminacy of the reason for their answers.

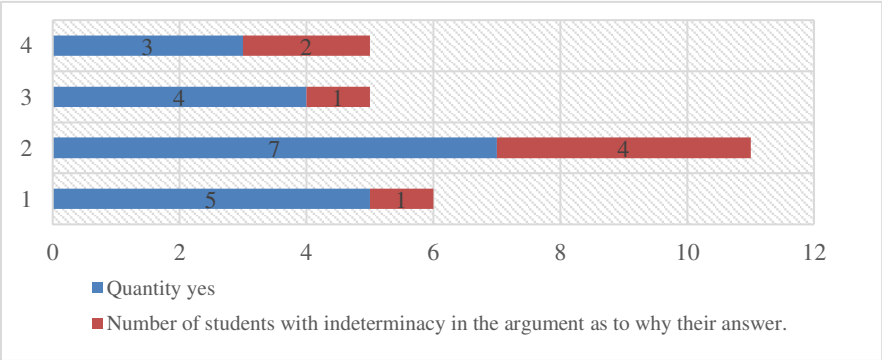


Figure 1: Neutrosophic graph. Number of students who expressed a positive response and the level of indeterminacy of their response.

When analyzing the 4 questions of the survey applied to the students, it is obtained that in question 1, 1 student expressed indeterminacy in his answers, in question 2 there were 4 students. On the other hand, in question 3, 1 student expressed it, and in question 4, only 2 students.

After the analysis of frequency distribution presented, it is necessary to calculate the mean of the data recorded to know this statistical indicator of the students who stated that they know the subject, taking into consideration the 4 questions asked to the university students, where there are students with indeterminacy in the argument of why they marked this option. Quantities containing an indeterminacy component are represented as classical neutrosophic numbers, of the form: N= a + Bi, according to [12], [15]:

Questions	Number of "yes" answers
1	5+1
2	7+4
3	4+1
4	3+2

Table 2: Results of the data for positive responses and indeterminacy.

To calculate the mean of these values, the same equation is applied as in classical statistics, taking into account the particularities of operations with neutrosophic numbers.

$$\bar{x}_N = \frac{(5+1I)+(7+4I)+(4+1I)+(3+2I)}{4}$$

$$\bar{x}_N = \frac{5+7+4+3}{4} + \frac{1+4+1+2}{4} \cdot I$$

$$\bar{x}_N = 4{,}7 + 4I$$

$$\bar{x}_N = 8{,}7$$

Therefore, the mean of the data obtained was 8.7, out of a sample of 18 students, only these were the mean of all the questions answered that they had nutritional orientation [16]. Therefore, the application of other investigations is demanded in order to achieve an important transformation in the studied sample.

Conclusion

The results derived from the theoretical study allow confirming the potential of neutrosophic studies for the evaluation of knowledge about nutritional orientation in university students of medicine at UNIANDES, Ecuador.

The results obtained in the research make evident the lack of knowledge of medical students about nutritional orientation, leaving open future lines of research on this topic.

References

[1] BC Shin, Chun IA, Ryu SY, Oh JE, Choi PK, Kang HG. Association between indication for therapy by nutrition support team and nutritional status. Medicine (Baltimore);97(52): e13932. DOI: 10.1097/MD.0000000000013932 2, 2018

[2] K, Riley Sulo S, Dabbous F, Partridge J, Kozmic S, Landow W, et al. Reducing Hospitalizations and Costs: A Home Health Nutrition-Focused Quality Improvement Program. JPEN J Parenter Enteral Nutr;44(1):58-68. DOI: 10.1002/jpen.1606, 2020

[3] J Rabat-Restrepo, Campos-Martín C. Nutrición enteral; [citado 12 de junio de 2018]. Disponible en: https://www.sapd.es/revista/2009/32/6/08 2009

[4] L Gramlich, Hurt R, Jin J, Mundi MS. Home Enteral Nutrition: Towards a Standard of Care. Nutrients;10(8):1020. DOI: 10.3390/nu10081020, 2018

[5] F. Smarandache. "Introduction to Neutrosophic Statistics". Ed. Infinite Study, 150, 2014

[6] F. Smarandache. "Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Similarly for Neutrosophic" Over-/Under-/Off-Logic, Probability, and Statistics. 2016

[7] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018

[8] G E, Sara; Z R Nazate Chugá; R I Tavera; M C Villareal Gel; D M Ramírez Guerra. Neutrosophic Statistical Analysis of Arthrofirosis of the KneeRehabilitation." Neutrosophic Sets and Systems 44, (1). 2021
[9] A. Palacios, Jesús Estupiñán Ricardo, Iyo Alexis Cruz Piza, y Marcia Esther España Herrería. «Phenomenological Hermeneutical Method and Neutrosophic Cognitive Maps in the Causal Analysis of Transgressions against the Homeless». Neutrosophic Sets and Systems 44: 147-56. 2021
[10] D. M. Ramírez Guerra, Y. M. Gordo Gómez, L. J. Cevallos Torres, F. G. Palacios Ortiz. Social sports Competition Scoring System Design Using Single Value Neutrosophic Environment. International Journal of Neutrosophic Science (IJNS), Vol. 19, No. 01, PP. 389-402, 2022
[11] J. Estupiñán, Diego Fernando Coka Flores, Jorge Alfredo Eras Díaz, y Karina Pérez Teruel. «An Exploration of Wisdom of Crowds using Neutrosophic Cognitive Maps». Neutrosophic Sets and Systems 37 (1): 2, 2020.
[12] M. Leyva & F. Smarandache. "Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre". Ed. Infinite Study.187, 2018
[13] K., M Pérez-Teruel, M. Leyva-Vázquez, y V. Estrada-Sentí. «Mental models consensus process using fuzzy cognitive maps and computing with words». Ingenieria y Universidad 19 (1): 173-88. https://doi.org/10.11144/Javeriana.iyu19-1.mmcp. 2015
[14] L. X. Cangas Oña, J. X. Iglesias Quintana & E. L. Hernández Ramos. "Papel de la enseñanza del derecho indígena en la formación de los futuros abogados". Universidad y Sociedad, vol. 14 no. S3, pp 555-565, 2022.
[15] O. R. Espinosa Lastra, A. C. Lastra Sánchez & M. E. Velastegui Córdova. "Influencia en el comportamiento en jóvenes de la ciudad de Puyo del confinamiento por COVID-19". Universidad y Sociedad, vol. 14 no. S3, pp 548-554, 2022.
[16] N. C. Barreiro Jiménez, S. M. Gavilánez Villamarín, J. F. Armijo Moreta & F. G. Santillán Molina. "Periodontitis dental en adolescentes, importancia de su evaluación oportuna". Universidad y Sociedad, vol. 14 no. S3, pp 537-547, 2022.
[17] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021.
[18] Ricardo, J. E., Peña, R. M., Zumba, G. R., & Fernández, I. I. O. "La Pedagogía como Instrumento de Gestión Social: Nuevos Caminos para la Aplicación de la Neutrosofía a la Pedagogía". Infinite Study, 2018.
[19] Vera, D. C., Suntaxi, A. V. T., Alcívar, G. C. I., Ricardo, J. E., & Rodríguez, M. D. O. "Políticas de inclusión social y el sistema de ingreso a las instituciones de educación superior del Ecuador". Dilemas Contemporáneos: Educación, Política y Valores. Vol. 1 no. 19, pp 1-18, 2018.
[20] Leyva Vázquez, M. Y., Estupiñán Ricardo, J., Coles Gaglay, W. S., & Bajaña Bustamante, L. J. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, 2021.
[21] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[22] Estupiñán Ricardo, J., Martínez Vásquez, Á. B., Acosta Herrera, R. A., Villacrés Álvarez, A. E., Escobar Jara, J. I., & Batista Hernández, N. "Sistema de Gestión de la Educación Superior en Ecuador. Impacto en el Proceso de Aprendizaje". Dilemas Contemporáneos: Educación, Política y Valores, 2018.
[23] von Feigenblatt, O. F., Calderon, R. D., & MacDonald, T. "The Case for an Eclectic and Flexible Leadership Research Agenda: Dealing with Social Justice and Diversity in the 21st Century Workplace". Centro Sur, vol. 6 no. 1, pp 130-142, 2022
[24] S. B. Gallegos Gallegos, H. R. Álava Arévalo, A. F. Solano Moreno & M. P. Villa Zura. "Análisis legal de la suspensión condicional de la pena". Universidad y Sociedad, vol. 14 no. S4, pp 270-277, 2022.
[25] W. A. Cacpata Calle, K. B. Larrea Vélez, G. A. Andrade Olvera & D. V. Garces Mayorga. "Los servicios sexuales como una forma de violencia contra las mujeres". Universidad y Sociedad, vol. 14 no. S4, pp 260-269, 2022.
[26] P. M. Moreno Arvelo & R. Garcia Lara. "El Derecho producto de la globalización: una teoría integracionista". Universidad y Sociedad, vol. 14 no. S4, pp 252-259, 2022.

Received: September 05, 2022. **Accepted:** October 26, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Conducive Factors of Adolescent Pregnancy in Ecuador through Neutrosophic Statistics (revisited)

Lenin Carlos Gabriel Flores[1], Iruma Alfonso Gonzáles[2], Kenia Mariela Peñafiel Jaramillo[3], and Olga Cristina Solis Solis[4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.leningabriel@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.irumaalfonso@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.keniapenafiel@uniandes.edu.ec
[4] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.olgass52@uniandes.edu.ec

Abstract. Teenage pregnancy in Ecuador is a problem that continues to increase year after year. This, in addition to violating the rights of all girls and adolescents, perpetuates violence and inequality. Knowing the causes and consequences of teenage pregnancy allows designing action plans to fight them. The analysis of preliminary studies and surveys confirms levels of indeterminacy in the responses obtained for the study. This integration between neutrosophic sets makes it possible to reflect, through the representation of neutrosophic statistics, the level of deterioration of the factors that intervene in the full development from adolescence to adulthood. Consequently, the existing indeterminacy makes it necessary to model each element of the group studied to analyze the levels of deterioration associated with preventing teenage pregnancy in Ecuador.

Keywords: Pregnancy, adolescence, neutrosophy.

1 Introduction

Adolescence is the period in a person's life between the ages of 10 and 19. In some cases, adolescence is interrupted when the young woman becomes pregnant. One in five women in the world has a child before the age of 18 and 16 million teenage births occur every year. In the poorest regions of the planet, one in three women is a mother during adolescence.

Teenage pregnancy greatly limits a woman's opportunities to develop autonomously, both due to emotional and physiological immaturity, which in turn implies changes in affective, social, and economic circumstances that trigger important situational crises, as a result of early pregnancy. For this reason, pregnancy in the adolescent stage has been described as a phenomenon framed within the problem with the highest social and family impact, with many consequences for sexual health [1], reproductive, economic, and family environment for the mother and the child. Pregnant adolescents have certain common sociodemographic characteristics in pregnancy. Among the causes of the highest incidence are the early age of beginning sexual relations, the low educational level, the origin of disintegrated families, and, above all, the low knowledge of contraceptive methods for the prevention of pregnancy. It is therefore considered a difficult event that affects the comprehensive health of adolescent mothers, their children, family members, and the community as a whole.

According to experts, the most appropriate age to become a mother is between 20 and 35 years, since the risk to the health of the mother and child is much lower. Pregnancy in adolescence is considered a high risk and carries more complications [2]. The adolescent is not physically or mentally prepared to have a baby and take on the responsibility of motherhood.

Teenagers who become pregnant present in many cases:

- Poor nutrition, with a lack of essential nutrients for the proper development of the baby [3]
- An increased number of miscarriages
- Premature births, with many adolescent babies being born before 37 weeks of gestation
- Their babies are underweight as their immature body means that their uterus has not fully developed
- Teen moms have children with more health problems and developmental disorders
- In cases of pregnancies of girls under 15 years of age, the baby is more likely to be born with malformations.

Other risks [4]

- Lack of medical attention due to ignorance of the pregnancy [5]

- Risk of pre-eclampsia and eclampsia
- Risk of obstetric fistula, an invisible injury with devastating effects on the lives of thousands of women
- High maternal mortality
- Complications due to clandestine abortions, such as sepsis or severe bleeding
- Pregnancy linked to sexually transmitted diseases
- Psychological complications for the pregnant adolescent

In general, the studies speak of a series of circumstances that teenage mothers go through:

- Fear of being socially rejected
- One of the consequences of adolescence and pregnancy is that the young woman feels criticized by her family and friends and tends to isolate herself from the group.
- Rejection of the baby
- They are still girls and do not want to take on the responsibility, time, and obligations of being a mother. However, this also makes them feel guilty and sad and their self-esteem is lowered.
- Family problems
- Communicating the pregnancy in the family is often a source of conflict and even rejection by their own environment.

Factors that give rise to pregnancy in adolescence [6]

- Sexual relations without the use of contraceptive methods, or erroneous or mistaken use of them
- Teenage marriage and the traditional role that some societies still assign to women
- Dangers of the consumption of drugs and alcoholic beverages and its consequences: disinhibition, lack of reflexivity, impulsiveness, etc.
- Social pressure and idealization of pregnancy in adolescence as ways to achieve acceptance in their close circles (friends and classmates, mainly).
- Lack of information and difficult access to good sexual education, as well as neglect or refusal of parents to talk about these issues openly and naturally [7, 18, 19].

In addition, on a psychological and social level it is common to find:

- Abandonment of studies, which will depend on the context and socioeconomic level, among other factors.
- The trauma of an induced or spontaneous abortion, as well as the risks of falling into the black market in countries where this practice is not legalized.
- In developed countries, the new family nucleus will often be unstable (adolescent parents or short-term relationships), while in developing countries, it will represent a greater number of children.
- Psychological problems: fear of being rejected, anxiety, stress and family problems, rejection of the baby, or the appearance of serious emotional disorders.
- Maintaining unstable relationships (dysfunctional families) or harmful to women due to economic and emotional needs.

That is why the present investigation intends to identify different factors that influence the increase in the number of pregnant adolescents. Pregnancy during the adolescent stage has a negative impact on its psychological, family, social and personal context. Therefore, there is a need to carry out an analysis to prevent teenage pregnancy in Ecuador

To analyze pregnancy during adolescence, this study defines:

- Problem situation: increase in teenage pregnancy in Ecuador
- Main objective: to analyze the levels of deterioration of the elements associated with preventing pregnancy in adolescence in Ecuador
- Specific objectives:
  - Determine the factors that affect the analyzed variable
  - Carry out the measurement and modeling of the variable

Project potential alternatives in terms of preventing pregnancy in adolescence.

2 Definition

NEUTROSOPHIC STATISTICS

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E occurs [8], the probability that event

E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$$NP(x) = (T(x), I(x), F(x)),$$

Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and to the methods to analyze them.

Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns [9].

Finally, the Neutrosophic Logic[10], the Neutrosophic Ensembles, and the Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference for study in full development.

Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data.

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number N.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Following the neutrosophic mean of the variable $(\bar{x}_N)$ by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\ \ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ n_N \in [n_l, n_u] \tag{2}$$

is a neutrosophic random sample. However, neutral squares (NNS) can be calculated as follows

$$\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n_N}\left[\begin{matrix}\min\left(\begin{matrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{matrix}\right) \\ \max\left(\begin{matrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U) \\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{matrix}\right)\end{matrix}\right], I \epsilon [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \epsilon [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows [11, 12, 13, 14].

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \epsilon [CV_L, CV_U] \tag{5}$$

The Neutrosophic Argumentation coefficient evaluates the criteria through Linguistic Terms with SVNN of consensus of justification of the expert opinion, (see Table 1).

Linguistic term	SVNN
No Deterioration (ND)	(1,0.05,0)
Almost No Deterioration (AND)	(0.95,0.12,0.15)
Very Low Deterioration (VLD)	(0.85,0.15,0.25)
Low Deterioration (LD)	(0.75,0.3,0.4)
Slight deterioration (SD)	(0.65,0.35,0.5)
Deteriorated (D)	(0.55,0.45,0.53)
Mildly Deteriorated (MD)	(0.49,0.5,0.55)
Severely Deteriorated (SD)	(0.3,0.75,0.8)
Very Deteriorated (VD)	(0.25,0.8,0.85)

Linguistic term	SVNN
High Deterioration (HD)	(0.15,0.9,0.95)
Extremely Deteriorated (ED)	(0,0.95,1)

Table 1. Linguistic terms representing factor weights

3 Results

Data collection: Statistics allow the analysis of situations in which the random components contribute significantly to the variability of the data obtained. To measure the levels of associated risks in pregnant adolescents, indeterminate random components are presented. The impossibility of measuring some determinants of health status in pregnant women is defined in the variability of responses of the respondents, similar to each other, who participated in the study.

Development of the method: For the neutrosophic statistical modeling, the experts select five factors that prevail in the neutrosophic sets (elements associated with preventing pregnancy in adolescence), based on defining the variable to be studied (Table 2).

Variable	Coding	Sample factor	Scale
Levels of deterioration of the elements associated with preventing pregnancy in adolescence in Ecuador	DPEA	[45;203]	$[0\ ;\ 1], \forall\ F_n$ RCD = 0 (false) RCD = 1 (True) $DCR\ \neq 0.5$(Existing uncertainty in DPEA)

Table 2. Characteristics of the variable

It should be considered that the recommendations are subject to constant updating motivated by advances in sociodemographic research and the contributions of statistical information on pregnancy in adolescence and its risk conditions.

Factor	source elements	Degree	Relation between factor and set	Scale	Element Decision Acceptance Range
F1	Socio-economic status	L	Neutrosophic set: (Malnutrition; level of poverty)	[0; 1]	Subsets: • Malnutrition index (high, medium, low, or none) • Poverty level (high, medium, low, or none)
F2	Adolescent reaction to pregnancy	R	Neutrosophic set: (Emotional state, level of acceptance)	[0; 1]	Subsets: • Emotional state (happiness, fear, sadness, surprise) • Acceptance level (low, medium, high)
F3	Level of sexual education and continuity of studies	N	Neutrosophic set: (Academic level, student improvement)	[0; 1]	Subsets: • Sex education level (low, medium, high) • Continuing studies (yes, maybe, no)
F4	Influence on the family and social environment	I	Neutrosophic set: (Family; society)	[0; 1]	Subsets: • Family; society (strong, medium, or low)
F5	Preparation and responsibility of the adolescent when caring for the son or daughter	P	Neutrosophic set: (Preparation; responsibility)	[0; 1]	Subsets: • Preparation and responsibility (high, medium, low, or none)

Table 3. Factors that influence the origin of teenage pregnancy

For the development of the neutrosophic statistical study, it is recommended by the experts to analyze the levels of deterioration of the elements associated with preventing pregnancy in adolescence in Ecuador. Studies in risk conditions are associated, based on the statistical bases and the surveys carried out (Table 3).

No	F1	F2	F3	F4	F5
1	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]
2	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
3	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
4	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
5	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
6	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]
7	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]
8	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]
9	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]
10	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
11	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.25,0.8,0.85)]
12	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
13	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
14	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
15	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]
16	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
17	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]
18	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]
19	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]
20	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]
21	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]
22	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]
23	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.49,0.5,0.55)]
24	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]
25	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]
26	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
27	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
28	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
29	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
30	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]
31	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0,0.95,1);(0.15,0.9,0.95)]
32	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]
33	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
34	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
35	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]

36	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]
37	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]
38	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]
39	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
40	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(1,0.05,0)]
41	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]
42	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]
43	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
44	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]
45	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]
46	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]
47	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]
48	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]
49	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
50	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]
51	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
52	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.49,0.5,0.55)]
53	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]
54	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
55	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
56	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]
57	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]
58	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]
59	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]
60	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
61	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]
62	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]
63	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
64	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
65	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
66	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
67	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(1,0.05,0)]
68	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(1,0.05,0)]	[(0,0.95,1);(0.15,0.9,0.95)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]
69	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]
70	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]
71	[(0.49,0.5,0.55);(1,0.05,0)]	[(0.15,0.9,0.95);(0.15,0.9,0.95)]	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0.25,0.8,0.85);(0.3,0.75,0.8)]
72	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.15,0.9,0.95);(0.49,0.5,0.55)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]
73	[(0.25,0.8,0.85);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0.49,0.5,0.55);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]

74	[(0.25,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]	[(0,0.95,1);(0.3,0.75,0.8)]
75	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.65,0.35,0.5)]
76	[(0,0.95,1);(0.25,0.8,0.85)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.75,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
77	[(0.25,0.8,0.85);(0.65,0.35,0.5)]	[(0.15,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.75,0.3,0.4)]	[(0.15,0.9,0.95);(0.25,0.8,0.85)]	[(0.25,0.8,0.85);(0.75,0.3,0.4)]
78	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0.25,0.8,0.85);(0.49,0.5,0.55)]	[(0.49,0.5,0.55);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]
79	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.95,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.49,0.5,0.55);(1,0.05,0)]
80	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.49,0.5,0.55)]	[(0.3,0.75,0.8);(0.49,0.5,0.55)]	[(0,0.95,1);(0.15,0.9,0.95)]
1-80	**[(0.3,0.75,0.8);(0.49,0.5,0.55)]**	**[(0.25,0.8,0.85);(0.3,0.75,0.8)]**	**[(0.3,0.75,0.8);(0.55,0.45,0.53)]**	**[(0.25,0.8,0.85);(0.49,0.5,0.55)]**	**[(0.3,0.75,0.8);(0.55,0.45,0.53)]**

Table 4. Neutrosophic frequency of DCR.

For the development of the statistical study, the neutrosophic frequencies of the factors are analyzed to determine the level of deterioration of the element that affects pregnancy in adolescence in Ecuador, associated with risk conditions. For each factor, a sample of the elements associated with the surrounding environment of the pregnant adolescent is analyzed by the specialists. The analysis of the sample that makes up the groups analyzed in the study with respect to determining the relationship between the deterioration of the elements and the associated risk condition (Table 3).

For the modeling, it is decided to take each term to a neutrosophic number according to equation (1). Table 3 analyzes the level of DPEA for a sample of [45;80] pregnant adolescents in Ecuador for each factor analyzed. Of the neutrosophic frequencies, it can be observed with a level of response in the weight of the factors, from the neutrosophic linguistic terms represented between $[0;\ 1]$. For each risk condition reviewed with a total indeterminacy level of $L = 19.7, R = 18.7, N = 22.6, I = 20.1, P = 22.3$, and with a representativeness level of $[49.21\%;\ 51.86\%]$, on the days that adolescent pregnant women affected by more than one risk condition are evaluated. [20, 21]

The preliminary screening results have an indeterminacy level close to 0.5 per analyzed factor, in all factors, except for F2. The result diagnoses the deterioration of each factor that affects the appearance of pregnant adolescents according to the analyzed sample:

- For the malnutrition index, it is very slightly moderate, while the level of poverty is medium for the interaction of the analyzed subsets.
- The emotional state is a state of fear in the face of a low level of acceptance at that stage of life.
- The academic level is low with some indeterminacy to continuing studies
- The impact on the family is very bad with a slight influence on society
- The preparation is very low for the new environment that surrounds them, while there is a certain indeterminacy in the responsibility of future teenage mothers.

Given the existing levels of indeterminacy, the use of classical statistics is not possible, so the use of neutrosophic statistics is necessary for a better understanding of interrelated neutrosophic sets.

Neutrosophic Statistical Analysis: The modeling of the data on the level of deterioration existing in the factors associated with the origin of pregnancy in adolescents shows that factors 3 and 5 require studies with a level of depth. To determine the level of incidence between the causes and the risk conditions in pregnancy, it is necessary to analyze the means (Table 4). To understand what factor implies a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic means are calculated for the study of the variations of the affectations, and the values of the standard neutrosophic deviation $S_N \in [S_L; S_U]$. To determine which factor requires a higher level of accuracy at the time of diagnosing each subset, therefore, the values of $CV_N \in [CV_L\ ;\ CV_U]$ are calculated.

Factors	$\bar{\mathbf{x}}_{\mathbf{N}}$	$\mathbf{Y_N}$	$\mathbf{CV_N}$
Socio-economic status	0.254 + 0.5I	0.015 + 0.315 I	0.059 + 0.63 I
Adolescent reaction to pregnancy	0.241 + 0.475 I	0.013 + 0.315 I	0.054 + 0.663 I
Level of sexual education and continuity of studies	0.258 + 0.54 I	0.018 + 0.324 I	0.07 + 0.6 I

Factors	$\bar{x}_N$	Y_N	CV_N
Influence on the family and social environment	0.239 + 0.49 I	0.016 + 0.334 I	0.067 + 0.682 I
Preparation and responsibility of the adolescent when caring for the son or daughter	0.259 + 0.538 I	0.014 + 0.326 I	0.054 + 0.606 I

Table 5. Neutrosophic statistical analysis of DPEA level. Source: own elaboration.

Table 4 shows the factors that affect the risk conditions in pregnant adolescents and the associated level of indeterminacy. So, it is necessary to analyze the current state of adolescents and propose solutions to mitigate their impact on society. This means that the level of risk associated with this risk situation is more common and easier to detect, but there are levels of uncertainty to analyze. On the other hand, the CV_{ND} analysis of these factors is lower for the *preparation and responsibility factors of the adolescent in caring for the son or daughter* and *the adolescent's reaction to the pregnancy*.

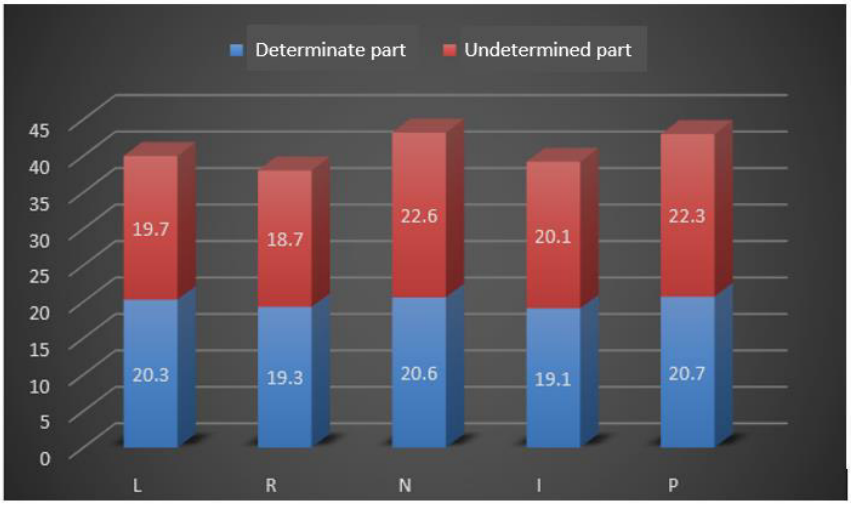


Figure. 1. Neutrosophic bar graph of the DPEA. Source: own elaboration.

The neutrosophic set for the *level of sexual education and continuity of studies* derives with a greater frequency from the analyzed studies. While the set *preparation and responsibility of the adolescent to care for the son or daughter* coexists a direct relationship between sets. It is visualized that low levels of sexual education lead to an increase in adolescent pregnancy, where preparation and responsibility are defined in a contradictory way, and the risk conditions in pregnancy increase (Figure 1).

Comparative analysis: To determine the associated referent indeterminacy measure for $\bar{x} = \in [\bar{x}_L; \bar{x}_U], S_N \in [S_L; S_U]$ and $CV_N \in [CV_L ; CV_U]$ to the form of neutrosophic numbers (Table 5). In the results obtained, it is observed that for the values of CV_N range from 0.054 to 0.07 with the measure of indeterminacy of [0.6;0.682] generated by a sample of [100; 203] questionnaires and statistical information, obtained from 80 pregnant adolescents. From the results expected by the neutrosophic study, it can be seen that:

- The prevalence of low socio-economic status in the family causes a low level of malnutrition and poverty in 19.7% of the respondents. The status of the factor analyzed in pregnant adolescents is between severely deteriorated and moderately deteriorated for a frequency of [20.3; 40].
- The adolescent's reaction to pregnancy is visualized with an emotional state of fear and a low level of acceptance for 18.7% of pregnant adolescents. The state of impairment of the factor is between very impaired and severely impaired for a frequency of [19.3; 38].
- The level of sexual education and the continuity of studies in pregnant adolescents is present in only 21.2% of those surveyed. The low educational level on sexuality is severely deteriorated and deteriorated with a level of indeterminacy of 88.3% for a frequency of [20.6; 43.2].
- The influence of the family and social environment is present in 19.3% of pregnant adolescents. The continuous effect caused in society is due to the low level that influences families in preparing adolescents for sexual life. This fact means that the factor is found on a scale between moderately impaired and highly impaired for a frequency of [19.1; 39.2].

- The preparation and responsibility of the adolescent when caring for the son or daughter responds to 20.7% of the pregnant women surveyed. It is defined that a deterioration of the factor between severely impaired and impaired, leads to a low level of responsibility towards the son or daughter of the adolescent, for a frequency of [20.7; 43].
- For the risk conditions in adolescent pregnant women, they increase with the deterioration of the analyzed factors. For these clinical pictures, deeper studies are required to track down the potential causes, such as the mitigation of the consequences that affect health. It is vital, for the analysis of statistical studies referring to the subject where the contradictions and indeterminacies are diversified in various degrees of weight in neutrosophic terms, to obtain a level of consensus of the specialists within the analyzed element of the neutrosophic set. [15, 16, 17]

Factors	$\bar{x}_N$	S_N	CV_N
F1	0.254 + 0.5II;I ∈ [0,0.492,0]	0.015 + 0.315 I;I ∈ [0,0.952,0]	0.059 + 0.63 I;I ∈ [0,0.906,0]
F2	0.241 + 0.475I;I ∈ [0,0.493,0]	0.013 + 0.315I;I ∈ [0,0.959,0]	0.054 + 0.663 I;I ∈ [0,0.919,0]
F3	0.258 + 0.54I;I ∈ [0,0.522,0]	0.018 + 0.324I;I ∈ [0,0.954,0]	0.07 + 0.6I;I ∈ [0,0.883,0]
F4	0.239 + 0.49 I;I ∈ [0,0.512,0]	0.016 + 0.334 I;I ∈ [0,0.952,0]	0.067 + 0.682 I;I ∈ [0,0.902,0]
F5	0.259 + 0.538 I;I ∈ [0,0.519,0]	0.014 + 0.326I;I ∈ [0,0.957,0]	0.054 + 0.606 I;I ∈ [0,0.911,0]

Table 6. Neutrosophic forms with measure of indeterminacy

From the results obtained in the study, it is proposed to promote alternatives based on the existing situation of pregnant adolescents. The variants presented allows the actions to be taken based on the level of indeterminacy and acceptance of the levels in each range and for the screening of health problems in pregnant women. Therefore, it is expected to:

- Implement promotional preventive programs with greater emphasis on pregnancy in adolescence, causes, and consequences based on the risk conditions present in the stage.
- Encourage interaction between parents and children to discuss sexual education issues.
- Work together with governing bodies to visualize strategies to mitigate the risks associated with pregnancy in adolescence and the impact caused in society.
- Create educational policies, campaigns, and awareness that lead to the use of contraceptive resources and the flow of information in society for the prevention of pregnancy in adolescence

Conclusion

Teenage pregnancies are considered a social problem that occurs and in turn, generates poverty and inequality. It is also considered an obstacle in the social and personal development of adolescents. In most cases, pregnancy at this stage of life occurs due to determinants of different social, personal, and socioeconomic levels, without considering the risks of early pregnancy for both the future mother and the fetus.

The modeling of neutrosophic statistics defines as the best prevention that young people have a good sexual education from within the family. Inform about the risks and complications of pregnancy in adolescence and all the changes that will occur from the moment the adolescent becomes pregnant. Guidance should be given to the level of responsibility required to be a mother.

Communication in the family is essential, therefore, there must be an open and transparent dialogue so that young people have all the information at their fingertips. Adolescents must have universal access to comprehensive sex education, for free decision-making, through the full exercise of sexual and reproductive rights for a life free of violence. Therefore, it is up to the governing bodies to use strategies so that adolescents go to health centers and thus promote an active sexual life with responsibility and without the risk of early pregnancy.

References

[1] Jeremic Stojkovic V, Matejic B, and T. K, " Serbian primary care physicians' perspectives on adolescents' right to confidentiality in sexual and reproductive healthcare—a qualitative interview study, ," Family Practice, vol. 36, pp. 317-324, 2018.

[2] D.D. Reidpath and P. Allotey, "Infant mortality rate as an indicator of population health," J Epidemiol Community Health,, vol. 57, pp. 344-346, 2003.

[3] SCIELO. (2020) Importancia de la nutrición durante el embarazo. Impacto en la composición de la leche materna. Available: https://www.hospitalesangeles.com/saludyvida/articulo.php?id=37
[4] M. Y. Leyva Vázquez and F. F. Smarandache, " Sistema de Apoyo a la Toma de Decisiones Basado en Mapas cognitivos Neutrosóficos para Instituciones que atienden a Embarazos con Alto Riesgo por Enfermedades Cardiovasculares " Revista Cubana de Ciencias Informáticas. Editorial "Ediciones Futuro" Universidad de las Ciencias Informáticas. La Habana, Cuba, vol. 13, pp. 16-29, Octubre-Diciembre, 2019 2019.
[5] Jaruseviciene L, Levasseur G, and L. J, "Confidentiality for adolescents seeking reproductive health care in Lithuania: the perceptions of general practitioners. ," Reprod Health Matters, vol. 14, pp. 129-137, 2006.
[6] Kelly F. Flanagan, Shayna D. Cunningham, Jessica B. Lewis, Jonathan N. Tobin, and Jeannette R. Ickovics, "Factors associated with pregnant adolescents' access to sexual and reproductive health services in Newtt York City," Sexual & Reproductive Healthcare, vol. 19, pp. 50-55, 2019.
[7] Lina Jaruseviciene, Jeffrey V. Lazarus, and A. Zaborskis, "Confidentiality and parental involvement in adolescent sexual and reproductive health care: A cross-sectional study of Lithuanian general practitioners," Scandinavtian Journal of Public Health, vol. 39, pp. 484-491, 2011.
[8] S. H. S. Al-Subhi, I. Pérez Pupo, R. García Vacacela, P. Y. Piñero Pérez, and M. Y. Leyva Vázquez, "A New Neutrosophic Cognitive Map with Neutrosophic Sets on Connections, Application in Project Management. ," Neutrosophic Sets and Systems, vol. 22. , pp. 63-75, 2018.
[9] W. B. Vasantha, I. Kandasamy, and F. Smarandache, "Algebraic Structure of Neutrosophic Duplets in Neutrosophic Rings < Z U I>,< Q U I> and < R U I.> " Neutrosophic Sets and Systems, vol. 23, pp. 85-95, 2018.
[10] E. J. H. Antepara, Competencies Interdepencies Analysis based on Neutrosophic Cognitive Mapping: Neutrosophic Sets and Systems, 2017.
[11] F. Smarandache, "A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Infinite Study.," 2005.
[12] J. L. Acosta Espinoza, A. R. Lenin León Yacelga & W. G. Sanafria Michilena. "Las aplicaciones móviles y su impacto en la sociedad". Universidad y Sociedad, Vol. 14 num. (2), pp- 237-243, 2022.
[13] C. R. Sampedro Guamán, S. A. Machuca Vivar, D. P. Palma Rivera, & B. E. Villalta Jadan. "Automatizar procesos de producción repetitivos en las PYMES con robots colaborativos". Universidad y Sociedad, Vol. 14 Num. 2, pp- 220-227, 2022.
[14] Molina, A. L. S., Ochoa, N. V. V., Salazar, C. F. B., & Ojeda, S. J. S. "Evaluación de la participación en actividades educativas en el centro de privación de libertad Manabí 4 en Ecuador". Universidad y Sociedad, vol. 14 no. 5, pp 503-513, 2022.
[15] Altamirano, G. L. V., Yugsi, E. P. C., Briones, F. M. A., & Rodríguez, J. A. V. "Implicaciones psicológicas y físicas causadas en el periodo de cuarentena durante la pandemia por covid-19 en Ecuador". Universidad y Sociedad, vol. 14 no. 5, pp 514-523, 2022.
[16] Cabrera, M. A. C., & Díaz, R. A. V. "Tecnología quick response (QR) para prevenir la transmisión del covid-19 a través de dinero en efectivo en el transporte público en Ecuador". Universidad y Sociedad, vol. 14 no. 5, pp 524-530, 2022.
[17] Matos, M. A., Cando, J. L. M., & Navarrete, W. R. P. "Propuesta de metodología para mejorar la calidad del trato a los adultos mayores víctimas de abuso en el cantón de Cuenca, Ecuador". Universidad y Sociedad, vol. 14 no. 5, pp 531-540, 2022.
[18] Álvarez Gómez, S. D., Romero Fernández, A. J., Estupiñán Ricardo, J., & Ponce Ruiz, D. V. "Selección del docente tutor basado en la calidad de la docencia en metodología de la investigación". Conrado, vol. 17 no. 80, pp 88-94, 2021.
[19] Estupiñán Ricardo, J., Domínguez Menéndez, J. J., Barcos Arias, I. F., Macías Bermúdez, J. M., & Moreno Lemus, N. "Neutrosophic K-means for the analysis of earthquake data in Ecuador". Neutrosophic Sets and Systems, vol. 44 no. 1, pp. 29, 2021.
[20] von Feigenblatt, O. "Mediation for management: Dealing with Conflict in the Workplace". Innovaciones de Negocios, vol. 18 no. 35, pp 113-119, 2021.
[21] von Feigenblatt, O. F. "Un estudio de caso sobre la competencia diplomática entre la República Popular China y la República de China (Taiwán): La experiencia de la República de Costa Rica de 1995 a 2010". Dilemas contemporáneos: Educación, Política y Valores. Vol. 9no. (Edición especial), pp 1-19, 2021.

Received: September 07, 2022. **Accepted:** October 27, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Analysis of Sustainable Development Indicators through Neutrosophic Correlation Coefficients

Jesús Estupiñán Ricardo[1], Ariel José Romero Fernández[2], Tanya Tupamara Camargo Martínez[3] and Wilson Alfredo Cacpata Calle [4]

[1] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: ua.jesusestupinan@uniandes.edu.ec
[2] Universidad Regional Autónoma de Los Andes, Matriz Ambato. Ecuador. E-mail: dir.investigacion@uniandes.edu.ec
[3] Universidad Regional Autónoma de Los Andes, Sede Ibarra. Ecuador. E-mail: ui.tanyacamargo@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes, Sede Santo Domingo. E-mail: us.wilsoncacpata@uniandes.edu.ec

Abstract. This study reviews the main initiatives for the development and implementation of environmental sustainability and sustainable development indicators. The indicators, built specifically for the corresponding users, constitute a system of signals that allow each country to evaluate its progress toward sustainable development. The purpose of this research is to identify, through neutrosophic logic, the specific indicators of sustainable development with the highest incidence in Ecuador. For this, a documentary analysis is carried out to provide the primary information on which to carry out the analysis and the knowledge of experts in the area. Correlation coefficients applied to single-value neutrosophic numbers are used to obtain a ranking of sustainable development indicators. Finally, policies and projects can be adopted to strengthen the national infrastructure in favor of sustainability. At the same time, it is shown that the application of neutrosophic techniques is a pillar to be exploited, through which to generate better discussed and studied reasoning.

Keywords: Indicators of sustainability, development, neutrosophic logic, neutrosophic numbers.

1 Introduction

Multi-criteria decision-making methods are an important consideration in the discipline of decision sciences. In recent years, the need to simultaneously consider criteria and alternatives in decision problems is more vital, especially in the presence of uncertain data sets. Therefore, decision-makers use subjective evaluation methods to deal with this obstacle [1].

To enrich this technique and in order to minimize the impossibility of traditional multicriteria decision methods, to handle indeterminate and inconsistent data intrinsic to the real world, the neutrosophic sets proposed by Smarandache [2] are used. These generalize the concepts of Classical Set (CS), Fuzzy Set (FS), Intuitionistic Fuzzy Set (IFS), Interval Valued Intuitionistic Fuzzy Set (IVIFS), etc.

Logic and neutrosophic sets constitute generalizations of Zadeh's logic and fuzzy sets, and Atanassov's intuitionistic logic, among others [7]. The inclusion of Neutrosophic Sets in the method allows the uncertainty of the decision-making process to be taken into account, including indeterminacies. Experts will assess in linguistic rather than numerical terms, which is the most natural form of measurement in humans.

Neutrosophic Analysis (or Neutrosophic Arithmetic) is a general term that encompasses both interval and set analysis. The neutrosophic analysis deals with all kinds of series (not only with intervals), and also includes situations of indeterminacy (sets, functions, or other notions defined on those sets). If sets are used and there is no indeterminacy, then neutrosophic analysis agrees with set analysis. If instead of sets, only intervals are used and indeterminacy exists, then neutrosophic analysis agrees with interval analysis. If there is any indeterminacy, it doesn't matter if you use only intervals or sets, you have neutrosophic analysis.

To overcome the difficulty of generating uncertain and imprecise data during decision-making, [7] introduced the theory of fuzzy sets with several contributions in this field. However, the fuzzy set theory could not address all possible types of uncertainty, such as indeterminacy and inconsistency that normally exist in natural decision-making processes [8], [31].

Neutrosophic Set Theory is a powerful formal framework that generalizes the concepts of Classical Set, Fuzzy Set, Interval-Valued Fuzzy Set, Intuitionistic Fuzzy Set, Interval-Valued Intuitionistic Fuzzy Set, and others [7], [9]. Neutrosophy is a branch of philosophy started by [10]. This theory studies the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra [3]–[6],[11].

The birth of neutrosophy generates a new concept called <NeutA> that represents indeterminacy with respect to <A>. According to the author, this element can solve certain problems that cannot be solved by fuzzy logic [12].

Various real-life problems, such as weather forecasting, stock price prediction, and political elections, contain indeterminate conditions that fuzzy set theory does not handle well. This theory deals with imprecise and vague situations where exact analysis is difficult or impossible [3].

Following the contributions made by Smarandache, several notions for neutrosophic sets have been introduced that provide a more reasonable mathematical framework for dealing with indeterminate and inconsistent information.[13]. In such a framework, the concepts of an interval neutrosophic set (INS) and a single-valued neutrosophic set (SVNS) were proposed. These elements constitute subclasses of the neutrosophic sets and provided the theoretic set operators and various properties of SVNS and INS. Therefore, SVNS and INS can be applied in real scientific and engineering fields [14], [27, 33, 34, 35].

Subsequently, the use of SVNS correlation coefficients based on the extension of the correlation coefficient of intuitionistic fuzzy sets was presented. This showed that the SVNS cosine similarity measure is a special case of the SVNS correlation coefficient, and was then applied to single-valued neutrosophic numbers applied to decision-making problems [15]–[17]. The application of neutrosophic methods constitutes a useful tool to determine the impact of development actions on sustainability. These methods make it possible to incorporate the conflicts that exist between economic, environmental, and social objectives, and between different decision-making levels.

The Sustainable Development Indicators (SDI) can be interpreted as a system of signals that make it easier to assess the progress of countries and regions toward sustainable development. The indicators are concrete tools that support the work of designing and evaluating public policy, strengthening informed decisions, as well as citizen participation, to drive nations toward sustainable development. It is important to keep in mind that both environmental and sustainable development indicators constitute an issue that is still in the process of development in the world, in which some countries have advanced more than others, in various aspects.

The experience is available, in varying degrees of print or digital publication, so accessing it is simple. The complicated thing is to be able to grasp it, because the diversity of initiatives is very wide, and it is increasing more and more. At the same time, initiatives have been emerging in various citizen spaces, study centers, and government, in the last five years.

The purpose of this paper is to identify the sustainability indicators with the greatest impact on Ecuador, through the use of neutrosophic logic. In this sense, correlation coefficients are a very important tool to judge the relationship between two objects. These coefficients have been widely applied to data analysis and classification, decision-making, pattern recognition, etc. [18], [19], [26]. The present study intends to carry out a selective evaluation of the SDI through the use of neutrosophic correlation coefficients.

In this paper, it is first discussed the preliminary aspects of neutrosophic logic and SVNS, as well as the formulas for the analysis of correlation coefficients defined in the domain of single-valued neutrosophic sets. Subsequently, the bases on which the analysis is carried out, the results, and the conclusions are presented.

2 Preliminaries

Definition 1. [20] Let X be a space of points (objects), with a generic element in X denoted by x. A neutrosophic set A in X is characterized by a membership function of truth $T_A(x)$, a membership function of indeterminacy $I_A(x)$, and a membership function of falsehood $F_A(x)$. The functions $T_A(x)$, $I_A(x)$ and $F_A(x)$, are standard or nonstandard real subsets of $]0^-, 1^+[$, that is, $T_A(x): X \rightarrow]0^-, 1^+[$, $I_A(x): X \rightarrow]0^-, 1^+[$ and $F_A(x): X \rightarrow]0^-, 1^+[$. There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, so $0^- \leq supT_A(x) + supI_A(x) + supF_A(x) \leq 3^+$.

Obviously, it is difficult to apply the neutrosophic set to practical problems. Therefore, [14] introduced the concept of a Single-Valued Neutrosophic Set (SVNS), which is an instance of a Neutrosophic Set, to be used in real scientific and engineering applications. Here is the definition of SVNS [14], [30].

Definition 2. [14] Let X be a space of points (objects) with generic elements in X denoted by x. An SVNS A in X is characterized by a truth membership function $T_A(x)$, an indeterminacy membership function $I_A(x)$, and a falsehood membership function $F_A(x)$ for each point x in X, $T_A(x), I_A(x), F_A(x) \in [0,1]$. Therefore, an SVNS A can be expressed as

$$A = \{x, T_A(x), I_A(x), F_A(x) \mid x \in X\}$$

So the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, satisfies the condition $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

Definition 3. [14] The complement of an SVNS A is denoted by Ac and is defined as

$$Ac = \{x, F_A(x), 1 - I_A(x), T_A(x) \mid x \in X\}$$

Definition 4. [14] A SVNS A is contained within another SVNS $B, A \subseteq B$ if and only if $T_A(x) \leq T_B(x), I_A(x) \geq I_B(x)$, and $F_A(x) \geq F_B(x)$ for every x in X.

Definition 5. [14] Two SVNSs A and B are equal, written as A = B, if and only if $A \subseteq B$ and $B \subseteq A$

Correlation coefficient of SVNSs

Definition 6 [21] For any two SVNSs A and B in the universe of discourse $X = \{x_1, x_2, \ldots, x_n\}$, the correlation coefficient between two SVNSs A and B is defined as follows:

$$M(A,B) = \frac{1}{3n}\sum_{i=1}^{n}[\phi_i(1-\Delta T_i) + \varphi_i(1-\Delta I_i) + \psi_i(1-\Delta F_i)] \quad (1)$$

where

$$\phi_i = \frac{3-\Delta T_i - \Delta T_{max}}{3-\Delta T_{min} - \Delta T_{max}},$$

$$\varphi_i = \frac{3-\Delta I_i - \Delta I_{max}}{3-\Delta I_{min} - \Delta I_{max}},$$

$$\psi_i = \frac{3-\Delta F_i - \Delta F_{max}}{3-\Delta F_{min} - \Delta F_{max}},$$

$$\Delta T_i = |T_A(x_i) - T_B(x_i)|,$$

$$\Delta I_i = |I_A(x_i) - I_B(x_i)|,$$

$$\Delta T_i = |T_A(x_i) - T_B(x_i)|,$$

$$\Delta T_{min} = min_i|T_A(x_i) - T_B(x_i)|,$$

$$\Delta I_{min} = min_i|I_A(x_i) - I_B(x_i)|,$$

$$\Delta F_{min} = min_i|F_A(x_i) - F_B(x_i)|,$$

$$\Delta T_{max} = max_i|T_A(x_i) - T_B(x_i)|,$$

$$\Delta I_{max} = max_i|I_A(x_i) - I_B(x_i)|,$$

$$\Delta F_{max} = max_i|F_A(x_i) - F_B(x_i)|,$$

For all $xi \in X$ and i = 1, 2, . . ., n

However, the differences of importance are considered in the elements of the universe. Therefore, the weight of the element $x_i (i = 1, 2, \ldots, n)$ must be taken into account. A weighted correlation coefficient between the SVNS is presented below.

Definition 7. [21] Let w_i be the weight of each element x_i $(i = 1, 2, \ldots, n)$, $w_i \in [0,1]$, and $\sum_{i=1}^{n} w_i = 1$, then we have the following weighted correlation coefficient between SVNS A and B:

$$M_w(A,B) = \frac{1}{3}\sum_{i=1}^{n} w_i[\phi_i(1-\Delta T_i) + \varphi_i(1-\Delta I_i) + \psi_i(1-\Delta F_i)] \quad (2)$$

Decision-making method using the correlation coefficient of SVNSs

In the multi-attribute decision problem with single-valued neutrosophic information, the characteristic of an alternative A_i $(i = 1, 2, \ldots, m)$ on an attribute C_j $(j = 1, 2, \ldots, n)$ is represented by the following SVNS: $A_i = \{C_j, T_{Ai}(C_j), I_{Ai}(C_j), F_{Ai}(C_j) | Cj \in C, j = 1, 2, \ldots, n\}$ where $T_{Ai}(C_j), I_{Ai}(C_j), F_{Ai}(C_j)) \in [0,1]$ and $0 \leq T_{Ai}(C_j), I_{Ai}(C_j), F_{Ai}(C_j) \leq 3$, for $Cj \in C, j = 1, 2, \ldots, n,$ and $i = 1, 2, \ldots, m.$

For convenience, the values of the three functions $T_{Ai}(C_j), I_{Ai}(C_j), F_{Ai}(C_j)$ are denoted by a single-valued neutrosophic value (SVNV) $d_{ij} = < t_{ij}, i_{ij}, f_{ij} >$ $(i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n)$, which is usually derived from the evaluation of an alternative A_i against a criterion C_j by the expert or decision maker. Thus, a single-valued

neutrosophic decision matrix $D = (d_{ij})_{mxn}$. is obtained

In multi-attribute decision problems, the ideal point concept has been used to help identify the best alternative in the decision set. Although the ideal alternative does not exist in the real world, it does provide a useful theoretical construct against which to evaluate alternatives [22], [23], [24], [29], [32].

In the decision-making method, an ideal SVNV can be defined by $d_j^* =< t_j^*, i_j^*, f_j^* >=< 1,0,0 > (j = 1,2,\dots,n)$ in the ideal alternative A^*. Therefore, applying Equation (2), the weighted correlation coefficient between an alternative A_i $(i = 1,2,\dots,m)$ and the ideal alternative A^* is given by:

$$M_w(A_i, A^*) = \frac{1}{3}\sum_{j=1}^{n} w_j\left[\phi_{ij}\left(1 - \Delta t_{ij}\right) + \varphi_{ij}\left(1 - \Delta i_{ij}\right) + \psi_{ij}\left(1 - \Delta f_{ij}\right)\right] \quad (3)$$

where

$$\phi_{ij} = \frac{3 - \Delta t_{ij} - \Delta t_{i\,max}}{3 - \Delta t_{i\,min} - \Delta t_{i\,max}},$$

$$\varphi_i = \frac{3 - \Delta i_{ij} - \Delta i_{i\,max}}{3 - \Delta i_{i\,min} - \Delta i_{i\,max}},$$

$$\psi_i = \frac{3 - \Delta f_{ij} - \Delta f_{i\,max}}{3 - \Delta f_{i\,min} - \Delta f_{i\,max}},$$

$$\Delta t_{ij} = \left|t_{ij} - t_j^*)\right|,$$

$$\Delta i_{ij} = \left|i_{ij} - i_j^*)\right|,$$

$$\Delta f_{ij} = \left|f_{ij} - f_j^*)\right|,$$

$$\Delta t_{i\,min} = min_j\left|t_{ij} - t_j^*\right|,$$

$$\Delta i_{i\,min} = min_j\left|i_{ij} - i_j^*\right|,$$

$$\Delta f_{i\,min} = min_j\left|f_{ij} - f_j^*\right|,$$

$$\Delta t_{i\,max} = max_j\left|t_{ij} - t_j^*\right|,$$

$$\Delta i_{i\,max} = max_j\left|i_{ij} - i_j^*\right|,$$

$$\Delta f_{i\,max} = max_j\left|f_{ij} - f_j^*\right|,$$

For $i = 1,2,\dots,m$ and $j = 1,2,\dots,n$. Using the correlation coefficient $M_w\ (A_i, A^*)$ $(i = 1,2,\dots,m)$, the ranking order of all the alternatives and the best one(s) is obtained.

2.1 Materials and methods

For the development of the study, a bibliographic review was carried out on statistical, environmental, and economic data related to sustainable development indicators. The search was made by consulting databases provided by specialists and officials from related areas.

The sustainable development indicators obtained after the analysis were listed and submitted for review by the work team. For better understanding during this work, they were coded as shown in Table 1.

Code	Sustainable development indicators
SDI_1	Workforce Productivity
SDI_2	Highly biodiverse plant formations
SDI_3	Industrial waste pollution
SDI_4	Soil fragility

Code	Sustainable development indicators
SDI_5	Territorial planning
SDI_6	Expenditures on research and development per inhabitant

Table 1: Coding for sustainable development indicators. Source: own elaboration.

To carry out the analysis of the indicators and determine those with the greatest general impact, three evaluation criteria were selected. In the first criterion (C_1) the potential that these SDI have as tools in government decision-making, in relation to other priorities on the public agenda.

The second criterion (C_2) to be analyzed focuses on the cost that matters to develop a quality SDI system and operate it over time.

Finally, the social impact (C_3) of each SDI is assessed. For such purposes, the impact on groups, bodies, organizations, and other entities of society and the state is taken into account; considering that this issue concerns all social edges. So it is important to consider the economic effects caused from all aspects, both directly and indirectly.

For the evaluation of the indicators with respect to the selected criteria, the experts are asked to complete a small form in which an evaluation that is as precise as possible must be included in this regard. Likewise, they are asked to weigh the importance of each one of the criteria with respect to the rest. For this, the evaluations to be given must specify to what extent the expert considers that the alternative Ai is good (Tx), bad (Fx), or is not entirely sure (Ix) with respect to the criterion C_j. it is considered that the evaluated criteria have the same weight wj=0.33.

3 Results

To carry out the described analysis, the arithmetic mean of the evaluations made by the experts is considered. The results obtained from the evaluations allow for obtaining a resulting decision matrix D, which is shown below in Table 2.

0.4	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.1**	**0.2**	**0.5**
0.3	0.2	0.5	0.7	0.1	0.2	0.6	0.3	0.3
0.4	0.3	0.2	0.5	0.4	0.3	0.5	0.1	0.2
0.7	0.1	0.1	0.1	0.2	0.5	0.4	0.2	0.2
0.2	0.3	0.5	0.6	0.1	0.2	0.3	0.2	0.3
0.6	0.1	0.2	0.5	0.2	0.3	0.6	0.3	0.2

Table 2: Decision matrix D. Source: own elaboration

In accordance with what has been described for the development of the method and the obtaining of the results, the values of the operators φ, μ and ψ are determined to obtain the correlation coefficients, to carry out the method. Tables 3 and 4 show the results of such operations. [25], [28]

	SDI	**SDI**	**SDI**	**SDI**	**SDI**	**SDI**
ΔTmin	0.6	0.3	0.5	0.3	0.4	0.4
ΔImin	0.2	0.2	0.2	0.1	0.2	0.2
ΔFmin	0.2	0.1	0.1	0.1	0.1	0.1
ΔTmax	0.9	0.7	0.6	0.9	0.8	0.5
ΔImax	0.5	0.5	0.3	0.5	0.5	0.3
ΔFmax	0.2	0.3	0.4	0.2	0.3	0.3

Table 3: Minimum and maximum values of variation in the membership functions of truth, falsehood, and indeterminacy. Source: own elaboration.

Indicators	**φ_1**	**φ_2**	**φ_3**	**μ_1**	**μ_2**	**μ_3**	**ψ_1**	**ψ_2**	**ψ_3**
SDI_1	1	0.87	0.8	1	0.96	0.87	1	1	1
SDI_2	0.8	1	0.95	0.87	1	0.96	0.96	1	1
SDI_3	0.95	1	1	1	0.96	1	0.92	0.88	1
SDI_4	1	0.67	0.83	1	0.83	0.96	1	0.96	1

Indicators	φ_1	φ_2	φ_3	μ_1	μ_2	μ_3	ψ_1	ψ_2	ψ_3
SDI_5	0.78	1	0.83	0.87	1	0.96	0.92	1	1
SDI_6	1	0.95	1	1	0.96	1	1	0.96	0.9

Table 4: Values of φ, μ, and ψ for each selection alternative. Source: own elaboration.

In this way, by using equation (3) the values of the correlation coefficients M_w (A_i, A^*) are obtained. Table 5 shows the values obtained and the ranking corresponding to the results.

Sustainability indicators	M coefficient
Workforce Productivity	0.55
Territorial planning	0.58
Soil fragility	0.62
Highly biodiverse plant formations	0.64
Industrial waste pollution	0.64
Expenditures on research and development per inhabitant	0.70

Table 5: Weighted correlation coefficients. Source: own elaboration.

According to the analysis carried out, it can be seen that, according to the criteria of the experts and the criteria analyzed, the sustainable development indicator with the highest incidence in Ecuador is the expenditure on research and development per inhabitant. In order close to this, but below, there is a high incidence of pollution by industrial waste.

For the analysis carried out and the objectives of this study, the promotion of research and the development of sustainability projects constitute a strong element for the sustainable organization of Ecuadorian society. On the other hand, it should be noted that constant industrial development is opposed to environmental sustainability. Therefore, immediate actions are required to balance these aspects, with the support of the community.

Conclusions

Using neutrosophic tools, it is possible to overcome uncertainties in the decision-making process. This ensures that the resolution of real-life problems has the imprecise elements of the complex decision-making process. In this study, the main experiences are highlighted, and the implications that development has for work in Ecuador are discussed. The analysis was carried out based on its development (environmental, sustainable development, systemic-binding).

Through the development of this study, the selection of the main Sustainable development indicators by using neutrosophic correlation coefficients. As a result of the application of the method, the existence of expenditures in research and development per inhabitant, and the Industrial waste pollution above the other indicators analyzed were verified.

Sustainable Development indicators are tools that constitute a system of signals that allow the evaluation of the progress of countries toward sustainable development. Through the application of neutrosophy and the neutrosophic correlation coefficients, it was possible to analyze this real-life problem of relevant importance and impact at an economic-social level for Ecuador.

References

[1] M. Y. L. Vázquez, "MODELO DE AYUDA A LA TOMA DE DECISIONES BASADO EN MAPAS COGNITIVOS DIFUSOS, ," 2013.

[2] F. Smarandache, *A unifying field in logics. neutrosophy: Neutrosophic probability, set and logic.* 1999.

[3] M. Y. L. Vázquez and F. F. Smarandache, "Sistema de Apoyo a la Toma de Decisiones Basado en Mapas cognitivos Neutrosóficos para Instituciones que atienden a Embarazos con Alto Riesgo por Enfermedades Cardiovasculares," *Rev. Cuba. Ciencias Informáticas*, vol. 13, pp. 16–29, 2019.

[4] M. Abdel-Basset, M. Mohamed, F. Smarandache, and A. H. P. Neutrosophic, "An Extension of for Strategic Planning and Decision-Making.," *Symmetry 116*, vol. 10, no. 4 SRC-BaiduScholar FG-0, 2018.

[5] M. Mullai and R. Surya, "Neutrosophic Inventory Backorder Problem Using Triangular Neutrosophic Numbers.," *Neutrosophic Sets Syst.*, vol. 31 SRC-, pp. 148–155, 2020.

[6] H. Wang, F. Smarandache, R. Sunderraman, and Y. Q. Zhang, *Interval neutrosophic sets and logic: theory and*

applications in computing: Theory and applications in computing, vol. 5. Arizona: Hexis, 2005.

[7] L. Zadeh, G. Klir, and B. Yuan, *Conjuntos difusos, lógica difusa y sistemas difusos: artículos seleccionados*, Vol. 6. World Scientific, 1996.

[8] F. Smarandache, *Conjunto plitogenico, una extension de los conjuntos crisp, difusos, conjuntos difusos intuicionistas y neutrosoficos revisitado*, vol. 3. Infinite Study, 2018.

[9] V. Vega Falcón, "Aplicación de la Matemática difusa al calculo del umbral de rentabilidad," *Rev. Costos y Gestión*, vol. 28, pp. 1–14, 1998.

[10] F. Smarandache, "Neutrosophic set – A generalization of the intuitionistic fuzzy set," *Neutrosophic Probab. set, Log.*, vol. 1, no. 1, pp. 1–15, 1995.

[11] M. L. Vázquez and F. Smarandache, *Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre.* Bruselas: Pons, 2018.

[12] A. Y. B. López, "Empleo de la Neutrosofia para la gestión de riesgo y su impacto en la generación de la actitud de la prevención de desastres," *Rev. Asoc. Latinoam. Ciencias Neutrosóficas*, vol. 7, no. 3, pp. 44–56, 2019.

[13] L. J. M. Chalacán, A. Z. Paredes, and L. O. A. Zambrano, "Manejos de numeros neutrosoficos basados en el consenso para la elección de servicios de computación en la nube," *Investig. Operacional*, vol. 41, no. 5, pp. 741–751, 2020.

[14] H. Wang, F. Smarandache, Y. Zhang, and R. Sunderraman, *Single valued neutrosophic sets*, vol. 17, no. 1. Infinite study, 2010.

[15] L. M. Chávez, O. F. S. Montoya, and D. V. G. Mayorga, "DEMATEL NEUTROSÓFICO APLICADO AL ESTUDIO DE LOS FACTORES QUE INFLUYEN EN EL COMPROMISO EXTRACONTRACTUAL DEL ESTADO ECUATORIANO. Infinite Study.," *Investig. Operacional*, vol. 41, no. 5, pp. 622–628, 2020.

[16] M. L. M. Hidalgo, J. E. Valladares, M. L. F. Coronado, J. R. R. Ruiz, and E. C. S. Chura, "Enfoque comunicativo y la evaluación formativa en la asignatura de inglés y de los estudiantes universitarios," *Univ. y Soc.*, vol. 14, no. S2, pp. 144–152, 2022.

[17] P. J. Menéndez Vera, C. F. Menéndez Delgado, M. P. Gónzalez, and M. L. Vázquez, "Las habilidades del marketing como determinantes que sustentaran la competitividad de la Industria del arroz en el cantón Yaguachi. Aplicación de los números SVN a la priorización de estrategias.," *Neutrosophic Sets Syst.*, vol. 13, 2016.

[18] E. Szmidt and J. Kacprzyk, "Correlation of intuitionistic fuzzy sets," in *International conference on information processing and management of uncertainty in knowledge-based systems*, 2010, pp. 169–177.

[19] J. Ye, "Multicriteria fuzzy decision-making method using entropy weights-based correlation coefficients of interval-valued intuitionistic fuzzy sets," *Appl. Math. Model.*, vol. 34, no. 12, pp. 3864–3870, 2010.

[20] F. Smarandache, *A unifying field in logics: neutrosophic logic. Neutrosophy, neutrosophic set, neutrosophic probability: neutrosophic logic. Neutrosophy, neutrosophic set, neutrosophic probability.* American Research Press, 2005.

[21] J. Ye, "Improved correlation coefficients of single valued neutrosophic sets and interval neutrosophic sets for multiple attribute decision making," *J. Intell. Fuzzy Syst.*, vol. 27, no. 5, pp. 2453–2462, 2014.

[22] J. Ye, "Multicriteria decision-making method using the correlation coefficient under single-valued neutrosophic environment," *Int. J. Gen. Syst.*, vol. 42, no. 4, pp. 386–394, 2013.

[23] J. E. Jami Carrera, & A. A. Monsalve Guamán. "Efluvio telógeno como secuela de Covid-19". Universidad y Sociedad, Vol. 14 Num. S2, pp- 465-470, 2022.

[24] P. E. Salas Medina, & M. E. Orozco Manobanda. "Análisis de las dificultades en el proceso de implementación de protocolos de bioseguridad para reapertura de establecimientos turísticos en Tungurahua post Covid-19". Universidad y Sociedad, Vol. 14 Num.S2, pp- 456-464, 2022.

[25] M. R. Aguilar Martínez, D. P. Gordillo Cevallos, J. A. Paredes López & G.P. León Burgos. "La aplicación de los principios procesales en la justicia electoral". Universidad y Sociedad, Vol. 14 Num. S2, pp- 450-455, 2022.

[26] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[27] García, J. M. B., Ricardo, J. E., & Villalva, I. M. "Acciones didácticas para la autorrealización física integral de los estudiantes de carreras agropecuarias". Didasc@ lia: Didáctica y Educación, vol. 7 no. 2, pp 57-66, 2016.

[28] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[29] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[30] Ricardo, J. E., & Vázquez, I. R. S. "La educación sexual para padres de niños con retraso mental, una vía para su consolidación". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 4 no. 3, pp 137-144, 2019.

[31] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de

desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.

[32] von Feigenblatt, O. F. "Un estudio de caso sobre la competencia diplomática entre la República Popular China y la República de China (Taiwán): La experiencia de la República de Costa Rica de 1995 a 2010". Dilemas contemporáneos: Educación, Política y Valores. Vol. 9no. (Edición especial), pp 1-19, 2021.

[33] P. E. Del Pozo Franco, A. J. Peñafiel Palacios & G. M. Peñafiel Huerta. "La política social y la investigación empírica en derecho". Universidad y Sociedad, vol. 14 no. S3, pp 168-178, 2022.

[34] L. I. Barahona Tapia, R. F. Sánchez Santacruz & R. L. Maldonado Manzano. "El estudio de caso para análisis del derecho constitucional y los trámites administrativos referente a la libertad". Universidad y Sociedad, vol. 14 no. S3, pp 158-167, 2022.

[35] P. E. Del Pozo Franco, A. J Peñafiel Palacios & S. E. Figueroa Colin. "El delito de femicidio en el cantón Babahoyo y su prevención". Universidad y Sociedad, vol. 14 no. S3, pp 147-157, 2022.

Received: September 08, 2022. **Accepted:** October 27, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Analysis of the Right to Monetary Contribution for Illness through Neutrosophic Statistics

Manaces Esaud Gaspar Santos[1], Nelson Francisco Freire Sánchez[2], Javier Dario Bosquez Remache[3] and Manuel Ricardo Velázquez[4]

[1] Universidad Regional Autónoma de los Andes, Extensión Quevedo, Ecuador. E-mail: uq.manacesgaspar@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes, Sede Riobamba. Ecuador. E-mail: ur.nelsonfreire@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes, Sede Santo Domingo. Ecuador. E-mail: us.javierbosquez@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes, Sede Puyo. Ecuador. E-mail: up.manuelricardo@uniandes.edu.ec

Abstract. The right to receive social assistance for sickness is considered a right of every low-income citizen. Social security must ensure that people without access to health insurance have the option of this type of compensation. However, to access the monetary contribution for illness, a rigorous process is required to validate and approve it. In some cases, some people have been affected by the budget deficit that the locality presents, due to the non-payment of taxpayers. Therefore, the present study focuses on determining the causes of non-compliance with the monetary contribution for the illness that affect the violation of the right to receive a subsidy. For the modeling of the study, neutrosophic statistics are used to detect the existing uncertainties. Among the neutrosophic results, the implementation of mechanisms and ways to control the collections for the monetary contribution for illness is proposed, in addition to informing society and giving attention to those workers who are disabled.

Keywords: monetary contribution, neutrosophy, neutrosophic statistics, subsidy.

1 Introduction

Many prerogatives that society enjoyed have been lost because people in their ignorance do not claim them. It is time for society to claim the subsidy as a fundamental human right that must be protected and increased. The lack of jobs, new educational spaces, and economic support to prepare human capital are some of the situations that occur with increasing frequency, even within the country.

The Constitution of Ecuador is a guarantor of rights and because it is the supreme norm as established in its article 424, the other norms must strictly comply with what is established in it and thus avoid the violation of the right to sick pay, to those affiliated to the Ecuadorian Institute of Social Security (EISS) [1].

The subsidy for disability derived from illness or accident of common origin is an economic benefit that initially corresponds to the employer and then, the responsibility for its recognition and payment, is transferred to the Comprehensive Social Security System. This, as part of its economic benefits, grants a temporary monetary subsidy when the member is unable to work, as a result of illness or maternity. Among the different types of disability are:

- Temporary Disability: It is the one that prevents the affiliated worker from going to work, due to an accident or professional illness. While the member receives medical, surgical, hospital, or rehabilitation care, he has the right to:
- ✓ Subsidy: In cases of temporary disability, the insured will receive a cash subsidy, in the percentages of the worker's remuneration, set in the Statutes, during a base year, in accordance with the certificates granted by the occupational hazard medical professionals. The cash subsidy is equal to 75% of the salary or contribution salary, during the first ten weeks; and 66%, during the time after those first ten weeks, until completing the year (52 weeks).
- ✓ Provisional Pension for up to two years: If the disability exceeds one year, the member will have the right, for the subsidized period, to a pension equivalent to 80%, prior opinion of the Disability Assessment Commission.
- Partial Permanent Disability: This is one that causes the worker an injury or definitive functional disturbance that means a decrease in the physical integrity of the member, which will be calculated subject to the Table of Values of Disabilities and the regulations in force.
- ✓ Compensation: When the percentage of partial permanent disability is up to 20% inclusive, the member is entitled to a Single Global Compensation only once.
- ✓ Pensions: They are paid monthly, for life. Income for partial permanent disabilities ranges from 21% to 80% decrease in capacity for work. These rents do not cause the right to montepío.

- Total Permanent Disability: Is that which disables the member from performing all the fundamental tasks of his or her usual profession or trade. The insured will receive a monthly income equivalent to 80% of the average wages or salaries of the last year of contribution or the average of the five best years, if higher. This disability causes the right to montepío.

The subsidy for incapacity for work is a cash benefit that is intended to cover the contingency or state of need that is generated to a worker due to the temporary suspension of the ability to work, caused by illness or common accident, professional illness or accident of the work or disease [2] [3], [17]. A monetary subsidy is granted to active dependent workers who for medical reasons are unable to work, the (EISS) grants it from the fourth day of disability caused by non-professional illness and for a maximum of 185 days. To acquire the right to this subsidy, the requirements established in article 189 of the Social Security Law must be met, of which [4], [16], [18]:

a) The insured registers no less than sixty monthly contributions, of which no less than six must be immediately before the incapacity;
b) The contingency has affected the main activity in such a way that it deprives the insured of obtaining most of the income necessary for sustenance;
c) It has been verified that the insured ceased in said activity due to the contingency, understanding as such that he interrupted the performance of his work or had to terminate the employment or contractual relationship under which he fulfilled it; and,
d) The disability is not covered by the General Work Hazard Insurance.

To access the sickness subsidy, members must complete a procedure and follow the process manual for validation, registration of medical certificates, and payment of monetary sickness benefits. For this, they must be aware of the medical certificates issued by the specialists, even when they are in the Intensive Care Unit (ICU), which means that the relatives who are in the care of these members must be aware of a cumbersome procedure. It consists of validating and registering each medical certificate, for which you must go to the social work area. If this procedure is not carried out due to lack of knowledge or information, you lose the right to receive this subsidy of 75% of your remuneration during the first sixty days, from 66 to 64 from day 61 to day 185 and only the amount equivalent to the days he was able to register would be paid. [19], [20]

Due to this situation, it is pertinent to analyze and establish qualitatively and quantitatively this violation of the rights of affiliates. Well, it contradicts the constitutional norm regarding the right to sick pay, especially when they suffer from an illness that generates a situation of disability, due to the lack of registration of the medical certificate, within the first three days.

The EISS protects its policyholders with financial and assistance benefits against contingencies that affect their ability to work. In addition, it protects the obtaining of an income according to their usual activity in cases of illness, maternity, work risks, old age, death, and disability which includes disability and unemployment [5].

Affiliates with these health conditions and their families go through a process that, due to the severity of the disease, alters their social environment and the normal socioeconomic development of the family group. Well, they are emotionally impacted, to which are added the administrative procedures to enjoy a right, which is not consistent with the situation and the care that the EISS owes to its affiliates.

Based on the analysis, it is considered necessary to approach, through the modeling of neutrosophic statistics, and determine the causes of non-compliance with the monetary contribution for an illness that affects the violation of the rights to receive a subsidy and that contradicts the constitutional norm regarding priority and specialized care that people have, in order to prevent negative effects on members, as well as proposals for potential solutions.

2 Materials and methods

2.1 Neutrosophic Statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that the event E occurs [6], the probability that the event E does not occur, and the probability of indeterminacy (not knowing if the event E occurs or not) [7]. In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$$NP(x) = (T(x), I(x), F(x)),$$

Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not

occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression [8], etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them [9].

Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns.

Finally, Neutrosophic Logic, Neutrosophic Sets, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a novel study reference in full development [10], [11], [12].

Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data.

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number N[13], [14], [15], [21], [22], [23], [24].

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represent the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Follow the neutrosophic mean of the variable $(\bar{x}_N)$ by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\quad \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ n_N \in [n_l, n_u], \tag{2}$$

However, for the calculation of neutral squares (NNS) it can be calculated as follows.

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\begin{bmatrix} \min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix} \\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{bmatrix}, I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2] \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows.

$$\mathbf{CV_N} = \frac{\sqrt{\mathbf{S_N^2}}}{\mathbf{\bar{X}_N}} \times \mathbf{100};\ \mathbf{CV_N} \in [\mathbf{CV_L}, \mathbf{CV_U}] \tag{5}$$

3 Method development

A neutrosophic frequency distribution is a table showing absolute and relative frequencies, partial or total uncertainties. Indeterminacies occur primarily due to imprecise, unknown, or incomplete data related to absolute frequencies. The relative frequencies then become imprecise, incomplete, or may even be unknown.

The development of the study of the distribution of neutrosophic frequencies associated with the analysis of the right to the monetary contribution for illness.

No	Causes	Absolute neutrosophic Frequency	Neutrosophic Relative Frequency
1	ignorance	15	[0.179 , 0.214]
2	Inaccessibility to counseling services	[20,30]	[0.238 , 0.429]
3	Arrears in payments and non-payments to the contribution	25	[0.298 , 0.357]
4	Violation when applying the regulations that respond to the contribution for illness	[10.14]	[0.119 , 0.2]
	Total	[70.84]	[0.833 , 1.2]

Table 1: Causes of non-compliance with the monetary contribution for illness. Source: own elaboration.

As can be seen, for the cases of *ignorance* and *delays in payments and non-payments of the contribution*, the number of individuals who present these causes of non-payment of the contribution (15 and 25 times respectively) is known exactly. However, it is not possible to specify the number of times that have been observed that the causes are *inaccessibility to counseling services* and *violation when applying the regulations that respond to the contribution for illness*.

In the table, it can be read that, for the case of 2, this has happened between 20 and 30 times, but the exact information is not available, the same for the number of *Violation when applying the regulations that respond to the contribution for illness*. This indicates the existence of uncertainties related to frequencies. The last column reveals the relative neutrosophic frequencies associated with each event.

Since there is imprecise information, it is necessary to calculate the extremes (min. and max.) of the absolute or estimated frequencies.

$$min_{fn} = 15 + 20 + 25 + 10 = 70$$

$$max_{fn} = 15 + 30 + 25 + 24 = 84$$

Subsequently, to calculate the relative frequencies, their minimum and maximum values must be calculated for each of the results tabulated as individuals who report that cause of non-compliance. For this, the following formula will be applied:

$$min_{fnri} = \frac{min_{fni}}{max_{fn}}, \text{Y}$$

$$max_{fnri} = \frac{max_{fni}}{min_{fn}}$$

In the case of frequencies that do not present indeterminacy, it is true that:

$$min_{fni} = max_{fni} = fni$$

Therefore:

$$min_{fnr0} = \frac{min_{fn0}}{max_{fn}} = \frac{15}{84} = 0.179$$

$$max_{fnr0} = \frac{max_{fn0}}{min_{fn}} = \frac{15}{70} = 0.214$$

$$min_{fnr15} = \frac{min_{fn15}}{max_{fn}} = \frac{20}{84} = 0.238$$

$$max_{fnr15} = \frac{max_{fn15}}{min_{fn}} = \frac{30}{70} = 0.429$$

$$min_{fnr20} = \frac{min_{fn20}}{max_{fn}} = \frac{25}{84} = 0.298$$

$$max_{fnr20} = \frac{max_{fn15}}{min_{fn}} = \frac{25}{70} = 0.357$$

$$min_{fnr30} = \frac{min_{fn20}}{max_{fn}} = \frac{10}{84} = 0.119$$

$$max_{fnr30} = \frac{max_{fn15}}{min_{fn}} = \frac{14}{70} = 0.2$$

The value of the accumulated neutrosophic relative frequency was then obtained through the sum of the reported neutrosophic relative frequencies.

$$Frna = [0.179\,, 0.214] + [0.238\,, 0.429] + [0.298\,, 0.357] + \ [0.119\,, 0.2] = \ [0.833\,, 1.2]$$

3.1 Neutrosophic Statistical Analysis

To visually show the absolute neutrosophic frequencies, different types of graphs can be used, which must contain and differentiate the determined and the indeterminate part of the analyzed data. It can be represented by a column graph, the frequency of recording the causes of non-compliance as shown in Figure 1.

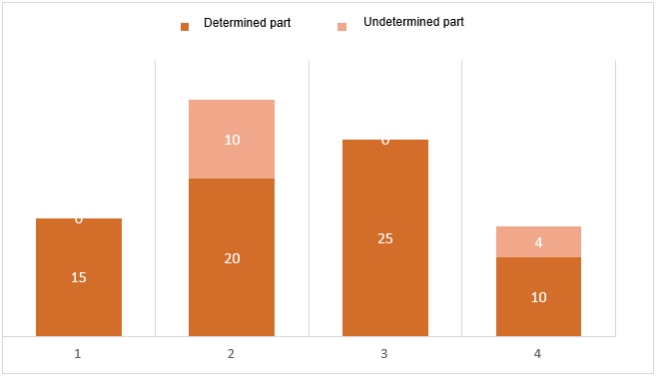


Figure 1: Neutrosophic column chart. Source: own elaboration.

The frequencies of having registered related to causes 2 and 3 are indeterminate with indeterminacy values of 10 and 4, respectively.

In this case, 15 specialists are selected from the neutrosophic sample and the possible causes of tax evasion are analyzed and modeled using a neutrosophic cognitive map. Indeterminacy is expressed with the question mark (?).

The identified causes are:

Node	Cause
N1	Ignorance
N2	Inaccessibility to counseling services
N3	Arrears in payments and non-payments to the contribution
N4	Violation when applying the regulations that respond to the contribution for illness

Table 2: Causes and nodes identified. Source: own elaboration.

N0 represents on the map the causes of not fulfilling the right to the monetary contribution for illness.

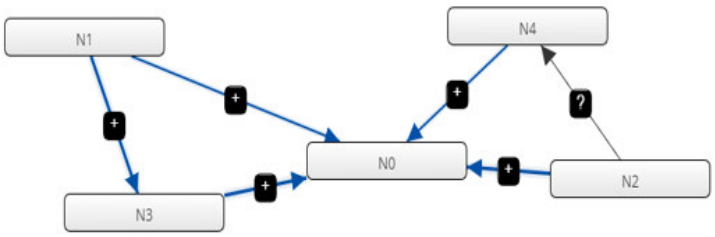


Figure 2: XYZ MCN graphical representation of the causes of non-compliance with the contribution. Source: own elaboration.

NCM with weights is represented in Table 3.

	N0	N1	N2	N3	N4
N0	0	0	0	0	0
N1	0.75	0	0.25	0	0
N2	0.5	0	I	0	I
N3	0.75	0	0	0	0
N4	0.25	0	0	I	0

Table 3: Neutrosophic adjacency matrix. Source: own elaboration.

The nodes are subsequently classified. The following measures are used in the proposed model based on the absolute values of the adjacency matrix

- Outdegree $od(v_i)$ is the sum of the rows in the neutrosophic adjacency matrix. Reflects the strength of the outgoing relationships (c_{ij}) of the variable.

$$od(v_i) = \sum_{i=1}^{N} c_{ij} \quad (6)$$

- Indegree $id(v_i)$ is the sum of the columns reflects the strength of outgoing relations (c_{ij}) of the variable.

$$id(v_i) = \sum_{i=1}^{N} c_{ji} \quad (7)$$

- Total centrality (total degree $td(v_i)$), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \quad (8)$$

The measures of centralities are calculated. The Outdegree and Indegree measurements are presented in Table 4.

Node	**Outdegree**	**Indegree**
N0	0	2.25
N1	1	0
N2	0.5+I	0.25
N3	0.75	0
N4	0.25	I

Table 4: Centrality measures. Source: own elaboration.

Nodes are classified according to the following rules:

- Transmitting variables have positive or indeterminate outdegree and zero indegree.
- The receiving variables: Have an indeterminate or positive indegree, and zero outdegree.
- Ordinary variables: Have a degree of indegree and outdegree other than zero.

Then, the nodes are classified:

In this case, nodes P1, E1, and T2 are transmitters, S1 is the receiver and T1 is ordinary.

	Transmitter	Receiver	ordinary
N0		X	
N1	X		
N2			X
N3	X		
N4			X

Table 5: Node classification. Source: own elaboration.

The total grade was calculated (Equation 8). The results are shown in Tables 5 and 6.

	td
N0	2.25
N1	1
N2	0.75+I
N3	0.75
N4	0.25+I

Table 6: Total degree. Source: own elaboration.

Static analysis in NCM initially results in neutrosophic numbers of the form (a+bI), where I = indeterminacy). That is why a neutralization process is required, as proposed by Salmerón and Smarandache $I \in [0,1]$, and is replaced by its maximum and minimum values.

	Td
N0	2.25
N1	1
N2	[0.75, 1.75]
N3	0.75
N4	[0.25, 1.25]

Table 7: Deneutrosophication of centrality values. Source: own elaboration.

The total grade was calculated (Equation 9). Finally, the mean of the extreme values are processed to obtain a single value.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (9)$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \quad (10)$$

The results are shown in Table 8.

	Td
N0	2.25
N1	1
N2	1.25
N3	0.75
N4	0.75

Table 8: Centrality using the mean of the extreme values. Source: own elaboration.

The order obtained is as follows:

$$\mathrm{N}_0 \succ \mathrm{N}_2 \succ \mathrm{N}_1 \succ \mathrm{N}_3 \sim N_4$$

Nodes trusting third parties and ignorance are the main factors. Therefore, it can be said that the governing institutions should focus on minimizing the negative effects of *inaccessibility to counseling services and ignorance*, as the main nodes that activate the neutrosophic network in non-compliance with the monetary contribution due to illness. Therefore, as a strategy to consider, the tax policy should be aimed at improving the perception that taxpayers have about the fulfillment of their obligations to the monetary contribution for illness. So that those people with a critical health situation can have the right to more equitable health. The governing bodies must make use of the current tax legal framework to increase the penalty rates for tax noncompliance. In addition to optimizing information systems to make taxpayers understand that the country and society need the commitment of all its citizens.

Conclusion

The governing bodies should focus on improving collection systems to mitigate the budget deficit. To achieve this, mechanisms and ways to control collections for the monetary contribution due to illness must be implemented. Access to technology constitutes an opportune means to inform society and give attention to those people entitled to the monetary contribution for illness. The neutrosophic statistical analysis and specifically the neutrosophic statistics can be used to determine the possible causes and non-compliance with the monetary contribution for illness. Failure to comply with formal duties constitutes one of the causes of non-contribution by taxpayers, an indeterminate element in the analysis of the study. Even though several taxpayers affirm that they were not aware or did not have accessibility to consulting services, it is a cause to be analyzed by the corresponding organisms.

References

[1] J. M. Dávila Villegas, "Subsidio por incapacidad como prestación económica a cargo del sistema integral de seguridad social. Aproximaciones a las responsabilidades de los distintos subsistemas.," *Páginas De Seguridad Social,* vol. 1, pp. 113-127, 2017.

[2] L. Navarro, "Social Responsibility Practices as a Factor in Economic Benefits," *International Journal of Business and Society,* vol. 23, pp. 1208-1228, 08/08 2022.

[3] A. L. Safonov and Y. V. Dolzhenkova, "REMUNERATION IN THE PUBLIC SECTOR: STATE AND DEVELOPMENT TRENDS," *Social & labor researches,* vol. 46, pp. 64-71, 01/01 2022.

[4] T. Aránguez, "El despido por enfermedad a la luz del principio de igualdad," *Revista General de Derecho del Trabajo y de la Seguridad Social* vol. 51, 12/30 2018.

[5] J. Guamán and V. Medina Medina, "La remuneración y su evolución histórica en Ecuador frente a economías de primer mundo," *Sociedad & Tecnología,* vol. 5, pp. 184-199, 05/18 2022.

[6] R. P. Alava, J. M. Murillo, R. B. Zambrano, & , and M. I. Zambrano Vélez, "PEST Analysis Based on Neutrosophic Cognitive Maps: A Case Study for Food Industry," *Neutrosophic Sets and Systems,* vol. 21, p. 10, 2018.

[7] K. P. Teruel, CedeñoCedeñ, J., Gavilanez, H. L., Diaz, C., & Vázquez, M. L., "A framework for selecting ccloud computing services based on consensus under single valued neutrosophic numbers. ," *Neutrosophic Sets and Systems,* vol. 22, pp. 38-40, 2018.

[8] U. Afzal, H. Alrweili, N. Ahamd, and M. Aslam, " Neutrosophic statistical analysis of resistance depending on the temperature variance of conducting material," *Scientific Reports,* vol. 11, p. 23939, 2021.

[9] N. G. Arias;, N. Q. Arnaiz;, S. G. Villamarín;, and M. C. Borbor., "Neutrosociology for the analysis of the Pros and Cons of Life Series in Uniandes, Ecuador.," *Neutrosophic Sets and Systems* vol. 34, 2020.

[10] W. Jiang and J. Ye, "Optimal design of truss structures using a neutrosophic number optimization model under an indeterminate environment.," *Neutrosophic Sets Sys,* vol. 14, pp. 93-97., 2016.

[11] U. G and N. Sivasubramaniam, "Impact of Neutrosophic Statistics on Acceptance Sampling Plans -A Review," *The International journal of analytical and experimental modal analysis,* vol. XIV, pp. 890-896, 07/11 2022.

[12] A Romero Fernández, I. Alonso González, L. F. Latorre Tapia, & G. A. Álvarez Gómez. "Procedimiento para el mejoramiento de la gestión de los servicios de alojamiento en hoteles de destinos de sol y playas. Revisión de literatura". Universidad y Sociedad, Vol. 14 Num. S2, pp- 406-414, 2022.

[13] P. A. Mena Silva, N. M Pérez Seminario & S. O Espinoza Guevara. "Comparación entre toxina botulínica tipo A y férulas oclusales para tratamiento de bruxistas". Revisión de literatura. Universidad y Sociedad, Vol. 14 Num. S2, pp- 398-405, 2022.

[14] P. Hayk, M. R. Meléndez Carballido, M. Alfaro Matos & K. E. Carrión León. "Genocidio cultural y la cuestión del Tibet". Universidad y Sociedad, Vol. 14 Num. S2, pp- 391-397, 2022.

[15] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[16] Ricardo, J. E., Villalva, M. I. M., Padilla, Z. A. O., & Hurtado, L. A. C. "Filosofía de la comunicación, complemento necesario en el aprendizaje de las Ciencias Sociales". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 3 no. 2, pp 39-52, 2018.

[17] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[18] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[19] Leyva, M., Estupiñán, J., Coles, W., & Bajaña, L. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, pp 130-135, 2021.

[20] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.

[21] von Feigenblatt, OF, Pardo, P. & Cooper, M. "Corporativismo y autoritarismo benévolo: antídotos viables contra el populismo". Revista de perspectivas alternativas en las ciencias sociales. Vol. 11 no. 1, pp 95-98, 2021

[22] R. G. López Torres, V. A. Salame Ortiz & F. D. R Lozada López. "Técnica conservadora: protección pulpar directa". Universidad y Sociedad, vol. 14 no. S3, pp 72-79, 2022.

[23] G. Ramos Serpa, C. E. Gómez Armijos & A. López Falcón. "Aspectos de éticas sobre la vacunación contra el COVID-19". Universidad y Sociedad, vol. 14 no. S3, pp 60-71, 2022.

[24] I. Alfonso González, A. J. Romero Fernández & A. E. Gallegos Cobo. "Leyes de etiquetado frontal como garantía de protección a la salud de los consumidores". Universidad y Sociedad, vol. 14 no. S3, pp 52-59, 2022.

Received: September 10, 2022. **Accepted:** October 28, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the Determinants of the Restoration of Democracy

Ingrid Joselyne Diaz Basurto[1], Janneth Ximena Iglesias Quintana[2], Victor Hugo Lucero Salcedo[3] and Mónica Alexandra Salame Ortiz[4]

[1] Universidad Regional Autónoma de Los Andes, Extensión Quevedo. Ecuador. E-mail: uq.ingrdidiaz@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes, Sede Riobamba. Ecuador. E-mail: ur.jannetiglesias@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes, Sede Tulcán. Ecuador. E-mail: ut.victorlucero@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes, Matriz Ambato. Ecuador. E-mail: ua.monicasalame@uniandes.edu.ec

Abstract. The emergence of a republic is characterized by achieving and reaching democracy, in a popular, representative, and responsible way. Although the country has been involved in anti-democratic coups that perpetuate the use of force, guidelines must be drawn to achieve democratic stability. It should be noted that over the years democracy has evolved and even in the 21st century each person, institution or nation has a different way of seeing its meaning. Throughout its republican life, Ecuador has had variations in the stability of democracy in society. Therefore, this paper focuses on analyzing the stability levels of democracy in Ecuadorian society. For the modeling of the study, the use of neutrosophic statistics is necessary due to the variation of the variable. As a result of the study, the deterioration of civil rights was determined as a key neutrosophic factor in the stability of democracy in society.

Keywords: democracy, neutrosophic statistics, society.

1 Introduction

The progress of society is built on fundamental pillars, among them, democracy stands out as progress among nations. A democratic, popular, representative, and responsible government is characterized by the election of authorities through direct and secret elections. Each democratic state is based on the recognition of guarantees or individual freedoms. Among the functions of the State are the executive, the legislative, and the judicial to direct a country that enjoys its rights [1].

The stability of democracy can be affected by causes that threaten the progress of society, such as:

- economic crisis [2],
- impoverishment,
- loss of monetary sovereignty,
- loss of social legitimacy of governments,
- institutions and parties,
- political instability,
- massive social protests,
- resounding fall of presidents,
- subjection to the directing role of the armed forces,
- corruption scandals,
- former rulers imprisoned or prosecuted,
- neoliberalism, and
- populism.

The stability of democracy positively influences society. Democracy allows the emergence and fulfillment of social rights related to family, work, property, education, and culture for marginalized sectors [3]. Minorities in society manage to achieve representation in congress. To achieve democracy, the relation of the electoral court must be independent of the executive, which allows future fraud to be reduced.

The court of Constitutional Guarantees is in charge of interpreting the Constitution, resolving conflicts between the Powers of the State, and determining the constitutionality of laws. Human rights and protection of society. The inclusion in the Electoral Court of political parties creates the necessary conditions for economic, social, and cultural development.

Therefore, the relationship between democracy and society requires defining in the study as:

- Main objective: to analyze the stability levels of democracy in Ecuadorian society.
- Specific objectives:
  - ❖ Factors Influencing the Stability of Democracy in Society
  - ❖ Carry out the measurement and modeling of the variable
  - ❖ Propose solutions to achieve a solid democracy based on the predominant neutrosophic factor

2 Materials and methods

2.1Neutrosophic Statistics

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the probability that the event E occurs [4], [16], the probability that the event E does not occur, and the probability of indeterminacy (not knowing if the event E occurs or not [5], [9], [15]. In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$$NP(x) = (T(x), I(x), F(x)),$$

Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression [6], [10], [11], [14], etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and to the methods to analyze them.

Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns. [18], [19]

Finally, Neutrosophic Logic, Neutrosophic Ensembles, and Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a novel study reference in full development.

Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data.

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number N..

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval $[I_l, I_u]$. Follow the neutrosophic mean of the variable $(\bar{x}_N)$ by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where, } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il}\ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu}\ n_N \in [n_l, n_u] \tag{2}$$

Additionally, for statistical processing, the following formula was used to calculate the neutrosophic random sample size.

$$n = \frac{ZNpq}{E^2(N-1) + Z^2pq} \tag{3}$$

Where, n: is the sample size, Z: the value of the normal distribution with the assigned confidence level, E is: desired sample error, N: is the population size. However, for the calculation of neutral squares (NNS) it can be calculated as follows.

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\left[\begin{matrix}\min\begin{pmatrix}(a_i + b_iI_L)(\bar{a} + \bar{b}I_L), (a_i + b_iI_L)(\bar{a} + \bar{b}I_U)\\ (a_i + b_iI_U)(\bar{a} + \bar{b}I_L), (a_i + b_iI_U)(\bar{a} + \bar{b}I_U)\end{pmatrix}\\ \max\begin{pmatrix}(a_i + b_iI_L)(\bar{a} + \bar{b}I_L), (a_i + b_iI_L)(\bar{a} + \bar{b}I_U)\\ (a_i + b_iI_U)(\bar{a} + \bar{b}I_L), (a_i + b_iI_U)(\bar{a} + \bar{b}I_U)\end{pmatrix}\end{matrix}\right], I \in [I_L, I_U] \tag{4}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by

$$S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2] \tag{5}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV,

the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows.

$$CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U] \tag{6}$$

The neutrosophic argumentation coefficient evaluates the criteria through Linguistic Terms with SVNN of consensus of justification of the expert opinion, (see table 1).

Linguistic term	SVNN
No Deterioration (NI)	(1,0.05,0)
Almost No Deterioration (ANI)	(0.9,0.12,0.15)
Very Low Deterioration (VLD)	(0.8,0.15,0.25)
Low Deterioration (LD)	(0.7,0.3,0.4)
Slight Deterioration (SD)	(0.6,0.35,0.5)
Deteriorated (D)	(0.5,0.45,0.53)
Fairly Deteriorated (MI)	(0.4,0.5,0.55)
Severely Deteriorated (SI)	(0.3,0.75,0.8)
Very Deteriorated (VI)	(0.2,0.8,0.85)
High Deterioration (HD)	(0.1,0.9,0.95)
Extremely Deteriorated (EI)	(0,0.95,1)

Table 1: Linguistic terms that represent the weight of the factors

3 Method development

3.1 Data Collection

For the study, the sample size of respondents is decided using equation 3, which is taken as 50% or 0.05 probabilities, according to the following results:

The maximum margin of error admitted = 10.0%

- Population size = 460
- Size for a confidence level of 95% …… 80
- Size for a confidence level of 97% …… 94
- Size for a confidence level of 99% …… 122

It is decided to work with 95% confidence, so surveys will be applied to determine the level of stability of democracy in society. To do this, the criteria of 80 respondents from the Universidad de Los Andes are evaluated.

Step 2: Groups of experts: 2 groups of 25 and one of 30 according to their specialty (total 80)

- Group of experts in political terms,
- Group of experts on the history and evolution of democracy in society,
- Group of legal experts.

The variability of the data and criteria obtained conditions the use of neutrosophic statistics. The level of instability of democracy characterized by experts denotes indeterminate random components. The existence of variability of similar responses [7], [8], [12], [13], [17], but with representative neutrosophic degrees makes the use of classical statistics impossible.

3.2 Development of the Method

For the neutrosophic statistical modeling, the experts select five factors as neutrosophic sets and their study subsets (elements associated with the relationship between democracy and society), based on defining the variable to be studied (table 2).

Variable	Coding	Sample factor	Scale
Stability levels of democracy in society	SDS	[0;80]	$[0;\ 1], \forall\ F_n$ RCD = 0 (false) RCD = 1 (True) $DCR \neq 0.5$(Existing indeterminacy in EIS)

Table 2: Characteristics of the variable. Source: own elaboration.

The data obtained may be subject to change based on changes in society and its political activity. The statistical information contributions in university studies of the Universidad de Los Andes recommend that the achievements of democracy in society are subject to change. For the development of the study, the factors that affect the stability of democracy in society were visualized (see table 3).

Factor	root causes	Degree	Relation between factor and set	Scale	Element Decision Acceptance Range
F1	Impairment of the right to a healthy environment	P	Neutrosophic set: (exploitation of resources; ecosystem risk)	[0 ; 1]	Subsets: • Exploitation level (high, medium, low, or none) • Risk index (high, medium, low, or none)
F2	Impairment of civil rights	E	Neutrosophic set: (repression of society, discrimination)	[0 ; 1]	Subsets: • Repression index (high, medium, low, or none) • Discrimination (occasional, medium, continuous)
F3	political disaffection	O	Neutrosophic set: (political corruption; political credibility)	[0 ; 1]	Subsets: • Corruption (low, medium, high) • Credibility (yes, apparent doubt, no)
F4	Worsening of the economic crisis	G	Neutrosophic set: (indebtedness and corruption)	[0 ; 1]	Subsets: • Debts with creditors (with negative impacts on the economy, non-payment, opening of investments) • Corruption (economic policies for empathy, bribes, for campaign support)
F5	Violation of regulations	C	Neutrosophic set: (constitutional weakness; relaxation of regulations)	[0 ; 1]	Subsets: • Weakness (violation, reforms, or drafts) • Flexibility (legal disability)

Table 3: Factors influencing the stability of democracy in society. Source: own elaboration.

For the development of the neutrosophic statistical study, it is recommended by the experts to analyze the variation in the stability of democracy in different periods in Ecuador. Studies in historical periods are associated, with the statistical bases and the surveys carried out (table 4). The answers must be obtained in neutrosophic terms for the modeling of the variable. Linguistic terms are converted to neutrosophic numbers as appropriate (see table 1).

No	F1	F2	F3	F4	F5
1	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
2	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
3	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]
4	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]
5	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0,0.95,1);(0.1,0.9,0.95)]
6	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]
7	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]
8	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]

9	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
10	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
11	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
12	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]
13	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0.1,0.9,0.95)]
14	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]
15	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
16	[(0,0.95,1);(0.2,0.8,0.85)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
17	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(1,0.05,0)]
18	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
19	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
20	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
21	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
22	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]
23	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0,0.95,1);(0.3,0.75,0.8)]
24	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
25	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]
26	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(1,0.05,0)]
27	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
28	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
29	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]
30	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]
31	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
32	[(0,0.95,1);(0,0.95,1)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]
33	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
34	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
35	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]
36	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.4,0.5,0.55);(1,0.05,0)]
37	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]
38	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]

39	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]
40	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]
41	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0,0.95,1);(0.2,0.8,0.85)]
42	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0,0.95,1);(0.4,0.5,0.55)]
43	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]
44	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]
45	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0,0.95,1);(0.1,0.9,0.95)]
46	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]
47	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]
48	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]
49	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]
50	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]
51	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(1,0.05,0)]
52	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.4,0.5,0.55);(1,0.05,0)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(1,0.05,0)]
53	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]
54	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]
55	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]
56	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
57	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0,0.95,1);(0,0.95,1)]
58	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]
59	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
60	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]
61	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]
62	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0,0.95,1);(0,0.95,1)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]
63	[(0.4,0.5,0.55);(0.9,0.12,0.15)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0,0.95,1);(0,0.95,1)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
64	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.1,0.9,0.95);(0.1,0.9,0.95)]
65	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]
66	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0,0.95,1);(0.3,0.75,0.8)]
67	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.6,0.35,0.5)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]
68	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]

69	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.7,0.3,0.4)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]
70	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0,0.95,1);(0.1,0.9,0.95)]	[(0.1,0.9,0.95);(0.2,0.8,0.85)]
71	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.4,0.5,0.55);(0.9,0.12,0.15)]
72	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]
73	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.4,0.5,0.55);(0.4,0.5,0.55)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
74	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0,0.95,1);(0.4,0.5,0.55)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.8,0.15,0.25)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]
75	[(0.1,0.9,0.95);(0.1,0.9,0.95)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0.4,0.5,0.55);(0.7,0.3,0.4)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]	[(0,0.95,1);(0.1,0.9,0.95)]
76	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.4,0.5,0.55)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]
77	[(0.1,0.9,0.95);(0.4,0.5,0.55)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.4,0.5,0.55);(0.8,0.15,0.25)]	[(0.1,0.9,0.95);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]
78	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.3,0.75,0.8);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0,0.95,1);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.4,0.5,0.55)]
79	[(0.2,0.8,0.85);(0.3,0.75,0.8)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0.1,0.9,0.95);(0.6,0.35,0.5)]
80	[(0.3,0.75,0.8);(0.9,0.12,0.15)]	[(0.3,0.75,0.8);(0.7,0.3,0.4)]	[(0.3,0.75,0.8);(0.3,0.75,0.8)]	[(0,0.95,1);(0.2,0.8,0.85)]	[(0.2,0.8,0.85);(0.6,0.35,0.5)]
1-80	**[(0.3,0.75,0.8);(0.5,0.45,0.53)]**	**[(0.3,0.75,0.8);(0.5,0.45,0.53)]**	**[(0.2,0.8,0.85);(0.4,0.5,0.55)]**	**[(0.3,0.75,0.8);(0.5,0.45,0.53)]**	**[(0.3,0.75,0.8);(0.4,0.5,0.55)]**

Table 4: IDLE neutrosophic frequency. Source: own elaboration.

The results obtained from the analysis of the neutrosophic frequency present an indeterminacy level close to 0.5. The result defines in what proportion the factor influences the stability of democracy in Ecuadorian society according to the sample analyzed. From the results, it is observed that:

- The right to a healthy environment, the deterioration of civil rights, and the worsening of the economic crisis affect the stability of democracy in society. These factors are severely impaired and impaired for the analyzed subset.
- Political disaffection affects the stability of democracy in society, as it is in a highly deteriorated to moderately deteriorated state.
- The infraction of the regulations affects the stability of democracy in society, with a severely deteriorated to moderately deteriorated state.

Given the existing levels of indeterminacy, it is required to visualize the neutrosophic points and the areas where each factor is found (see figure 1). Each subset is determined by the neutrosophic state of each factor within the democracy set in society.

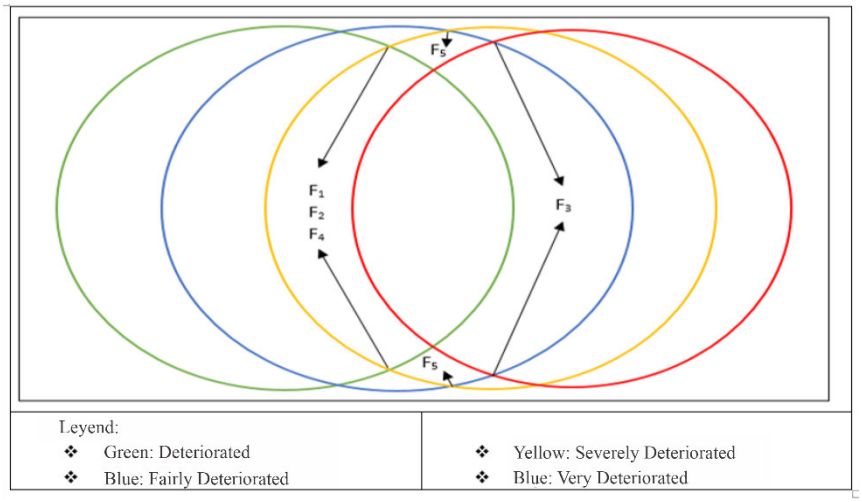


Figure 1: Neutrosophic interception of the analyzed sample subsets. Source: own elaboration.

From the analysis, it can be observed that of the eleven neutrosophic states in which the variable stability of democracy in society is represented, it is only manifested in four. Of the five factors that the study variable represents, three (F1, F2, and F4) are found in the same dimension among the study subsets. For factors, F3 and F5 are unique in the same dimension among subsets with unique state properties.

To measure the uncertainty value of each factor, the associated referent uncertainty measure is calculated for and in the form of neutrosophic numbers (Table 6). In the results obtained, it is observed that the values range from 0.056 to 0.71 with the measure of indeterminacy of [0.625; 0.0.713]. The resulting information is generated by a sample of [0;80] questionnaires and statistical information, obtained from 80 experts (table 4).

Factors	$\bar{x}_N$	Y_N	CV_N
F1	0.263 + 0.519 I;I ∈ [0,0.493,0]	0.016 + 0.325I;I ∈ [0,0.951,0]	0.061 + 0.626 I;I ∈ [0,0.903,0]
F2	0.275 + 0.549 I;I ∈ [0,0.499,0]	0.017 + 0.343 I;I ∈ [0,0.950,0]	0.062 + 0.625I;I ∈ [0,0.901,0]
F3	0.224 + 0.468 I;I ∈ [0,0.521,0]	0.016 + 0.307 I;I ∈ [0,0.948,0]	0.071 + 0.656 I;I ∈ [0,0.892,0]
F4	0.259 + 0.513 I;I ∈ [0,0.495,0]	0.016 + 0.355I;I ∈ [0,0.955,0]	0.062 + 0.692 I;I ∈ [0,0.910,0]
F5	0.268 + 0.498 I;I ∈ [0,0.462,0]	0.015 + 0.355I;I ∈ [0,0.958,0]	0.056 + 0.713 I;I ∈ [0,0.921,0]

Table 5: Neutrosophic forms with a measure of indeterminacy. Source: own elaboration.

As a result of the analysis of the neutrosophic frequencies, the deterioration of civil rights in the stability of democracy in society in Ecuador is determined with greater incidence. For each factor, a sample of the elements associated with the subset visualized by the group of experts is analyzed. The analysis of the sample that makes up the groups analyzed in the study regarding the relationship between the deterioration of civil rights, democracy, and society.

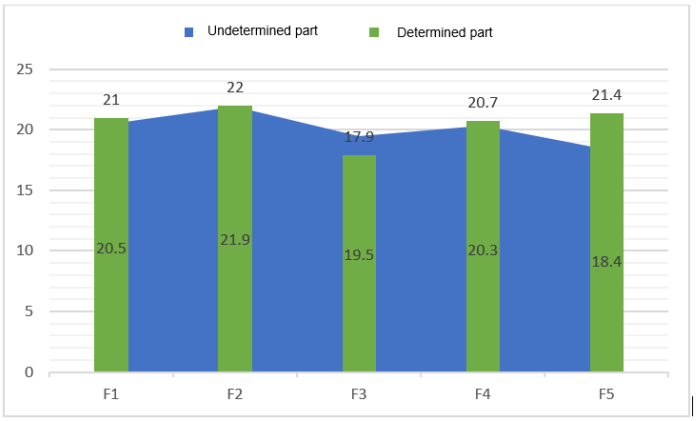


Figure 2: SDS neutrosophic bar graph. Source: own elaboration.

Figure 2 shows that for the study variable, the determined part is found between [18.4; 21.9], while the indeterminate part varies between [17.9; 22]. The existing levels of indeterminacy for both sub-sets are up to 52.14% in the EDS variable. The analysis implies that each specialist defines a criterion of stability of democracy in the society exposed to factors that vary according to the terms of office.

Partial solutions

From these neutrosophic interceptions, the solutions to be visualized are defined, of which the deterioration of civil rights is a key factor.

In order to achieve a solid democracy, it is proposed:

- Carry out structural changes that are essential in the protection of civil rights,
- Support and encourage economic and political progress, where institutions act in favor of the development of the country and the welfare of society.
- Develop a critical mentality in politicians and citizens, with a projection to prepare the new generation that contributes effectively to the transformation of the country
- Carry out policies aimed at protecting environmental rights and collective rights.

Conclusion

Neutrosophic statistics respond to the level of indeterminacy of the factors analyzed. Of the subsets, three intercepts are defined, the first in which the factors F1, F2, and F4 are found, in the second F3 and F5 are displayed in the last two intercepts. The result defines in what proportion the factor of deterioration of civil rights influences the stability of democracy in Ecuadorian society according to the sample analyzed.

The analysis shows that of the eleven neutrosophic states, the variable is present in four. Of the five factors represented by the study variable, only the right to a healthy environment, the deterioration of civil rights, and the worsening of the economic crisis are found in the same dimension. Of these factors, the one that has a lower value of CV corresponds to the deterioration of civil rights with 90.10% of neutrosophic representativeness. Therefore, we must work and dedicate actions to achieve a participatory democracy in society.

References

[1] Dadang Sundawa and A. Dahliyana, "Strengthening civic education through project citizen as an incubator for democracy education.," *Kasetsart Journal of Social Sciences,* vol. 43, no. 3, 2022.

[2] D. P. Jumbo Ordóñez, J. A. Campuzano Vásquez, F. Y. Vega Jaramillo, & , and Á. E. Luna Romero, "Crisis económicas y covid-19 en Ecuador: impacto en las exportaciones. ," *Revista Universidad y Sociedad,* vol. 12, pp. 103-110, 2020, doi: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2218-36202020000600103&nrm=iso.

[3] Jantana Suttijareea and W. Trakarnsirinont, "The strengthening of local citizens: A cases study of Umong Sub-district Municipality, Lamphun Province and Korrum Sub-district Administration Organization, Uttaradit Province.," *Kasetsart Journal of Social Sciences,* vol. 42, no. 4, 2021, DOI: https://so04.tci-thaijo.org/index.php/kjss/article/view/255716.

[4] R. P. Alava, J. M. Murillo, R. B. Zambrano, & , and M. I. Zambrano Vélez, "PEST Analysis Based on Neutrosophic Cognitive Maps: A Case Study for Food Industry," *Neutrosophic Sets and Systems,* vol. 21, no. 1, p. 10, 2018.

[5] K. P. Teruel, CedeñoCedeñ, J., Gavilanez, H. L., Diaz, C., & Vázquez, M. L., "A framework work for selecting ccloud computing services based on consensus under single valued neutrosophic numbers. ," *Neutrosophic Sets and Systems,* vol. 22, no. 1, pp. 38-40, 2018.

[6] U. Afzal, H. Alrweili, N. Ahamd, and M. Aslam, " Neutrosophic statistical analysis of resistance depending on the temperature variance of conducting material," *Scientific Reports,* vol. 11, no. diciembre, p. 23939, 2021.

[7] M. Á. Quiroz Martínez, J. M. Mora, J. M. Gruezo, &, and M. Y. Leyva Vázquez, "Causal models as an aid to understanding complex systems: Analysis of critical success factors in the development of chatbots.," *Universidad y Sociedad,* vol. 12, no. 4, pp. 64-72, 2020, doi: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85100871445&partnerID=40&md5=d951f67d1cf1afadf66ef494d9ee5e6d.

[8] R. González Salas & I. Pimienta Concepción. "El enfoque "Una sola salud" y las zoonosis reemergentes". Revista Universidad y Sociedad, vol. 14 no. S2, pp 385-390, 2022.

[9] B D. Narváez Montenegro, F.J Caicedo Banderas, E. J. Naranjo Luzuriaga & F. D. Guaigua Vizcaíno. "El goce de la licencia de maternidad en el Ecuador". Universidad y Sociedad, vol. 14 no. S2, pp 379-384, 2022.

[10] W. A. Cacpata Calle, V. V. Ponce Meza, A. S. Gil Betancourt, & J. P. Pardo. "La conciliación como mecanismo de justicia restaurativa en el delito de robo: cantón Santo Domingo". Universidad y Sociedad, vol. 14 no. S2, pp 373-378, 2022.

[11] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[12] Ricardo, J. E., Villalva, M. I. M., Padilla, Z. A. O., & Hurtado, L. A. C. "Filosofía de la comunicación, complemento necesario en el aprendizaje de las Ciencias Sociales". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 3 no. 2, pp 39-52, 2018.

[13] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[14] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[15] Leyva, M., Estupiñán, J., Coles, W., & Bajaña, L. "Investigación científica. Pertinencia en la educación superior del siglo XXI". Conrado, vol. 17 no. 82, pp 130-135, 2021.

[16] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.

[17] Von Feigenblatt, O. F. “Honor, Loyalty, and Merit: The Cultura Contemporary of the Spanish Nobility”. Ediciones Octaedro, 2022.

[18] V. A. Salame Ortiz, R. G. López Torres & F. M. Armijos Briones. “La correlación entre la maloclusión y la postura corporal”. Universidad y Sociedad, vol. 14 no. S3, pp 45-51, 2022.

[19] R. F. Donoso Noroña, N. Gómez Martínez & A. Rodriguez Plasencia. “Relación del estrés, afectaciones respiratorias y el vértigo con el tratamiento del tinnitus”. Universidad y Sociedad, vol. 14 no. S3, pp 35-44, 2022

Received: September 11, 2022. **Accepted:** October 29, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Neutrosophic Analysis of the Irrational Exploitation of Natural Resources

María Lorena Merizalde Avilés[1], Sheila Belén Esparza Pijal[2], Milton Rodrigo Hidalgo Ruiz[3] and Simón Bolívar Gallegos Gallegos[4]

[1] Universidad Regional Autónoma de los Andes, Matriz Ambato. Ecuador. E-mail: ua.mariamerizalde@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes, Sede Ibarra. Ecuador. E-mail: docentetp81@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes, Sede Puyo. Ecuador. E-mail: up.miltonhidalgo@uniandes.edu.ec
[4] Universidad Regional Autónoma de los Andes, Sede Santo Domingo. Ecuador. E-mail: us.simongallegos@uniandes.edu.ec

Abstract: Natural resources are used by human beings to satisfy their subsistence needs. In this sense, the conservation of the environment requires a system of social, socioeconomic, and technical-productive measures, aimed at the rational use of natural resources, the conservation of natural complexes, as well as the defense of the environment against pollution and degradation. The objective of this study is to analyze the factors that influence the irresponsible use of natural resources through neutrosophic statistics. From the results, it was obtained that a proposal to reform the environmental legislation should be recommended to control and avoid the overexploitation of natural resources, in addition to achieving environmental education in the population and thus acquiring responsible ecological behavior in society.

Keywords: Environment, natural resources, conservation, ecological behavior.

1. Introduction

The conservation of natural resources is an essential task to move towards a more sustainable economy that takes into account their availability. Life depends heavily on natural resources. Everything is made of materials that, in one way or another, have been extracted from nature. Natural resources are the elements and forces of nature that man can use and take advantage of. They are those goods that nature provides and that are used by people either to consume them directly or to be used in some production process. These represent sources of wealth for economic exploitation. They can be biotic or abiotic and are classified into renewable and non-renewable resources.

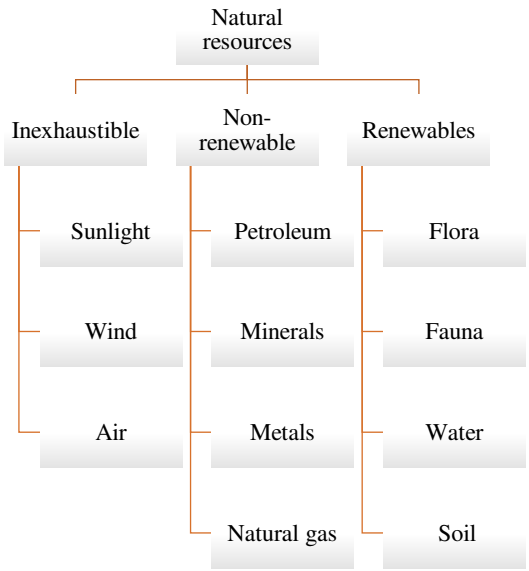


Figure 1: Natural resources. Source: own elaboration

The exploitation of non-renewable natural resources has caused the destruction of the environment. A perhaps

irreversible environmental impact if nothing is done about it so as not to continue with this type of activity that is harmful to nature. In environmental legislation, restoration mechanisms should be specified, and strict and necessary measures should be taken to prevent companies from continuing to destroy the environment itself.

Among the renewable resources are the flora and fauna where there is a very close dependence, based on natural laws that govern the structure and functions of the associations of living beings. Feeding relationships, or trophic relationships, determine the so-called food chains, in which herbivorous animals constitute the basic food for other groups of animals that, in turn, will serve as food for others. This has the consequence that the decrease in number or the disappearance of one of these links in the chain, due to natural causes or the influence of man, endangers the entire system. That is, the balance that characterizes the relationships between the biotic and abiotic environment of nature is broken.

Currently, the development of society is equally attacking the species of animals and plants, in those countries subject to the excessive exploitation of natural resources. The development of industry, which pollutes the environment with its waste, also affects the natural environment and, consequently, the living systems that inhabit it. This leads to reflecting on the care that man must have when exploiting the resources that nature provides.

Ecuador recognizes and guarantees constitutional rights to nature: full respect for its existence, and restoration. Therefore, it is necessary to fight for the protection of all the species and ecosystems that coexist in it, to live in harmony with nature and not unbalance everything that has meant millions of years of evolution, but that can be demolished in decades of irrational human exploitation. The supreme norm establishes state and citizen duties, framed in respect for nature, the Ecuadorian Constitution, provides for its application and interpretation according to the principles of the supreme norm [1, 2].

It is a customary practice to locate industries and human settlements on the banks of water currents, to use said liquid, and, at the same time, dump the waste from the industrial process and human activity. This results in the contamination of water sources and the loss of large volumes of this resource. Currently, many countries that are concerned about conservation, prohibit this practice and require the treatment of waste to bring it to admissible measures for human health.

The responsible use of natural resources guarantees a healthier and more balanced environment. It is necessary to make people aware of the negative effects that the planet suffers when excessively using its resources. Humanity has always taken advantage of the natural resources in its environment to make life easier and better. And that is the exploitation of natural resources [3].

When talking about exploitation, reference is made to how benefits are extracted from nature to be used in a market economy. Because, although the Ministry of the Environment of Ecuador, exercises the governing role of environmental management and its function is to guarantee a healthy and ecologically balanced environment to make the country a nation that conserves and sustainably uses its biodiversity. In addition to maintaining and improving environmental quality and seeking and promoting sustainable development and social justice, it is not enough because the exploitation of the resources that nature provides must be planned, in order to anticipate problems and seek alternatives.

Human beings are part of the ecosystem and infer or cause environmental problems through their behavior, depending on the degree of knowledge, respect, and responsibility they have towards nature. The concept of environment has almost always been associated exclusively with natural systems, with the protection and conservation of ecosystems, perceived as the unique relationships between biotic and abiotic factors, without analysis or reflection on the incidence of sociocultural, political, and economic aspects in the dynamics of these natural systems.

In the case of Ecuador, due to its geographical location, it enjoys great natural wealth and among its natural resources, it contains water resources, forestry, soil, fauna, flora, etc. These are used by Ecuadorians as a source of work and subsistence, which promotes the economy and other social aspects. The production of wood is an important economic source for the country, but the deforestation suffered by the great demand for wood causes a degenerative process to take place in the area.

In the country, in addition to identifying a positive increase in its economic variables in recent years, concern for the environment has intensified with not very clear results on the reduction of pollution and the increase in levels of degradation. It is not enough to protect the environment as a place in which human beings live, it is necessary to promote the sustainable development of the environment to guarantee the efficient use of these and future generations.

The environmental degradation with greater notoriety is anthropic. It generally originates because a series of economic agents behave in such a way that, by solving certain particular problems, they generate environmental deterioration as a consequence. The solution to the problem likely involves designing a series of measures, of all kinds, aimed at modifying this behavior. Natural resources are depleted due to a practice of exploitation governed by economic, productive, and extractive logic and rationality, which also generates negative environmental and social impacts, of a local, regional and global nature, in the worst case irreversible. The action of human beings on the environment has produced a planetary environmental emergency [4], [17], [20].

In Ecuador, the social development of communities influences environmental deterioration. This is described by internal disparities between the development of the provinces and the gross national income. No development

model is considered as such if it does not link the community in its efforts, so it is important to link the endogenous development of the communities in order to favor economically and socially the most unprotected.

On the other hand, the technological development that is unmatched by others, allowed a substantial improvement in the quality and life expectancies of the human being, compared to pre-industrial times. But it also brought with it pollution, overexploitation, and ecological destruction. [16]

Consequences of overexploitation:

- Resource depletion. The extinction of species, the rapid exhaustion of mines, or the end of exploitable surfaces weaken the industry and lead to a crisis of raw materials.
- Environmental destruction. The destruction of natural habitats affects the quality of life of numerous species, leading to extinction and the impoverishment of global biodiversity.
- Pollution. Overexploitation releases a greater amount of toxic, radioactive, or ecological balance-modifying waste, without giving the ecosystem time to deal with them or recover from its impact.
- Socioeconomic crisis. The imbalance of the extraction mechanisms usually leads to a raw material crisis and, therefore, to imbalances in the international market, now that the economy is globalizing. This translates into poverty and social and economic damage for the weakest countries.
- Increased global warming and climate change.

The care of natural resources is transcendental, not only because they are the basis of modern productive societies, but also because they are an essential part of nature and are what allows the existence of living beings on planet Earth. Human activity exploits them intensely, so there must be regulations in the different territories to control and prevent their overexploitation. The environmental impact caused by human action is even greater, and has irreversible consequences, because non-renewable resources are exploited, which at a given moment can end, and even worse, without being restored or rehabilitated. [22], [23], [24]

This study aims to analyze the factors that influence the irresponsible use of natural resources, to mitigate or eliminate the environmental impact caused by their irrational exploitation. As well as to propose a reform to the environmental legislation to implement the mechanisms of restoration to nature.

2 Materials and methods

2.1 Neutrosophic Statistics

Neutrosophic Statistics was founded by Prof. Florentin Smarandache who developed it in 2014 introducing Neutrosophic Descriptive Statistics (NDS). Later, Prof. Muhammad Aslam, from King Abdulaziz University, Saudi Arabia, founded Neutrosophic Inferential Statistics (NIS), Neutrosophic Applied Statistics (NAS), and Neutrosophic Statistical Quality Control (NSQC) in 2018.

Neutrosophic probabilities and statistics are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of event E is the probability that event E occurs [5], [18], the probability that event E does not occur, and the probability of indeterminacy (not knowing whether event E occurs or not). In classical probability nsup≤1, while in neutrosophic probability nsup≤3+.

The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$NP(x) = (T(x), I(x), F(x))$,

Where T(x) represents the probability that value x occurs, F(x) represents the probability that value x does not occur, and I(x) represents the undetermined or unknown probability of value x.

Neutrosophic Statistics is the analysis of neutrosophic events and deals with neutrosophic numbers, neutrosophic probability distribution, neutrosophic estimation, neutrosophic regression, etc. It refers to a set of data, which is formed totally or partially by data with some degree of indeterminacy and the methods to analyze them [6], [19].

While Classical Statistics deals with determined data and determined inference methods, Neutrosophic Statistics deals with indeterminate data, that is, data that has some degree of indeterminacy (unclear, vague, partially unknown, contradictory, incomplete, etc.), and of indeterminate inference methods that also contain degrees of indeterminacy (for example, instead of arguments and crisp values for probability distributions, graphs, diagrams, algorithms, functions, etc. may have inaccurate or ambiguous arguments and values)

Neutrosophic Statistics is also a generalization of Interval Statistics because while Interval Statistics is based on Interval Analysis, Neutrosophic Statistics is based on Set Analysis (understanding by such all types of sets, not just intervals).

If all the data and methods of inference are determined, then Neutrosophic Statistics coincides with Classical Statistics. Since in our world, we have more indeterminate than determined data, more neutrosophic than classical statistical procedures are needed [7,8, 14].

Neutrosophic statistical methods allow neutrosophic data (data that may be ambiguous, vague, imprecise, incomplete, or even unknown) to be interpreted and organized to reveal underlying patterns.

Finally, the Neutrosophic Logic [9], the Neutrosophic Sets, and the Neutrosophic Probabilities and Statistics have a wide application in various research fields and constitute a new reference for study in full development.

Neutrosophic Descriptive Statistics comprises all the techniques for summarizing and describing the characteristics of neutrosophic numerical data [10, 11, 13, 21, 22, 23, 24].

Neutrosophic Numbers are numbers of the form $N = a + bI$ where a and b are real or complex numbers, while "I" is the indeterminacy part of the neutrosophic number N.

The study of neutrosophic statistics refers to a neutrosophic random variable where X_l and $X_u I_N$ represents the lower and correspondingly higher level that the studied variable can reach, in an indeterminate interval. Following the neutrosophic mean of the variable by formulating:

$$X_N = X_l + X_u I_N;\ I_N \in [I_l, I_u] \tag{1}$$

$$\text{Where } \bar{x}_a = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{il},\ \ \bar{x}_b = \frac{1}{n_N}\sum_{i=1}^{n_N} X_{iu},\ n_N \in [n_l, n_u], \tag{2}$$

is a neutrosophic random sample. However, for the calculation of neutral squares (NNS) it can be calculated as follows

$$\sum_{i=1}^{n} N(X_i - \bar{X}_{iN})^2 = \sum_{i=1}^{n} N\begin{bmatrix} \min\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix} \\ \max\begin{pmatrix}(a_i + b_i I_L)(\bar{a} + \bar{b} I_L), (a_i + b_i I_L)(\bar{a} + \bar{b} I_U)\\ (a_i + b_i I_U)(\bar{a} + \bar{b} I_L), (a_i + b_i I_U)(\bar{a} + \bar{b} I_U)\end{pmatrix}\end{bmatrix}, I \in [I_L, I_U] \tag{3}$$

Where $a_i = X_l b_i = X_u$. The variance of the neutrosophic sample can be calculated by:

$$\boldsymbol{S_N^2 = \frac{\sum_{i=1}^{n_N}(X_i - \bar{X}_{iN})^2}{n_N};\ S_N^2 \in [S_L^2, S_U^2]} \tag{4}$$

The neutrosophic coefficient (NCV) measures the consistency of the variable. The lower the value of the NCV, the more consistent the performance of the factor is than that of the other factors. The NCV can be calculated as follows [12, 13].

$$\boldsymbol{CV_N = \frac{\sqrt{S_N^2}}{\bar{X}_N} \times 100;\ CV_N \in [CV_L, CV_U]} \tag{5}$$

3 Results

Application of the techniques outlined above, for the analysis of the factors that influence the irresponsible use of natural resources. Due to the complexity and indeterminacy of the data, it was decided to apply neutrosophic statistics for the modeling of the analyzed variable.

From the processing of the information and the consensus of the experts, the factors that most influence the irrational exploitation of natural resources and the variable to be modeled were determined (Table 1).

Factors that affect the irrational exploitation of natural resources	**Scale**	**Traits**	**Category of incidence**
Industrial activity	[0 ; 5]	Insufficient or null development of production techniques that are not harmful to the environment.	0 – They do not constitute a danger to natural resources. 1 – Likely to affect in the long term. 2 – It affects on a smaller scale. 3 – It is considered an affectation.
Poverty	[0 ; 5]	Insufficient income that forces a certain number of people to participate in environmental deterioration.	
Lack of regulations	[0 ; 5]	Low level of implementation of rules and regulations by governing and control	

		bodies in the fight to conserve natural resources.	4 – It is considered an affectation with an impact in the region.
Economic needs of the community.	[0 ; 5]	Insufficient income levels and internal differences between the development of communities.	5 – It constitutes a threat to the ecosystem.
Minimal existence of educational tools.	[0 ; 5]	Lack of reorientation of environmental education.	

Table 1. Incidence category for each factor. Source: own elaboration

It was decided to codify the factors and thus make the results viable, for the modeling of neutrosophic statistics (Figure 1). Variable analyzed: irrational exploitation of natural resources, for a sample of n=130 for each factor (f).

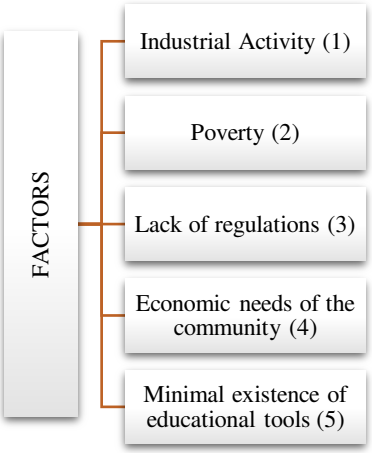


Figure2: Determining factors in the irrational exploitation of natural resources. Source: Own elaboration.

For the development of the statistical study, the neutrosophic frequencies of the determining factors in the irrational exploitation of natural resources are analyzed. For each factor, an incidence score is analyzed, which makes up the set of affectations to anticipate problems and look for alternatives.

Days	Neutrosophic frequencies				
	1	**2**	**3**	**4**	**5**
1	[2 , 5]	[0 , 0]	[1, 3]	[0 , 2]	[1 , 1]
2	[1, 3]	[0 , 0]	[0 , 3]	[0 , 0]	[1 , 2]
3	[0 , 3]	[2, 4]	[2 , 5]	[1, 4]	[1, 4]
4	[1, 1]	[2, 4]	[1, 3]	[0 , 2]	[1 , 1]
5	[0 , 1]	[0 , 3]	[0 , 3]	[1 , 2]	[1 , 2]
6	[1 , 2]	[2, 4]	[1, 1]	[0 , 2]	[1 , 1]
7	[0 , 1]	[2 , 2]	[0 , 1]	[2 , 2]	[1 , 2]
8	[1 , 2]	[1, 4]	[2 , 2]	[1 , 1]	[0 , 1]
9	[2, 3]	[1 , 2]	[1, 4]	[0 , 1]	[1 , 2]
10	[2 , 5]	[1, 4]	[0 , 2]	[0 , 0]	[2, 3]
11	[1, 4]	[2, 3]	[2, 4]	[2 , 5]	[2, 3]
12	[1, 4]	[0 , 0]	[2 , 5]	[2 , 5]	[1 , 2]
13	[2 , 2]	[1 , 2]	[2, 4]	[2, 3]	[1, 3]
14	[1, 4]	[2, 4]	[1, 3]	[0 , 1]	[1, 4]
15	[1 , 2]	[1 , 2]	[2, 4]	[1 , 2]	[2 , 5]
16	[1 , 2]	[1 , 1]	[2, 4]	[0 , 0]	[1, 4]

17	[2, 4]	[0 , 0]	[0 , 3]	[1, 4]	[1 , 1]
18	[0 , 0]	[2, 4]	[2, 4]	[2, 4]	[0 , 1]
19	[2, 3]	[1, 3]	[1 , 1]	[1 , 2]	[2 , 5]
20	[2 , 5]	[1, 3]	[0 , 2]	[0 , 0]	[2 , 2]
21	[2, 4]	[2 , 2]	[2, 3]	[0 , 0]	[0 , 2]
22	[2 , 2]	[0 , 0]	[1, 3]	[0 , 0]	[2 , 5]
23	[2 , 5]	[0 , 0]	[1, 4]	[0 , 3]	[0 , 1]
24	[0 , 1]	[1, 3]	[1, 4]	[1 , 1]	[0 , 3]
25	[0 , 3]	[0 , 2]	[2 , 2]	[0 , 2]	[0 , 0]
26	[2, 4]	[1 , 1]	[0 , 0]	[0 , 1]	[2 , 5]
27	[2, 4]	[0 , 3]	[1, 4]	[1 , 2]	[2, 3]
28	[2, 3]	[2 , 2]	[1 , 2]	[1, 4]	[0 , 3]
29	[1, 3]	[2, 3]	[2 , 2]	[2, 3]	[0 , 0]
30	[1 , 2]	[1, 4]	[2, 3]	[0 , 0]	[2, 3]
0-130	[132, 366]	[142, 343]	[153, 361]	[110, 287]	[137, 352]

Table 2. Neutrosophic frequencies of the factors. Source: own elaboration

Table 2 analyzed the neutrosophic frequencies of occurrence of the determining factors in the irrational exploitation of natural resources, for 130 days, with an occurrence level of [0; 5] for each factor per day with a total uncertainty level of 1=234, 2=201, 3=208, 4=177, 5=215, and a representativeness level of [57.62%; 63.93%], on the days that 5 affectations per factor are registered, with an incidence of 60% in terms of poverty. The poor move to areas of high diversity to acquire the resources they need to meet social demands in an unsustainable way, without implementing restoration strategies based on natural regeneration.

From the results of the affectations of the design (Table 3), it will be possible to understand which factor implies a representative mean $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, the values of the neutrosophic measures are calculated, and for the study of the variations of the affectations, the values of the standard deviation neutrosophic $S_N \in [S_L; S_U]$. To determine which affectation requires a greater incidence in the irrational exploitation of natural resources, the values $CV_N \in [CV_L\ ;\ CV_U]$ are calculated.

Factors	$\bar{x}_N$	S_N	CV_N
Industrial activity	[1,015 ; 2,815]	[0.423 ; 2024]	[0.417 ; 0.719]
Poverty	[1,092 ; 2,638]	[0.433 ; 2001]	[0.397 ; 0.759]
Lack of regulations	[1,177 ; 2,777]	[0.419 ; 1826]	[0.356 ; 0.658]
Economic needs of the community.	[0.846 ; 2,208]	[0.439 ; 2,075]	[0.519 ; 0.94]
Minimal existence of educational tools.	[1,054 ; 2,708]	[0.445 ; 2,167]	[0.422 ; 0.8]

Table 3. Neutrosophic statistical analysis of incidents in the irrational exploitation of natural resources. Source: own elaboration.

It was determined that factors 3 and 1, have higher average values that affect the other factors (Table 3). Therefore, they are, on average, the ones that incur the most in the excessive use of natural resources and the conservation of the environment. On the other hand, the value of CV_{Nb} in 3 is lower than the rest. Therefore, its result has a more solid, coherent, and exact impact than the other factors when evaluating indeterminacy, in the efficient use and care of the environment.

Factors	$\bar{x}_N$	Y_N	CV_N
1	1,015 + 2,815 I	0.423 + 2.024 I	0.417 + 0.719 I
2	1,092 + 2,638 I	0.433 + 2.001 I	0.397 + 0.759 I
3	1,177 + 2,777 I	0.419 + 1.826 I	0.356 + 0.658 I
4	0.846 + 2.208 I	0.439 + 2.075 I	0.519 + 0.94 I
5	1,054 + 2,708 I	0.445 + 2.167 I	0.422 + 0.8I

Table 4. neutrosophic forms. Source: Own elaboration

Factors	$\bar{x}_N$	Y_N	CV_N
1	$I \in [0.0; 63.9]$	$I \in [0.0; 79.1]$	$I \in [0.0; 42.0]$
2	$I \in [0.0; 58.6]$	$I \in [0.0; 78.4]$	$I \in [0.0; 47.7]$
3	$I \in [0.0; 57.6]$	$I \in [0.0; 77.1]$	$I \in [0.0; 45.9]$
4	$I \in [0.0; 61.7]$	$I \in [0.0; 78.8]$	$I \in [0.0; 44.8]$
5	$I \in [0.0; 61.1]$	$I \in [0.0; 79.5]$	$I \in [0.0; 47.3]$

Table 5. Uncertainty measures. Source: own elaboration.

The associated referent uncertainty measure is calculated, $\bar{x} = \in [\bar{x}_L; \bar{x}_U]$, $S_N \in [S_L; S_U]$ y $CV_N \in [CV_L\ ;\ CV_U]$ and in the form of neutrosophic numbers (comparative analysis. Tables 4 and 5). The results show that the values range from 0.356 to 0.658, with the measure of indeterminacy generating a negative impact on the lack of regulations regarding the a45.9. Application of regulations that guarantee supervised exploitation and the conservation of the environment.

Man must study the relationships and laws that determine the balance in nature and become its maximum protector, since, in a general sense, all the effects suffered by the natural environment have repercussions on it in one way or another. The actions that are carried out to promote the sustainable and economic development of Ecuador must be taken into account as government policies to guarantee the economic and social sustainability of the citizenry. It is a duty to take care of resources, as well as to create awareness of the role they play in the life of all living beings. [14]

Reorient education towards sustainable development. Therefore, educational approaches aimed at promoting the development of communities, which can act in favor of the establishment of development and environmental models, should be incorporated into environmental education. Awareness must be generalized to the entire population because the responsible use of what is obtained from nature is important in the daily life of all people. Environmental care and the efficient use of natural resources is a task that involves the interest of all humanity. In the country, promoting the efficient use of environmental resources through research studies is of great importance since they promote the balanced use of the satisfaction of human needs in the present. Care and respect for the environment, as well as for the diversity of life and natural resources, are the guarantee of being able to satisfy the environmental needs of future generations. [15]

Conclusion

Human beings use elements obtained from the natural environment to supply basic needs. Other resources are used for the production of tools and products in various industries. This type of activity witnessed a great increase as a result of the industrial revolution and subsequent technological revolutions that allowed the emergence of contemporary society. The new consumer society needed to mass-produce its goods, which required constant raw materials in large quantities. All this use without measure has a negative impact on ecosystems and results in global warming, the clearing of forests, and the reduction of species of flora and fauna.

The analysis of the neutrosophic statistics arrived at a level of indeterminacy of 45.9% that the lack of regulations is the affected factor since there are legal gaps in determining compliance with the laws and the levels to achieve natural renewal. This has an inversely proportional influence with respect to the other factors so that if this factor decreases, the other factors increase and the exploitation suffered by natural resources would be reversible through the conservation of the environment.

All of the above leads to the conclusion that it is of great importance to reform the Environmental Management Law. In this, actions must be taken such as planning the exploitation of the resources that nature provides, in order to anticipate problems and look for alternatives. Regulate the application of good environmental practices, as well as decrees that sanction those who do not have an environmental license. The State must undertake policies that guarantee the preservation of the environment since the intensive use of natural resources translates into a decrease in income, which condemns a country to poverty.

References

[1] I. A. Cruz Piza, L. J. Bajaña Bustamante, and M. O. Morales Campoverde, "Derechos de la naturaleza en Ecuador," Universidad Y Sociedad, vol. 14, pp. 351-357, 2022.

[2] G. R.E.A., "THE HUMAN RIGHTS FROM THEIR PERSPECTIVE OF THE ECUADORIAN LEGISLATION," Universidad y Sociedad, vol. 14, pp. 498-503, 2022.

[3] J. A. Orellana Salas and T. D. C. Lalvay Portilla, "Uso e importancia de los recursos naturales y su incidencia en el desarrollo turístico. Caso Cantón Chilla, El Oro, Ecuador," Revista interamericana de ambiente y turismo, vol. 14, pp. 65-79, 2018.

[4] D. Cadena-Piedrahita, S. Helfgott-Lerner, A. Drouet-Candel, F. Cobos-Mora, and N. Rojas-Jorgge, "Herbicides in the Irrigated Rice Production System in Babahoyo, Ecuador, Using Neutrosophic Statistics," Neutrosophic Sets and Systems, vol. 39, pp. 153-163, 2021.
[5] S. H. S. Al-Subhi, I. Pérez Pupo, R. García Vacacela, P. Y. Piñero Pérez, and M. Y. Leyva Vázquez, "A New Neutrosophic Cognitive Map with Neutrosophic Sets on Connections, Application in Project Management. ," Neutrosophic Sets and Systems, vol. 22. , pp. 63-75, 2018.
[6] Y. Alhasan, "The neutrosophic integrals and integration methods," Neutrosophic Sets and Systems, vol. 43, pp. 290-301, 2021.
[7] R. Refaat and I. M. El-Henawy, "Innovative method to evaluate quality management system audit results' using single value neutrosophic number," Cognitive Systems Research, vol. 57, pp. 197-206, 2019.
[8] J. Estupiñan Ricardo, M. E. Llumiguano Poma, A. M. Argüello Pazmiño, A. D. Albán Navarro, L. Martín Estévez, and N. B. Hernandez, "Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador," Neutrosophic Sets & Systems, vol. 26, 2019.
[9] Pérez-Teruel, Neutrosophic logic for mental model elicitation and analysis.: Neutrosophic Sets and Systems, 2012.
[10] F. Smarandache, Neutrosophy, a new Branch of Philosophy: Infinite Study, 2002.
[11] F. Smarandache, "A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Infinite Study.," 2005.
[12] R. F. Sánchez Santacruz, L. I. Barahona Tapia, & R. L. Maldonado Manzano. "Causas fundamentales de la migración hacia y desde el Ecuador". Universidad y Sociedad, Vol. 14 Num. S2, pp- 308-314, 2022.
[13] R. F. Sánchez Santacruz, R. L Maldonado Manzano & L. I. Barahona Tapia. "La rehabilitación social en el Estado Constitucional del Ecuador". Universidad y Sociedad, Vol. 14 Num. S2, pp- 300-307, 2022.
[14] M. J. Cabezas Arellano, F. M. Pozo Hernández & O. R. Aldaz Bombón. "Competitividad de empresas envasadoras de agua en Santo Domingo". Universidad y Sociedad, Vol. 14 Num. S2, pp- 290-299, 2022.
[15] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021
[16] Ricardo, J. E., Vázquez, M. Y. L., Palacios, A. J. P., & Ojeda, Y. E. A. "Inteligencia artificial y propiedad intelectual". Universidad y Sociedad, vol. 13 no. S3, pp 362-368, 2021.
[17] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.
[18] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.
[19] Álvarez Gómez, G. A., Viteri Moya, J. R., Viteri Intriago, D. A., & Estupiñán Ricardo, J. "Integración de los procesos sustantivos para la mejora de la calidad del aprendizaje". Conrado, vol. 17 no. 80, pp 21-27, 2021.
[20] Caballero, E. G., Leyva, M., Ricardo, J. E., & Hernández, N. B. "NeutroGroups Generated by Uninorms: A Theoretical Approach". In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global, 2022.
[21] Acuña, B. P., & Von Feigenblatt, O. F. "La lengua y la literatura en el aula del futuro enmarcado en el aprendizaje personalizado. In Aprendizaje personalizado y education maker: Nuevos paradigmas didácticos y otras aproximaciones" (pp. 13-24). Ediciones Octaedro, 2022.
[22] W. R. Paredes Navarrete, D. R. Samaniego Carrillo, I. J. Diaz Basurto & J. W. Soxo Andachi. "La motivación como una garantía del debido proceso en el sistema de aplicación de justicia ecuatoriana". Universidad y Sociedad, vol. 14 no. S4, pp 674-681, 2022.
[23] S. M. Gavilánez Villamarín, K. I. Agualsaca Pallares, C. G. Rosero Martínez & O. F. Silva Montoya. "Valoración del nivel de conocimiento de los funcionarios judiciales sobre los delitos contra la flora y fauna silvestres en el cantón Santo Domingo, Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 668-673, 2022.
[24] L. D. Valverde Maya, C. F. Benavides Salazar, M. L. Merizalde Avilés & F. A. Guanoluisa Almache. "Vulneración al derecho de libertad de las personas aprehendidas en supuesto delito flagrante en Ecuador". Universidad y Sociedad, vol. 14 no. S4, pp 657-667, 2022.

Received: September 12, 2022. **Accepted:** October 30, 2022

NSS
Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022
University of New Mexico

Application of Neutrosophy in the Study of the Factors that Influence Ecuadorian Tourism Development

Sharon Diznarda Álvarez Gómez[1], Ariel José Romero Fernández[2] and Manuel Ricardo Rivas Bravo[3]

[1] Universidad Regional Autónoma de los Andes, Matriz Ambato. Ecuador. E-mail: dirfinanciera@uniandes.edu.ec
[2] Universidad Regional Autónoma de los Andes, Matriz Ambato. Ecuador. E-mail: dir.investigacion@uniandes.edu.ec
[3] Universidad Regional Autónoma de los Andes, Matriz Ambato. Ecuador. E-mail: direccionty g@uniandes.edu.ec

Abstract. Tourism worldwide is one of the most important sectors of the economy, taking into account the sources of employment it generates, as well as the growth of world GDP, which is why it occupies one of the main measures of sustainable development in the countries. Ecuador is one of the countries with the greatest biodiversity on the planet, and it has kept an increase in the arrival of tourists in recent years due to its natural wonders, which include visits to beaches, snow-capped mountains, and even excursions to jungle areas. It is worth mentioning that in all destinations you can appreciate biodiversity in all its splendor. The objective of this scientific paper is to carry out a study of the main factors that influence the development of Ecuador as a tourist destination. Two neutrosophic methods were used for this: (Neutrosophic AHP and DEMATEL) due to their versatility in decision-making and expert criteria processing. The conclusions reached indicate that the factors that need more attention are the prices in the tourist packages and the security of the tourist destination, its correct treatment will guarantee to turn Ecuador into a sustainable tourist destination.

Keywords: Tourism, Ecuador, Neutrosophy, AHP, DEMATEL.

1. Introduction

Ecuador is an important pillar in the tourist development of the Americas. The tourism sector has become a key structure that guarantees one of the four main foreign exchange contributions to the country's economic development. This situation motivates and drives a constant spirit of creativity, innovation, and entrepreneurship towards new ways and means of maintaining and improving this tourism development. It is a mega-diverse country and, without a doubt, one of the richest on the planet, thanks to its great contrasts; in its small territory, they combine four natural regions: Galapagos, Coast, Andes, and Amazon that offer an immensity of soils, climates, mountains, moors, beaches, islands and jungles that are home to thousands of species of flora and fauna [1, 2].

In its provinces, you can find 10,000 species of plants, 8,200 plant species, of which 2,725 belong to the group of orchids, 1,640 species of birds, 4,500 butterflies, 345 reptiles, 358 amphibians, and 258 mammals, etc. To preserve this natural wealth, Ecuador has a heritage of 49 State Protected Areas. UNESCO has recognized the natural wealth of the country, declaring the Marine Reserve, the Galapagos National Park, and the Sangay National Park as "Natural Heritage of Humanity" and cities such as Cuenca and Quito as World Heritage Sites.

One of the most important tourist attractions in the country is the Galapagos Islands, they are unique in the world because they have beautiful beaches and a spectacular climate where you can enjoy accommodation services, food and beverages, transportation, operation, brokerage, hot springs, spas, bowling alleys, skating rinks, racetracks and recreation centers, which allows national and international tourists to enjoy this wonderful place [3, 4]. In addition, it constitutes one of the largest, most complex, diverse, and best-preserved oceanic archipelagos in ecological terms that currently exist on the planet, it is considered the second largest marine reserve in the world behind the Australian Great Barrier Reef.

2 Neutrosophy

2.1 General aspects of neutrosophy

In this paper, Neutrosophy will be used as a calculation tool. Neutrosophy is the branch of philosophy that studies the origin, nature, and scope of neutralities. Logic and Neutrosophic Sets are generalizations of other theories, such as fuzzy sets, intuitionistic fuzzy sets, and interval-shaped fuzzy sets, among others [5].

The use of Neutrosophic Sets allows, in addition to the inclusion of membership functions of truth and falsehood, also membership functions of indeterminacy. This indeterminacy is due to the existence of contradictions, ignorance, and inconsistencies, among other causes due to lack of information, contradictory information, and inconsistent paradox, among others. Neutrosophic logic is a generalization of fuzzy logic based on the concept of Neutrosophy. A neutrosophic matrix, on the other hand, is a matrix where the elements $a = (a_{ij})$ have been replaced by elements in $\langle RUI \rangle$, where $\langle RUI \rangle$ is an integer neutrosophic ring.

On the other hand, the technique known as AHP (Analytic Hierarchy Process): is an easy-to-apply and effective method, which allows alternatives to be sorted, according to an order calculated from the evaluation of a group of experts. This evaluation is carried out using a scale where the relative relationships between criteria, sub-criteria, and finally the alternatives are evaluated.

Neutrosophic AHP has several advantages over classical AHP, for example, it presents the user with a richer structure framework than classical AHP, fuzzy AHP, and intuitionistic fuzzy AHP. It describes the expert's judgment values efficiently handling vagueness and uncertainty about the fuzzy AHP and the intuitionistic fuzzy AHP because it considers three different degrees: degree of membership, degree of indeterminacy, and degree of non-membership. Another advantage is that it is calculated from linguistic terms, which allows more natural communication with experts.

The method known as DEMATEL (DEcision MAking Trial and Evaluation Laboratory): especially the neutrosophic DEMATEL method, consists of the formation of matrices that include expert evaluations of the cause-effect relationship of a set of selected criteria or factors. The result is a graph where the importance as a cause and as an effect of each of the factors is measured. The neutrosophic DEMATEL includes calculus with neutrosophic sets.

The DEMATEL neutrosophic method allows studying complex cause-effect relationships, where indeterminacy and the use of linguistic terms will be included, which is the natural form of communication of human beings [6].

The objective of this paper is to carry out a study of the main factors that influence the development of Ecuador as a tourist destination. To do this, two neutrosophic methods will be used: (Neutrosophic AHP and Neutrosophic DEMATEL) due to their versatility in decision-making and expert criteria processing.

3 Materials and Methods

This section summarizes the definitions, theories, and methods that will be used to achieve the objective proposed. The techniques known as Neutrosophic AHP and Neutrosophic DEMATEL will be applied, for which it is necessary to start from the evaluation of a group of experts who will intervene in decision-making.

3.1 Neutrosophic AHP Saaty

In this paper, Neutrosophy will be used as a calculation tool. Neutrosophy is the branch of philosophy that studies the origin, nature, and scope of neutralities. Logic and neutrosophic sets constitute generalizations of other theories, such as fuzzy sets, intuitionistic fuzzy sets, and interval-shaped fuzzy sets, among others [5]. For the description of the method it is necessary to expose the following definitions:

Definition 1: ([7, 8]) The *Neutrosophic Set* N is characterized by three membership functions, which are the truth-membership function TA, indeterminacy-membership function IA,and 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 $-0 \leq \inf TA(x) + \inf AI(x) + \inf AF(x) \leq \sup TA(x) + \sup AI(x) + \sup FA(x) \leq 3+$.

Notice that, according to the definition, TA(x), IA(x) and FA(x) are real standard or non-standard subsets of]-0, 1+[and hence, TA(x), IA(x) and FA(x) can be subintervals of [0, 1].

Definition 2: ([7, 8]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{ \langle x; AT(x), AI(x), FA(x) \rangle : x \in U \}$ c, where $TA: U \rightarrow [0, 1]$, $AI: U \rightarrow [0, 1]$, and $FA: U \rightarrow [0, 1]$, $0 \leq AT(x) + AI(x) + FA(x) \leq 3$.

The *Single-Valued Neutrosophic 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*, $\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy, and falsehood membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, \text{ otherwise} \end{cases} \quad (2)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \beta_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{\left(x - a_2 + \beta_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \gamma_{\tilde{a}}(x - a_1)\right)}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{\left(x - a_2 + \gamma_{\tilde{a}}(a_3 - x)\right)}{a_3 - a_2}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \quad (4)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \le a_2 \le a_3 \le a_4$.

Definition 4: ([7-10]) given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$ (5)
3. Inversion: $\tilde{a}^{-1} = \langle ({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.
4. Multiplication by a scalar number:

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

Definitions 3 and 4 refer to *single-valued triangular neutrosophic numbers* when the condition a2 = a3. For simplicity, we use the linguistic scale of triangular neutrosophic numbers, see Table 1 and also compare it with the scale defined in [11]. The Analytical Hierarchy Process was proposed by Thomas Saaty in 1980 [12], [23]. This technique models the problem that leads to the formation of a representative hierarchy of the associated decision-making scheme. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision-maker must break down the problem into its relevant components [13], [22]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next levels. In a typical hierarchy, the highest level locates the problem of decision-making. The elements that affect decision-making are represented at the intermediate level, the criteria occupying the intermediate level. At the lowest level, the decision options are understood. The levels of importance or weighting of the criteria are estimated using paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (6) [14].

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \quad (6)$$

In [11] is the theory of the AHP technique in a neutrosophic framework. Thus, we can model the indeterminacy of decision-making by applying Neutrosophic AHP or NAHP for short. Equation 7 contains a generic neutrosophic pair-wise comparison matrix for NAHP.

$$\tilde{A} = \begin{vmatrix} & \vdots & \ddots & \vdots \end{vmatrix} \quad (7)$$

The matrix must satisfy the condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4.

To convert neutrosophic triangular numbers into crisp numbers, there are two indexes defined in[11], they are the so-called score and accuracy indexes, respectively, see Equations 8 and 9:

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

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3]\left(2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}\right) \quad (9)$$

Saaty's 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	$\tilde{2} = \langle(1,2,3);0.40,0.65,0.60\rangle$
		$\tilde{4} = \langle(3,4,5);0.60,0.35,0.40\rangle$
		$\tilde{6} = \langle(5,6,7);0.70,0.25,0.30\rangle$
		$\tilde{8} = \langle(7,8,9);0.85,0.10,0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale.

Step 1 Select a group of experts.

Step 2 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies, through the linguistic terms shown in Table 1.

The neutrosophic scale is attained according to expert opinions [15]. The neutrosophic pair-wise comparison matrix of factors, sub-factors, and strategies are as described in Equation 7.

Step 3 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, i.e., $a_{ik} = a_{ij}a_{jk}$ for all i,j, and k, then the comparison matrix is consistent, focusing only on the lower, median, and upper values of the triangular neutrosophic number of the comparison matrix.

Step 4 Calculate the weight of the factors from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using Equations 10 and 11. To get the score and the accuracy degree of $\tilde{a}_{ji}$ the following equations are used:

$$S(\tilde{a}_{ji}) = {}^{1}\!/_{S(\tilde{a}_{ij})} \tag{10}$$

$$A(\tilde{a}_{ji}) = {}^{1}\!/_{A(\tilde{a}_{ij})} \tag{11}$$

With compensation by the accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \tag{12}$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous 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 calculus of the Consistency Index (CI) when applying this technique, which is a function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by equation $CI = \frac{\lambda_{max}-n}{n-1}$ [16], where n is the order of the matrix. In addition, the Consistency Ratio (CR) is defined by the equation CR = CI/RI, where RI is given in Table 2.

Order(n)	1	2	3	4	5	6	7	8	9	10
IR	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated with every order.

If CR≤0.1 it can be assumed that the experts' evaluation is sufficiently consistent and hence we can proceed to use NAHP. We apply this procedure to matrix A in Equation 12.

3.2 Neutrosophic DEMATEL

Definition 1 ([17]) Let X be a space of points (objects) with generic elements in X denoted by x. A single-valued neutrosophic set (SVNS) A in X is characterized by the truth-membership function TA (x), indeterminacy-membership function IA (x), and falsehood membership function FA (x). Then, an SVNS A can be denoted by A = {x, TA(x), IA(x), FA(x) x ∈ X}, where TA (x), IA (x), FA (x) ∈ [0, 1] for each point x in X. Therefore, the sum of TA (x), IA (x) and FA (x) satisfies the condition $0 \leq TA(x) + IA(x) + FA(x) \leq 3$ [18, 28, 29, 30].

Definition 2 ([19]) Let $E_k = (T_k , I_k , F_k)$ be a neutrosophic number defined for the rating of k-th decision maker. Then, the weight of the k-th decision maker can be written as:

$$\psi_k = \frac{1-\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(\mathrm{F}(x))^2]/3}}{\sum_{k=1}^{p}\sqrt{[(1-T_k(x))^2+(I_k(x))^2+(\mathrm{F}(x))^2]/3}} \tag{13}$$

Further, in achieving a favorable solution, group decision-making is important in any decision-making process. In the group decision-making process, all the individual decision-maker assessments need to be aggregated into one aggregated neutrosophic decision matrix. This can be done by using a single-valued neutrosophic weighted averaging (SVNWA) aggregation operator proposed by Ye [20], [27].

Definition 3 ([20]) Let $D^{(k)}=(d_{ij}^{(k)})_{mxn}$ be the single-valued neutrosophic decision matrix of the k-th decision maker and $\psi = (\psi_1\psi_2, \dots, \psi_p)^T$ be the weight vector of decision maker such that each $\psi_k \in [0,1], D = (d_{ij})_{mxn}$ where

$$d_{ij} = \langle 1 - \prod_{k=1}^{p}\left(1 - T_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(I_{ij}^{(p)}\right)^{\psi_k}, \prod_{k=1}^{p}\left(F_{ij}^{(p)}\right)^{\psi_k}\rangle \tag{14}$$

Definition 4 ([19], [21]) Deneutrosophication of SVNS $\tilde{N}$ can be defined as a process of mapping $\tilde{N}$ into a single crisp output for $xf: \tilde{N} \rightarrow \psi^* \in X$. If $\tilde{N}$ is discrete set then the vector of tetrads $\tilde{N} = \{(x \mid T\tilde{N}(x), I\tilde{N}(x), F\tilde{N}(x)) \mid x \in X\}$ is reduced to a single scalar quantity $\psi* \in X$ by deneutrosophication. The obtained scalar quantity $\psi* \in X$ best represents the aggregate distribution of three membership degrees of neutrosophic element $T\tilde{N}$ (x), $I\tilde{N}$ (x), $F\tilde{N}$ (x). Therefore, deneutrosophication can be obtained as follows.

$$\psi^* = 1 - \sqrt{[(1 - T_k(x))^2 + (I_k(x))^2 + (\mathrm{F}(x))^2]/3} \tag{15}$$

Decision-making normally involves human language (commonly referred to as linguistic variables). A linguistic variable simply represents words or terms used in human language. Therefore, this linguistic variable approach is a convenient way for decision-makers to express their assessments. Ratings of criteria can be expressed by using linguistic variables such as very influent (VI), influent (I), low influent (LI), not influence (NI), etc. Linguistic variables can be transformed into SVNSs as shown in Table 1.

Integer	Linguistic variable	SVNNs
0	No influence / Not important	(0.1,0.8,0.9)
1	Low influence/important	(0.35,0.6,0.7)
2	Medium influence/important	(0.5,0.4,0.45)
3	High influence/important	(0.8,0.2,0.15)
4	Very high influence/important	(0.9,0.1,0.1)

Table 3: Linguistic variable and Single Valued Neutrosophic Numbers (SVNNs) [19].

DEMATEL (Decision Making Trial and Evaluation Laboratory) is a technique developed in 1972 by Fontela and Gabus at the Geneva Research Center of the Battelle Memorial Institute [18],[19], [24], [26]. Basically, the steps to apply DEMATEL in its neutrosophic variant are listed below using the steps outlined below and can be found in more detail at [17].

- Identify the factors or elements to be analyzed: Through the application of various information collection techniques, a universe of factors or elements of interest can be obtained to be evaluated by the selected method.
- Determine the relative importance of the experts: The group of experts selected for the analysis may have their own importance values according to different circumstances of interest, such as the level of experience and knowledge in the decision problem. In this sense, the weight of each decision-maker may be different from that of other decision-makers. The weight of each decision-maker is considered with linguistic variables and is transmitted in SVNN.
- Get individual evaluations from experts. The experts are then asked to evaluate the direct influence between the factors through paired comparisons, using the score shown in Table 1.
- Convert the linguistic evaluations given by the experts in SVNN: From the individual sharp integer matrices obtained from the evaluations of the experts, the individual neutrosophic matrices of the decision-makers are constructed according to what is indicated in Table 1.

- Obtain the initial direct relationship matrix: To obtain the initial direct relationship matrix that is in the form of sharp numbers, the neutrosophic matrices of the individual decision-makers must be added and deneutrosophicated.
- Identify cause-effect relationships between factors using the DEMATEL method: Based on the aggregate direct relationship matrix A obtained in step 4, the total relationship matrix T can be easily calculated using equations (4-6) as shown below [18], [25]:
-

$$D = A * S \tag{16}$$

where

$$S = \frac{1}{\max\limits_{1\le i\le n} \sum_{j=1}^{n} a_{ij}} \tag{17}$$

And

$$T = D * (I * D) - 1 \tag{18}$$

I: is the identity matrix.

The values tij of the matrix T reflect the direct and indirect interdependence exerted by the row element i on the column element j. Indirect interdependence is that which an element i can exert on another j through third elements of the system. These indirect interdependencies emerge when matrix X is raised to successive powers.

Obtain the Causal Prominence-Relationship Diagram. In this step, the vectors R (sum of rows of T) and C (sum of columns of T) are first calculated. Next, on the horizontal axis of the causal diagram, the "Prominence" is defined as the vector $R + C$. This vector indicates the importance or relevance of each element of the system. The higher the value of $R + C$, the greater the prominence of the element. A high value of $R + C$ indicates that an element:

a) influences a lot on other elements,

b) receives a lot of influence from other elements,

c) influences and is influenced in a balanced way, so the sum of both concepts is high.

If $R + C$ is low, the element is of little "prominence" because both types of influence are low. On the vertical axis, the "Ratio" is defined as the RC vector. This vector establishes the net influence of each element. If $RC > 0$ indicates that the element influences more than it is influenced. This element would be the "cause" (influencer/driver) of influence. If $RC < 0$, it indicates that the element receives more influence than it emits, so it is considered an "effect" (influenced/receiver). Taking these values, a relationship map $(R + C, RC)$ can be created [20], [21].

4 Results and Discussion

In this section, the identification of factors that influence tourism development in Ecuador will be carried out, which are shown below:

1. Formality in tourist services (F1)
2. Adequate tourist promotion and diffusion (F2)
3. Appropriate basic services (F3)
4. The prices of tour packages (F4)
5. Security in the tourist destination (F5)
6. Natural or anthropogenic phenomena (F6)
7. Infrastructure in health services (F7)
8. Promotion of tourist culture (F8)
9. Competent staff with a high degree of knowledge (F9)
10. Tourist attractions offered by the destination (F10)

Once the different previous factors have been identified, the aforementioned techniques will be applied, as follows: with the AHP Neutrosophic method, the weights of the different influencing factors in Ecuadorian tourism development are determined.

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	$\hat{1}$	⟨(6,7,8);0.90,0.10,0.10⟩	(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩	⟨(6,7,8);0.90,0.10,0.10⟩
F2	1/⟨(6,7,8);0.90,0.10,0.10⟩	$\hat{1}$	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(4,5,6);0.80,0.15,0.20⟩

Fac-tors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F3	1/⟨(6,7,8);0.90,0.10,0.10⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	Î	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(2,3,4);0.30,0.75,0.70⟩
F4	1/⟨(6,7,8);0.90,0.10,0.10⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	Î	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(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⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩
F5	1/⟨(6,7,8);0.90,0.10,0.10⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	Î	⟨(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⟩	⟨(2,3,4);0.30,0.75,0.70⟩	⟨(2,3,4);0.30,0.75,0.70⟩
F6	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	Î	⟨(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⟩	⟨(1,1,1);0.50,0.50,0.50⟩
F7	1/⟨(6,7,8);0.90,0.10,0.10⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	Î	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩	⟨(1,1,1);0.50,0.50,0.50⟩
F8	1/⟨(6,7,8);0.90,0.10,0.10⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	Î	⟨(4,5,6);0.80,0.15,0.20⟩	⟨(1,1,1);0.50,0.50,0.50⟩
F9	1/⟨(6,7,8);0.90,0.10,0.10⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	Î	⟨(1,1,1);0.50,0.50,0.50⟩
F10	1/⟨(6,7,8);0.90,0.10,0.10⟩	1/⟨(4,5,6);0.80,0.15,0.20⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(2,3,4);0.30,0.75,0.70⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	1/⟨(1,1,1);0.50,0.50,0.50⟩	Î

Table 4: Neutrosophic AHP paired matrix. Source: own elaboration.

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Weight
F1	0.44	0.72	0.58	0.33	0.38	0.27	0.27	0.26	0.23	0.26	**0.34**
F2	0.06	0.10	0.19	0.23	0.27	0.14	0.19	0.19	0.16	0.21	**0.17**
F3	0.06	0.04	0.08	0.23	0.13	0.29	0.19	0.09	0.16	0.12	**0.14**
F4	0.08	0.02	0.01	0.04	0.05	0.05	0.09	0.09	0.08	0.12	**0.08**
F5	0.06	0.02	0.03	0.05	0.05	0.05	0.09	0.09	0.08	0.12	**0.08**
F6	0.09	0.04	0.01	0.05	0.05	0.05	0.03	0.17	0.03	0.04	**0.06**
F7	0.06	0.02	0.01	0.02	0.02	0.06	0.04	0.06	0.03	0.04	**0.03**
F8	0.06	0.02	0.03	0.02	0.02	0.01	0.04	0.03	0.16	0.04	**0.04**
F9	0.06	0.02	0.01	0.02	0.02	0.06	0.04	0.01	0.03	0.04	**0.03**
F10	0.06	0.02	0.03	0.02	0.02	0.02	0.04	0.04	0.03	0.04	**0.03**

Table 5: Determination of weights of the criteria applying the Neutrosophic AHP method

Criteria	AxWeights	Approximate eigenvalues
F1	4.97	13.10022024
F2	2.08	12.04701762
F3	1.55	11.42619663
F4	0.63	10.67475612
F5	0.66	10.88168554
F6	0.66	11.57857201
F7	0.35	10.09006268
F8	0.46	10.80851719
F9	0.32	10.74705897
F10	0.35	11.25772836
	Eigenvalue = 5.400855	

Table 6: Analysis of the consistency of the paired matrix

The analysis of the consistency of the method exposed that the most influential factors in the development of tourism in Ecuador are the formality in tourist services, mainly in lodging, since it is very common for natural persons to offer lodging services in which a part of their property, or they also offer shared rooms that were not agreed with the client, it is also evident in the intermediation through recruiters, to offer transportation or tourist guidance. Also, adequate dissemination and promotion of the benefits that the tourist destination has, since most

of the clients are loyal through social networks, making the client fall in love through the internet ensures an excellent tourist season.

Other important factors are having appropriate services for the population, bearing in mind that if these services are insufficient, not only the population is affected, but also the tourists, since all services are aimed at them, and when there are inconveniences with respect to these services, tourist demand weakens, the price of tourist packages, since it is very important to know what services the reservation includes if the package is all-inclusive, how many services are integrated into the package, etc. since they mark consumption decisions. The security of the destination and that foreigners like to explore and walk through the streets of the city when there are murders that intimidate tourists who prefer to stay in the hotel or simply not return to the country.

After selecting the five most important factors, it is decided to apply the DEMATEL method, it is carried out with the help of five decision-makers involved in providing the evaluation of the indicated factors. They were asked to choose an integer from 0 to 4 that represented the degree of influence of one factor on another factor. The data obtained is analyzed, for which, firstly, the evaluation matrices of each of the decision-makers are obtained. Tables 7, 8, 9, 10, and 11 show the comparison matrices for pairs of criteria according to the evaluations issued by Experts 1, 2, 3, 4, and 5, respectively. Table 12 shows the weights of the decision-makers in their linguistic form and their conversion to SVNN.

	F1	F2	F3	F4	F5
F1	NI	VI	MI	NI	LI
F2	LI	NI	LI	LI	VI
F3	HI	HI	LI	NI	HI
F4	LI	HI	HI	NI	MI
F5	VI	VI	MI	VI	NI

	F1	F2	F3	F4	F5
F1	NI	HI	HI	NI	MI
F2	LI	LI	HI	MI	HI
F3	HI	HI	LI	NI	HI
F4	LI	HI	VI	NI	MI
F5	HI	VI	VI	VI	NI

	F1	F2	F3	F4	F5
F1	NI	HI	LI	NI	LI
F2	LI	NI	MI	NI	HI
F3	MI	VI	NI	NI	VI
F4	LI	VI	VI	HI	MI
F5	HI	HI	VI	VI	NI

Tables 7, 8, y 9: Evaluation made by Experts 1, 2, and 3 by pairs of factors on the degree of direct influence of the factor of the row on the factor of the column.

	F1	F2	F3	F4	F5
F1	NI	VI	MI	NI	LI
F2	LI	LI	LI	MI	HI
F3	VI	HI	LI	LI	MI
F4	LI	HI	VI	NI	MI
F5	HI	HI	HI	VI	NI

	F1	F2	F3	F4	F5
F1	NI	MI	HI	NI	LI
F2	MI	NI	LI	LI	HI
F3	HI	VI	LI	HI	VI
F4	LI	HI	HI	NI	LI
F5	HI	MI	VI	VI	NI

Tables 10 y 11: Evaluation carried out by Experts 4 and 5 by pairs of factors on the degree of direct influence of the factor of the row on the factor of the column.

	Decision-maker 1	Decision-maker 2	Decision-maker 3	Decision-mak 4	Decision-maker 5
SVNN	Very im-portant (0.8;0.2;0.15)	moderately important (0.5;0.4;0.45)	Very im-portant (0.8;0.2;0.15)	Very im-portant (0.8;0.2;0.15)	moderately important (0.5;0.4;0.45)
numerical im-portance	0.2302	0.1548	0.2302	0.2302	0.1548

Table 12: Decision-makers' weights.

After obtaining the evaluations of each expert and their relative importance, the direct relationship matrix A is prepared:

$$\mathbf{A} = \begin{vmatrix} 0.0000 & 0.8409 & 0.6298 & 0.2375 & 0.5489 \\ 0.4119 & 0.0000 & 0.4978 & 0.5164 & 0.8400 \\ 0.8040 & 0.8135 & 0.0000 & 0.3922 & 0.7706 \\ 0.3762 & 0.7938 & 0.8392 & 0.0000 & 0.6117 \\ 0.8400 & 0.8334 & 0.7923 & 0.8742 & 0.0000 \end{vmatrix}$$

Subsequently, the normalized initial direct relationship matrix D is computed, as shown below:

$$\mathbf{D} = \begin{vmatrix} 0.0000 & 0.2518 & 0.1886 & 0.0711 & 0.1644 \\ 0.1233 & 0.0000 & 0.1490 & 0.1546 & 0.2515 \\ 0.2407 & 0.2436 & 0.0000 & 0.1174 & 0.2307 \\ 0.1126 & 0.2377 & 0.2513 & 0.0000 & 0.1831 \\ 0.2515 & 0.2495 & 0.2372 & 0.2617 & 0.0000 \end{vmatrix}$$

Next, the total direct relationship matrix T is shown below:

$$\mathbf{T} = \begin{vmatrix} 0.5190 & 0.8604 & 0.7162 & 0.5150 & 0.7256 \\ 0.6491 & 0.6808 & 0.7145 & 0.6003 & 0.8042 \\ 0.8184 & 0.9859 & 0.6716 & 0.6385 & 0.8850 \\ 0.6997 & 0.9489 & 0.8495 & 0.5125 & 0.8266 \\ 0.9212 & 1.1179 & 0.9772 & 0.8266 & 0.8094 \end{vmatrix}$$

Finally, after obtaining the total direct relationship matrix T, the direct and indirect effects of the factors indicated can be determined by analyzing the prominence and relationship axes for the cause and effect group, as shown in Table 13.

	Ri	Ci	Ri+Ci	Ri-Ci
F1	3.3362	3.6074	6.9436	-0.2712
F2	3.4489	4.5939	8.0428	-1.1450
F3	3.9994	3.9290	7.9284	0.0704
F4	3.8372	3.0929	6.9301	0.7443
F5	4.6523	4.0508	8.7031	0.6015

Table: 13: Axes of prominence and relationship

The data obtained are used for the construction of the causal diagram that is drawn in Fig. 1.

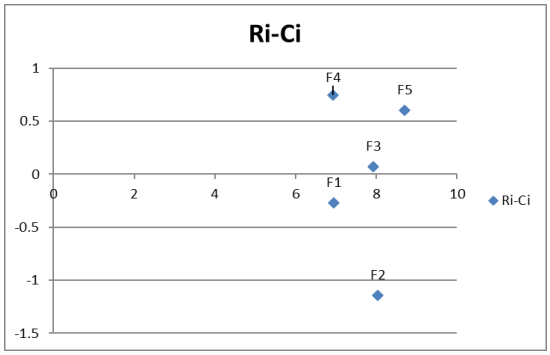


Figure 1: Graphical representation of the pairs (Ri+Ci, Ri-Ci)

According to table 13, the importance of the analyzed factors can be prioritized as F5>F2>F3>F1>F4 according to the values (ri + ci), where the safety of the tourist destination is the most important factor with the value of 8.7031, while the prices of tourist packages are the least important factor with the value of 6.9301. The cause diagram in Figure 1 shows that the prices of tour packages (F4) are the most influential factor. In short, much attention should be paid to the group of causes rather than effects. According to the data obtained, there are only two factors that stand out in the group of causes: the prices of tourist packages (F4) and the safety of the tourist destination (F5). Of the two, the prices of tourist packages (F4) have the highest value (ri - ci) which means that it tends to be the one with the greatest impact among the factors that influence the development of tourism in the country.

Conclusion

With the completion of this study, the following conclusions were reached: neutrosophy is a mathematical tool applicable to many fields of study. The application of the neutrosophic version of the AHP method was carried out to know the most influential factors in the development of the tourism sector in the country and the application of the neutrosophic DEMATEL method to develop the cause-effect relationship between these factors. The most important factor is the formality in tourist services, mainly in lodging services in which a part of their property is offered, or they also offer shared rooms that were not agreed upon with the client, and also in intermediation through recruiters to offer transportation or tourist guidance.

The DEMATEL method was applied in situations of indeterminacy through the application of linguistic variables and a neutrosophic aggregation operator. By processing the data, it was possible to determine the importance of each factor indicated, as well as the causal and effect relationships between them. Through the construction of the visible cause-effect relationship diagram, it was observed that there is a defined group of causal factors (F4, F5, and F3) that are the ones that have the greatest influence on the system, while F1 and F2 constitute the effect group. It is suggested, therefore, that the government dedicate greater efforts to mitigate the rise in prices of tourist packages and increase the safety of the tourist destination, such as basic services of drinking water, electricity, sewage, etc.

References

[1] J. G. Monge and R. M. Yagüe Perales, "El desarrollo turístico sostenible: Tren Crucero del Ecuador," *Estudios y perspectivas en turismo,* vol. 25, pp. 57-72, 2016.

[2] M. Abdel Basset, A. Gamal, R. K. Chakrabortty, and M. Ryan, "A New Hybrid Multi-Criteria Decision-Making Approach for Location Selection of Sustainable Offshore Wind Energy Stations: A Case Study," *Journal of Cleaner Production, Journal Pre-proof,* vol. 51, 2020.

[3] W. P. Proaño Ponce and J. F. Ramírez Pérez, "Modelo de Desarrollo Turístico Sostenible para cantones costeros: herramienta para actores locales de Manabí, Ecuador," *Posgrado y Sociedad Revista Electrónica del Sistema de Estudios de Posgrado,* vol. 15, pp. 65-78, 2017.

[4] C. Zambrano Murillo, J. R. Hechavarría Hernández, and M. Leyva Vázquez, "Environmental Certification Proposal for Sustainable Buildings in the Satellite Parish "La Aurora", Guayas, Ecuador," in *Advances in Intelligent Systems and Computing* vol. 1214 AISC, ed, 2020, pp. 63-70.

[5] E. G. Caballero, F. Smarandache, and M. Leyva Vázquez, "On Neutrosophic Offuninorms," *Symmetry,* vol. 11, pp. 1136-1136, 2019.

[6] G. George-Ufot, Y. Qu, and I. J. Orji, "Sustainable lifestyle factors influencing industries' electric consumption patterns using Fuzzy logic and DEMATEL: The Nigerian perspective," *Journal of Cleaner Production,* vol. 162, pp. 624-634, 2017.

[7] P. Biswas, S. Pramanik, and B. C. Giri, "Value and ambiguity index based ranking method of single-valued trapezoidal neutrosophic numbers and its application to multi-attribute decision making," *Neutrosophic Sets and Systems,* vol. 12, pp. 127-138, 2016.

[8] J. Ye, "Trapezoidal neutrosophic set and its application to multiple attribute decision-making," *Neural Computing and Applications,* vol. 26, pp. 1157-1166, 2015.

[9] I. Del, "Operators on Single Valued Trapezoidal Neutrosophic Numbers and SVTN-Group Decision Making," *Neutrosophic Sets and Systems,* vol. 22, pp. 131-150, 2018.

[10] P. Biswas, S. Pramanik, and B. C. Giri, "Distance Measure Based MADM Strategy with Interval Trapezoidal Neutrosophic Numbers," *Neutrosophic Sets and Systems,* vol. 19, pp. 40-46, 2018.

[11] M. Abdel-Basset, M. Mohamed, and F. Smarandache, "An Extension of Neutrosophic AHP-SWOT Analysis for Strategic Planning and Decision-Making," *Symmetry,* vol. 10, p. 116, 2018.

[12] T. L. Saaty, *Toma de decisiones para líderes*: RWS Publications, 2014.

[13] L. K. B. Villanueva, D. A. V. Intriago, L. K. Á. Gómez, and A. M. I. Morán, "Business Plan for Entrepreneurs, Actors and Organizations of Social and Solidarity Economy based on Neutrosophic AHP-SWOT," *Neutrosophic Sets and Systems,* vol. 37, pp. 27-27, 2020.

[14] W. Ho and X. Ma, "The state-of-the-art integrations and applications of the analytic hierarchy process," *European Journal of Operational Research,* vol. 267, pp. 399-414, 2018.

[15] F. Smarandache, J. E. Ricardo, E. G. Caballero, M. Y. Leyva Vázquez, and N. B. Hernández, "Delphi method for evaluating scientific research proposals in a neutrosophic environment," *Neutrosophic Sets & Systems,* vol. 34, 2020.

[16] J. Aczél and T. L. Saaty, "Procedures for Synthesizing Ratio Judgments," *Journal of Mathematical Psychology,* vol. 27, pp. 93-102, 1983.

[17] A. Awang, A. T. A. Ghani, L. Abdullah, and M. F. Ahmad, "A DEMATEL method with single valued neutrosophic set (SVNS) in identifying the key contribution factors of Setiu Wetland's coastal erosion," *AIP Conference Proceedings,* vol. 1974, 2018.

[18] H.-S. Lee, G.-H. Tzeng, W. Yeih, Y.-J. Wang, and S.-C. Yang, "Revised DEMATEL: Resolving the Infeasibility of DEMATEL," *Applied Mathematical Modelling,* vol. 37, pp. 6746-6757, 2013.

[19] A R. Soria Acosta, & Y. C. Hernández Zambrano. "Claves de emergencia obstétrica en la hemorragia post parto". Universidad y Sociedad, Vol. 14 Num. S2, pp- 445-449, 2022.

[20] M. M Vidal del Río, & A. A. Monsalve Guamán. "La equinococosis canina, una zoonosis de importancia". Universidad y Sociedad, Vol. 14 Num. S2, pp- 440-444, 2022.

[21] Romero Fernández, A. J., Álvarez Gómez, G. A., & Estupiñán Ricardo, J. "La investigación científica en la educación superior como contribución al modelo educativo". Universidad Y Sociedad, vol. 13 no. S3, pp 408-415, 2021

[22] García, J. M. B., Ricardo, J. E., & Villalva, I. M. "Acciones didácticas para la autorrealización física integral de los estudiantes de carreras agropecuarias". Didasc@ lia: Didáctica y Educación, vol. 7 no. 2, pp 57-66, 2016.

[23] Leyva Vázquez, M. Y., Viteri Moya, J. R., Estupiñán Ricardo, J., & Hernández Cevallos, R. E. "Diagnóstico de los retos de la investigación científica postpandemia en el Ecuador". Dilemas contemporáneos: educación, política y valores, vol. 9 no. (SPE1), 2021.

[24] Ricardo, J. E. (2018). "Estrategia de Gestión en la Educación Superior; pertinencia e impacto en la interrelación de los procesos académicos, de investigación científica y de vinculación con la sociedad en el periodo enero 2016-mayo 2018 en la Facultad de Ciencias Jurídicas, Sociales y de la Educación de la Universidad Técnica de Babahoyo en Ecuador". Infinite Study, 2018.

[25] Ricardo, J. E., & Vázquez, I. R. S. "La educación sexual para padres de niños con retraso mental, una vía para su consolidación". Magazine de las Ciencias: Revista de Investigación e Innovación, vol. 4 no. 3, pp 137-144, 2019.

[26] Ramos Sánchez, R. E., Ramos Solorzano, R. X., & Estupiñán Ricardo, J. "La transformación de los objetivos de desarrollo sostenible desde una dinámica prospectiva y operativa de la Carrera de Derecho en Uniandes en época de incertidumbre". Conrado, vol. 17 no. 81, pp 153-162, 2021.

[27] von Feigenblatt, O. F., Pardo, P., & Cooper, M. "Sufficiency Economy Philosophy (SEP): Thailand's Emic Approach to Governance and Development as Evidence of an Asian-value Oriented Inclusive Leadership Management Philosophy". Journal of Asia Pacific Studies, vol. 6. No. 2, pp 289-300, 2021.

[28] A. J. Romero Fernández, I. Alfonso González, G. A. Álvarez Gómez & L. F. Latorre Tapia. "Habilidades de investigación de los estudiantes de odontología". Universidad y Sociedad, vol. 14 no. S3, pp 136-146, 2022.

[29] R. González Salas, M. M Vidal del Río & A. A. Monsalve Guamán. "El ozono y su empleo en la industria para el procesamiento y conservación de alimentos". Universidad y Sociedad, vol. 14 no. S3, pp 127-135, 2022.

[30] R. E. Olivo Torres, E. S. Cocha Chicaiza & G. C. Romero Paredes. "El uso de ordenadores electrónicos como factor para el desarrollo de astenopia". Universidad y Sociedad, vol. 14 no. S3, pp 118-126, 2022.

Received: September 13, 2022. **Accepted:** October 31, 2022

Neutrosophic Sets and Systems
{Special Issue: Neutrosophic in Latin America, progress and perspectives}, Vol. 52, 2022

University of New Mexico

Neutrosophic Genetic Algorithm for solving the Vehicle Routing Problem with uncertain travel times

Rafael Rojas-Gualdron [1] and Florentin Smarandache [2]

[1] Department of Industrial Engineering, Universidad de Investigación y Desarrollo, Barrancabermeja, Colombia;
E-mail: rrojas7@udi.edu.co
[2] Mathematics Department, University of New Mexico, 705 Gurley Ave., Gallup, NM 87301, USA
E-mail: smarand@unm.edu

Abstract: The Vehicle Routing Problem (VRP) has been extensively studied by different researchers from all over the world in recent years. Multiple solutions have been proposed for different variations of the problem, such as Capacitive Vehicle Routing Problem (CVRP), Vehicle Routing Problem with Time Windows (VRP-TW), Vehicle Routing Problem with Pickup and Delivery (VRPPD), among others, all of them with deterministic times. In the last years, researchers have been interested in including in their different models the variations that travel times may experience when exposed to all kind of phenomena, mainly vehicle traffic. This article addresses the VRP from this perspective, proposing the design and implementation of a genetic algorithm based on neutrosophic theory for calculating the fitness function of each route, considering the variability and uncertainty present in travel times. A deterministic genetic algorithm is also implemented with the average travel times to compare it with the neutrosophic algorithm using simulation. As conclusion, a deterministic algorithm does not necessarily generate the best solution in the real world, full of uncertainty. Also, the quantification of uncertainty using neutrosophic theory can be used in route planning, opening a broad and interesting field of research for future investigations.

Keywords: Vehicle Routing Problem (VRP); Neutrosophic Theory; Uncertain Travel Times; Stochastic Vehicle Routing Problem (SVRP); Genetic Algorithm

1. Introduction

One of the characteristics that most affect the proper functioning of supply chains today is the variability and uncertainty present in their transportation systems [1], mainly due to three causes: firstly, the high complexity of its large-scale processes, secondly, to the occurrence of complex and random traffic phenomena, and, thirdly, to the susceptibility of being affected by external and unpredictable factors.

It is a common practice in companies to face the challenge of planning routes with many customers and demands using the empirical knowledge of their most experienced workers [2]. However, they face exceptionally tough working conditions due to the increasing number of routes and diversity of demands. For this reason, it is necessary to develop decision support systems that facilitate this task and allow planning efficient routes in short times applicable to the daily operation of companies.

It should also be considered that the flow of traffic on urban roads in developing countries is characterized by being heterogeneous, due to the large number of buses on its main roads [3]. This condition makes it especially difficult to model traffic behavior in its most populated cities and, particularly complex, to estimate vehicle travel times through its streets.

Among the external factors that affect the planning of the routes and cause the calculations to move away from reality, generating an increase in costs, we can consider the unpredictable behavior of some users, the various weather conditions that may occur, some of them extreme, in addition to the errors in the measurement or estimation of the travel times of each one of the routes [4].

Stochastic vehicle routing problems (SVRP) arise whenever some elements of the problem are random [5]. The most common cases found in the literature can be classified into three large groups: vehicle routing problems

with stochastic demand, vehicle routing problems with stochastic travel times, or problems in which both conditions are present.

SVRPs differ from their deterministic counterpart in several fundamental aspects, mainly in a different solution concept, which results in much more complex solution methodologies, which are often considered computationally intractable, since only relatively small instances can be solved optimally and the difficulty programmers face when designing and evaluating good heuristics for this kind of problem.

For the scope of this article, the authors focus on vehicle routing problems with stochastic travel times, mainly affected by unpredictable traffic behavior over time. This uncertainty is mainly due to two possible causes: the first, the probability of occurrence of traffic accidents and, the second, the variability of the demand of the transport networks, which generates phenomena such as peak hours or hours of high flow of vehicles and off-peak hours or hours with low vehicle traffic. These factors are the reason why the travel time between any two nodes in the transport network is considered stochastic [6].

A widely used tool to treat this stochasticity is the information available through historical data that is collected and analyzed to be converted into models or probability distributions of the random variables available, for our case study, of the travel times of each one of the arcs of the network [7]. In a pure SVRP, these distributions are available, and the route optimization process is static and is performed only once, without considering the changes that occur during the route.

Among the different solutions found in the literature, we can cite branch and price algorithms [8], [9], simulation-based heuristics [10], simheuristics [11], [12], adaptive local search algorithms, ALNS, [13], scatter search [14], tabu search [15], iterative local search, ILS [16], particle swarm optimization, PSO [17], genetic algorithms [18], non-dominated sorting genetic algorithms, NSGA [19] and memetic algorithms [20], [21].

For the scope of this article, the authors focus on the difficulty of modeling traffic, due to its complexity and randomness, especially on last-mile route planning. Authors based on the open-source data published by Uber Movement of the historical travel times to get the minimum, maximum and average values for travel times between two nodes. Also, a function is proposed to convert this data into a triangular neutrosophic number [22] to make use of the score function to compare two neutrosophic numbers. This score function is used to calculate the fitness function of the proposed genetic algorithm. Finally, the results are compared and a good behavior of the neutrosophic algorithm is observed in stochastic scenarios.

2. The proposed algorithm

The methodology proposed for the development of this research consists of the following phases: the definition of the structure of the data available to carry out the study, the design of a function to convert the available data into neutrosophic triangular numbers, the definition of a fitness function based on a neutrosophic score function to compare two triangular neutrosophic numbers, the definition of the parameters and the design of the genetic algorithm, the implementation of a deterministic genetic algorithm to solve the VRP problem using the mean values of the travel times to compare it with the neutrosophic algorithm and finally the simulation through the generation of scenarios to test the performance of both algorithms.

2.1. Definition of the structure of the data

This research is based on the open-source data provided by Uber Movement [23] on the history of travel times between two nodes, in our case, in the city of Bogotá, Colombia. The data structure that we are going to use includes the minimum, maximum and mean value of the data history of each route for the period between March 1 and March 31, 2020.

2.2. Design of a function to convert the data to neutrosophic triangular number

Once the travel times between a pair of nodes are obtained as a triplet [a, b, c] where a is the minimum value of the interval, b is the mean value and c the maximum value of the interval, we must proceed to convert this triplet into a neutrosophic triangular number $\langle [a, b, c], (T, I, F) \rangle$. For this purpose, the authors propose the use of the following function:

$$TNS\ number = \langle [a, b, c], (T, I, F) \rangle$$

where:

$$\Delta_T = \min\begin{pmatrix} b-a \\ c-b \end{pmatrix}$$

$$\Delta_F = \max\begin{pmatrix} b-a \\ c-b \end{pmatrix}$$

$$T = \begin{bmatrix} 1-\frac{\Delta_T}{b}, & \Delta_T < b \\ 0, & otherwise \end{bmatrix}$$

$$I = \begin{bmatrix} \frac{c-a}{b}, & c-a < b \\ 1, & otherwise \end{bmatrix}$$

$$F = \begin{bmatrix} \frac{\Delta_F}{b}, & \Delta_F < b \\ 1, & otherwise \end{bmatrix}$$

2.3. Definition of the fitness function

To calculate the fitness function, we rely on the score function used to compare two neutrosophic triangular numbers.

Definition 1 [24]**:** (Comparison of any two random TNS numbers). Let $\hat{r}^{NS} = \langle [\hat{r}_T, \hat{r}_I, \hat{r}_P], (T_{\hat{r}}, I_{\hat{r}}, F_{\hat{r}}) \rangle$ be a TNS number, and then the score function is defined as follows:

$$s(r^{NS}) = \frac{1}{12} \cdot [\hat{r}_T + 2 \cdot \hat{r}_I + \hat{r}_P] \cdot [2 + T_{\hat{r}} - I_{\hat{r}} - F_{\hat{r}}]$$

Let $\hat{r}^{NS} = \langle [\hat{r}_T, \hat{r}_I, \hat{r}_P], (T_{\hat{r}}, I_{\hat{r}}, F_{\hat{r}}) \rangle$ and $\hat{s}^{NS} = \langle [\hat{s}_T, \hat{s}_I, \hat{s}_P], (T_{\hat{s}}, I_{\hat{s}}, F_{\hat{s}}) \rangle$ be two arbitrary TNSNs, the ranking of $\hat{r}^{NS}$ and $\hat{s}^{NS}$ by score function is defined as follows:

if $s(\hat{r}^{NS}) \succ s(\hat{s}^{NS})$ then $\hat{r}^{NS} \succ \hat{s}^{NS}$
if $s(\hat{r}^{NS}) \prec s(\hat{s}^{NS})$ then $\hat{r}^{NS} \prec \hat{s}^{NS}$
if $s(\hat{r}^{NS}) \approx s(\hat{s}^{NS})$ then $\hat{r}^{NS} \approx \hat{s}^{NS}$

The value of the fitness function of each individual is equal to the sum of the score function of the neutrosophic triangular number that represents the distance between each pair of nodes of the route.

2.4. Definition of parameters and design of the genetic algorithm

2.4.1. Individual

Each individual is represented by a chromosome of n+2 positions, where n is the number of customers that are visited on the route. For example, for 10 clients, the chromosome would have 12 positions, one for each of the clients represented by 1, 2, 3..., n plus a zero at the beginning and at the end of the chromosome that represent the deposit from which the route starts and where the route finishes as seen on figure 1.

0	3	1	5	6	9	2	4	8	10	7	0

Figure 1. Chromosome for an individual with 10 clients.

2.4.2. Parent selection

The selection is carried out by a selection function, proportional to the fitness function, in which each individual has a probability of being selected as a parent that is proportional to the value of its fitness function. Because for the VRP the best individual is the one with the lowest value of the fitness function, the probability of being selected will be inversely proportional to their fitness.

2.4.3. Crossover function

The crossover function generates two random positions from the first parent to cut a chromosome fragment between the two positions. That fragment is then inserted at a random location within the second parent. Finally, the values that are repeated within the chromosome are eliminated from this resulting chromosome to generate the child. Figure 2 shows an example of the crossover function.

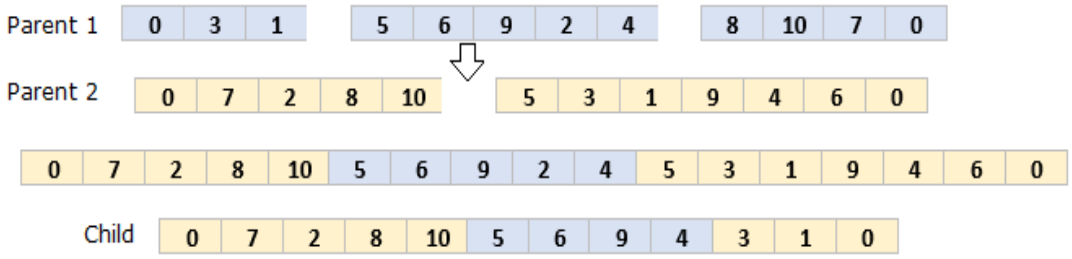


Figure 2. Example of the crossover function.

2.4.4. Mutation function

The mutation probability was set at 5 percent to diversify the individuals and avoid falling into a local optimum. If an individual is chosen for the mutation, two chromosome positions are randomly selected, and their values are swapped. Figure 3 shows an example of a mutation.

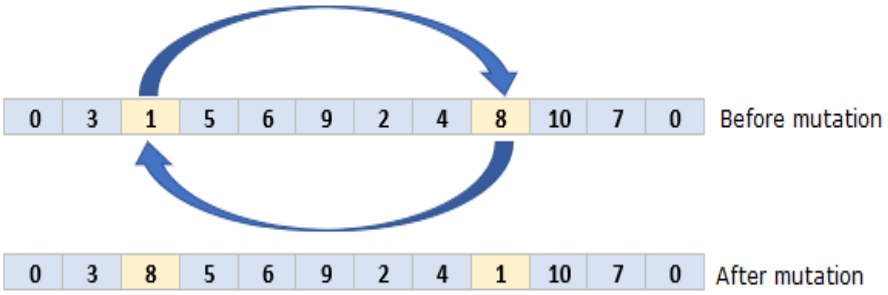


Figure 3. Example of the mutation function.

2.4.5. Pseudocode

Step 1. Generate random population
Step 2. Calculate fitness
Step 3. Update the incumbent
Step 4. For the number of generations:
    Step 4.1. Parent selection
    Step 4.2. Crossover function
    Step 4.3. Mutation function
    Step 4.4. Calculate fitness
    Step 4.5. Update the incumbent

2.5. Design of the deterministic genetic algorithm

To test the results of the proposed neutrosophic algorithm, we are going to implement a deterministic algorithm, which will have the same design as the neutrosophic algorithm with the difference that its fitness function will be equal to the sum of the mean travel times of each pair of nodes.

2.6. Simulation

In order to simulate the behavior of the algorithm in the real world we are going to randomly generate one hundred scenarios based on the data we have. To randomly generate the travel times between any pair of nodes, we need to fit the data we have to a probability distribution. For our case, the probability distribution that is closest to the behavior of the travel times and to the data we have is the triangular distribution, for which we need the values of the maximum, minimum, and mode. The maximum and minimum values are available in the data; however, the mode is not. To calculate the mode, we rely on the following equation applicable to a triangular distribution:

$$Mean = \frac{Maximum + Mode + Minimum}{3}$$

Bearing in mind that we have the value of the mean in the data, we only have to get the mode from the equation to be able to calculate it for the travel times between each pair of nodes.

$$Mode = 3 \cdot Mean - Maximum - Minimum$$

Having the values of maximum, minimum and mode we proceed to randomly generate the travel times between each pair of nodes using the triangular distribution. One hundred scenarios are generated, and the best solution obtained by the neutrosophic algorithm is compared against the best solution obtained by the deterministic algorithm to evaluate the results and draw conclusions.

3. Results

To test the performance of the algorithm, eleven locations will be selected from the Uber Movement database. Ten will be the customers and will be numbered from 1 to 10 and one will be the supplier and will have the number zero. The values in seconds for the maximum value of the range of travel times between each location can be seen in table 1.

Table 1. Maximum value for the range of travel times between each pair of nodes.

CUSTOMER	0	1	2	3	4	5	6	7	8	9	10
0	0	2217	1076	1965	2780	2518	3402	1344	2071	1778	2242
1	1945	0	1732	1505	2586	2926	3635	2283	1339	1037	2000
2	1490	1425	0	719	2095	1719	3692	1371	1231	855	1187
3	2125	1367	1141	0	2323	2758	2376	950	889	984	737
4	2486	2668	2200	1945	0	784	1015	2968	1798	1419	2511
5	1984	1986	1715	1542	773	0	1690	2544	1341	907	2113
6	3086	3558	3491	2517	1273	1583	0	3743	2754	2299	2901
7	1236	2503	1219	1278	3055	2723	3103	0	1762	1823	1058
8	2051	1194	1873	927	1954	2240	2963	1770	0	1009	1552
9	1016	998	809	819	2000	1964	2870	1597	542	0	1362
10	2064	2647	1894	1229	3900	3676	4547	1318	2301	2507	0

The values in seconds for the mean value of the range of travel times between each location can be seen in table 2.

Table 2. Mean value for the range of travel times between each pair of nodes.

CUSTOMER	0	1	2	3	4	5	6	7	8	9	10
0	0	1604	739	1333	1938	1768	2448	922	1491	1228	1550
1	1392	0	1194	1046	1705	1930	2432	1587	942	685	1354
2	896	971	0	481	1379	1147	2351	837	824	546	734
3	1370	989	699	0	1471	1857	1582	578	574	600	405
4	1742	1821	1475	1341	0	342	633	1979	1203	888	1706
5	1459	1393	1199	1089	327	0	988	1726	928	602	1450
6	2234	2576	2376	1865	798	991	0	2487	1889	1533	2164
7	805	1743	711	775	2098	1902	2134	0	1191	1208	585
8	1419	824	1198	600	1215	1435	1856	1171	0	615	976
9	726	688	507	550	1129	1108	1792	1016	364	0	877
10	1375	1905	1194	669	2658	2529	3008	724	1412	1684	0

The values in seconds for the mean value of the range of travel times between each location can be seen in table 3.

Table 3. Minimum value for the range of travel times between each pair of nodes.

CUSTOMER	0	1	2	3	4	5	6	7	8	9	10
0	0	1160	507	904	1350	1241	1761	632	1073	847	1071
1	995	0	823	726	1124	1272	1626	1102	662	452	916
2	538	661	0	321	907	765	1496	510	551	348	453
3	882	715	428	0	931	1250	1052	351	370	365	222
4	1220	1242	988	924	0	149	394	1319	804	555	1158
5	1072	976	837	768	138	0	577	1170	642	399	994
6	1617	1864	1616	1381	500	620	0	1652	1295	1021	1613
7	524	1213	414	469	1490	1328	1467	0	804	800	323
8	981	568	766	387	755	919	1162	774	0	374	613
9	518	473	317	369	637	624	1118	646	244	0	564
10	915	1370	752	364	1811	1739	1989	397	866	1131	0

Using the function defined in section 2.2, we proceed to calculate the degrees of truth, indeterminacy, and falsity of each triplet. The degrees of truth of each of the travel times between each pair of nodes can be seen in table 4.

Table 4. Degree of truth for the values of travel times between each pair of nodes.

CUSTOMER	0	1	2	3	4	5	6	7	8	9	10
0		0,723	0,686	0,678	0,697	0,702	0,719	0,685	0,720	0,690	0,691
1	0,715		0,689	0,694	0,659	0,659	0,669	0,694	0,703	0,660	0,677
2	0,600	0,681		0,667	0,658	0,667	0,636	0,609	0,669	0,637	0,617
3	0,644	0,723	0,612		0,633	0,673	0,665	0,607	0,645	0,608	0,548
4	0,700	0,682	0,670	0,689		0,436	0,622	0,666	0,668	0,625	0,679
5	0,735	0,701	0,698	0,705	0,422		0,584	0,678	0,692	0,663	0,686
6	0,724	0,724	0,680	0,740	0,627	0,626		0,664	0,686	0,666	0,745

CUSTOMER	0	1	2	3	4	5	6	7	8	9	10
7	0,651	0,696	0,582	0,605	0,710	0,698	0,687		0,675	0,662	0,552
8	0,691	0,689	0,639	0,645	0,621	0,640	0,626	0,661		0,608	0,628
9	0,713	0,688	0,625	0,671	0,564	0,563	0,624	0,636	0,670		0,643
10	0,665	0,719	0,630	0,544	0,681	0,688	0,661	0,548	0,613	0,672	

The degrees of indeterminacy of each of the travel times between each pair of nodes can be seen in table 5.

Table 5. Degree of indeterminacy for the values of travel times between each pair of nodes.

CUSTOMER	0	1	2	3	4	5	6	7	8	9	10
0		0,659	0,770	0,796	0,738	0,722	0,670	0,772	0,669	0,758	0,755
1	0,682		0,761	0,745	0,857	0,857	0,826	0,744	0,719	0,854	0,801
2	1,000	0,787		0,827	0,861	0,832	0,934	1,000	0,825	0,929	1,000
3	0,907	0,659	1,000		0,946	0,812	0,837	1,000	0,904	1,000	1,000
4	0,727	0,783	0,822	0,761		1,000	0,981	0,833	0,826	0,973	0,793
5	0,625	0,725	0,732	0,711	1,000		1,000	0,796	0,753	0,844	0,772
6	0,658	0,658	0,789	0,609	0,969	0,972		0,841	0,772	0,834	0,595
7	0,884	0,740	1,000	1,000	0,746	0,733	0,767		0,804	0,847	1,000
8	0,754	0,760	0,924	0,900	0,987	0,921	0,970	0,851		1,000	0,962
9	0,686	0,763	0,970	0,818	1,000	1,000	0,978	0,936	0,819		0,910
10	0,836	0,670	0,956	1,000	0,786	0,766	0,850	1,000	1,000	0,817	

The degrees of falsity for each of the travel times between each pair of nodes can be seen in table 6.

Table 6. Degree of falsity for the values of travel times between each pair of nodes.

CUSTOMER	0	1	2	3	4	5	6	7	8	9	10
0		0,382	0,456	0,474	0,434	0,424	0,390	0,458	0,389	0,448	0,446
1	0,397		0,451	0,439	0,517	0,516	0,495	0,439	0,421	0,514	0,477
2	0,663	0,468		0,495	0,519	0,499	0,570	0,638	0,494	0,566	0,617
3	0,551	0,382	0,632		0,579	0,485	0,502	0,644	0,549	0,640	0,820
4	0,427	0,465	0,492	0,450		1,000	0,603	0,500	0,495	0,598	0,472
5	0,360	0,426	0,430	0,416	1,000		0,711	0,474	0,445	0,507	0,457
6	0,381	0,381	0,469	0,350	0,595	0,597		0,505	0,458	0,500	0,341
7	0,535	0,436	0,714	0,649	0,456	0,432	0,454		0,479	0,509	0,809
8	0,445	0,449	0,563	0,545	0,608	0,561	0,596	0,512		0,641	0,590
9	0,399	0,451	0,596	0,489	0,771	0,773	0,602	0,572	0,489		0,553
10	0,501	0,390	0,586	0,837	0,467	0,454	0,512	0,820	0,630	0,489	

Now with the data of the travel times converted to neutrosophic triangular numbers we proceed to execute the genetic algorithm for the proposed example. The best solution obtained by the neutrosophic genetic algorithm with a fitness of 3456.4 can be seen in figure 4.

0	2	1	9	4	6	5	8	3	10	7	0

Figure 4. Best individual for the neutrosophic genetic algorithm.

The next step is to execute the deterministic genetic algorithm using the average values of the travel times between each pair of nodes. The best individual, with a fitness of 8508, for the deterministic genetic algorithm, can be seen in figure 5.

0	2	4	6	5	9	1	8	3	10	7	0

Figure 5. Best individual for the deterministic genetic algorithm.

Afterwards, the travel times between each pair of nodes are simulated for one hundred scenarios. Then the travel time of each of the best routes obtained by both the neutrosophic algorithm and the deterministic algorithm is calculated. The results can be seen in figure 6.

The neutrosophic algorithm obtained a shorter total travel time than the deterministic algorithm in 52 of the 100 simulated scenarios, while the deterministic algorithm obtained a shorter total travel time in 48 of the 100 simulated scenarios. The graph of the percentage of success of each of the algorithms can be seen in figure 7.

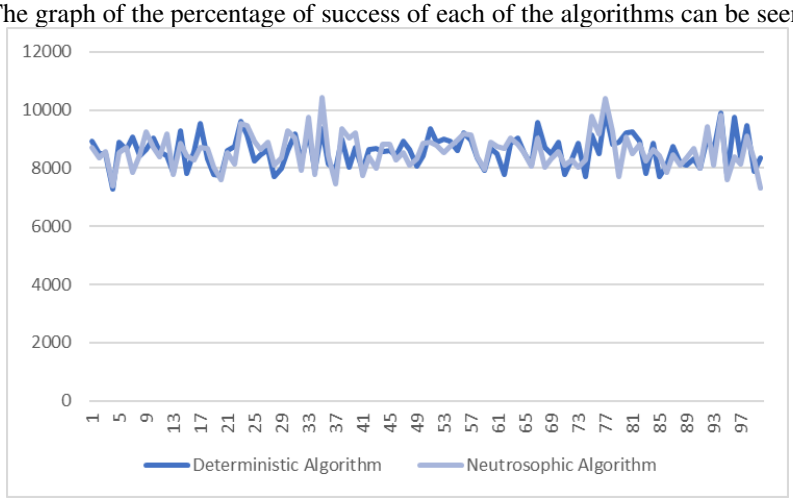


Figure 6. Travel times for both, the neutrosophic algorithm and the deterministic algorithm in the simulation.

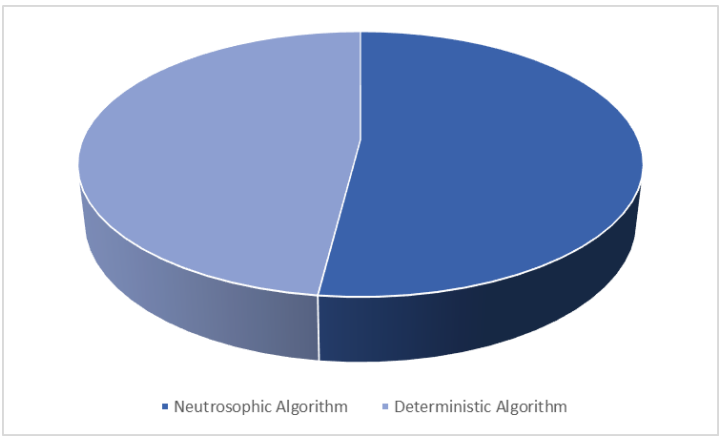


Figure 7. Percentage of successes of each algorithm.

4. Conclusions

Throughout this investigation we were able to verify the importance of including the uncertainty present in the data in the models we use for route planning. Working with mathematical models that only consider deterministic values can lead to generating solutions that in real life will not have the same behavior that was observed when solving the model.

The good performance of the neutrosophic theory was once again verified to work with values subject to different types of uncertainty, since it allows quantifying this uncertainty in order to take it into account in mathematical models and, as in this case, in the algorithms used to solve complex problems.

Even though the simulation was based on fitting the data to a triangular distribution, which greatly reduces the uncertainty present in them, the algorithm presented good results for the problem we were studying. This research is expected to open a new branch in neutrosophic research by combining metaheuristics with neutrosophic theory to solve complex problems that are also subject to high levels of uncertainty.

Funding: "This research received no external funding".

Conflicts of Interest: "The authors declare no conflict of interest".

References

1. D. Kubek, P. Więcek, and K. Chwastek, "The Impact of Short Term Traffic Forecasting on the Effectiveness of Vehicles Routes Planning in Urban Areas," Transp. Res. Procedia, vol. 18, no. June, pp. 172–179, 2016, doi: 10.1016/j.trpro.2016.12.024.
2. X. Yu and K. Liu, "A spatial decision support system for large scale vehicle routing," 2009 Int. Conf. Meas. Technol. Mechatronics Autom. ICMTMA 2009, vol. 3, pp. 444–449, 2009, doi: 10.1109/ICMTMA.2009.270.
3. Z. Yao, B. Zhao, L. Qin, Y. Jiang, B. Ran, and B. Peng, "An efficient heterogeneous platoon dispersion model for real-time traffic signal control," Phys. A Stat. Mech. its Appl., vol. 539, p. 122982, 2020, doi: 10.1016/j.physa.2019.122982.
4. D. Kubek, "Zastosowanie optymalizacji odpornej w problematyce wyznaczania tras pojazdom: charakterystyka oraz kierunki bada," Logistyka, no. 3, pp. 2654–2663, 2015.
5. M. Gendreau, G. Laporte, and R. Séguin, "Stochastic vehicle routing," Eur. J. Oper. Res., vol. 88, no. 1, pp. 3–12, 1996, doi: 10.1016/0377-2217(95)00050-X.
6. J. Gao, "Model and algorithm of vehicle routing problem with time windows in stochastic traffic network," 2010 Int. Conf. Logist. Syst. Intell. Manag. ICLSIM 2010, vol. 2, pp. 848–851, 2010, doi: 10.1109/ICLSIM.2010.5461065.
7. U. Ritzinger, J. Puchinger, and R. F. Hartl, "A survey on dynamic and stochastic vehicle routing problems," Int. J. Prod. Res., vol. 54, no. 1, pp. 215–231, 2016, doi: 10.1080/00207543.2015.1043403.
8. G. Laporte, F. Louveaux, and H. Mercure, "Vehicle routing problem with stochastic travel times," Transp. Sci., vol. 26, no. 3, pp. 161–170, 1992, doi: 10.1287/trsc.26.3.161.
9. B. Rostami, G. Desaulniers, F. Errico, and A. Lodi, "Branch-price-and-cut algorithms for the vehicle routing problem with stochastic and correlated travel times," Oper. Res., vol. 69, no. 2, pp. 436–455, 2021.
10. Z. Wang and L. Lin, "A Simulation-based algorithm for the capacitated vehicle routing problem with stochastic travel times," J. Appl. Math., vol. 2013, 2013, doi: 10.1155/2013/127156.
11. D. Guimarans, O. Dominguez, J. Panadero, and A. A. Juan, "A simheuristic approach for the two-dimensional vehicle routing problem with stochastic travel times," Simul. Model. Pract. Theory, vol. 89, pp. 1–14, 2018, doi: 10.1016/j.simpat.2018.09.004.
12. J. Panadero, A. A. Juan, A. Freixes, C. Serrat, M. Grifoll, and M. Dehghanimohamamdabadi, "A SIMHEURISTIC FOR THE UNMANNED AERIAL VEHICLE SURVEILLANCE-ROUTING PROBLEM WITH STOCHASTIC TRAVEL TIMES AND RELIABILITY CONSIDERATIONS," in 2019 WINTER SIMULATION CONFERENCE (WSC), 2019, pp. 1883–1893.
13. D. Taş, N. Dellaert, T. van Woensel, and T. de Kok, "The time-dependent vehicle routing problem with soft time windows and stochastic travel times," Transp. Res. Part C Emerg. Technol., vol. 48, pp. 66–83, 2014, doi: 10.1016/j.trc.2014.08.007.
14. T. Zhang, W. A. Chaovalitwongse, and Y. Zhang, "Scatter search for the stochastic travel-time vehicle routing problem with simultaneous pick-ups and deliveries," Comput. Oper. Res., vol. 39, no. 10, pp. 2277–2290, 2012, doi: 10.1016/j.cor.2011.11.021.
15. X. Li, P. Tian, and S. C. H. Leung, "Vehicle routing problems with time windows and stochastic travel and service times: Models and algorithm," Int. J. Prod. Econ., vol. 125, no. 1, pp. 137–145, 2010, doi: 10.1016/j.ijpe.2010.01.013.
16. E. Messaoud, "A chance constrained programming model and an improved large neighborhood search algorithm for the electric vehicle routing problem with stochastic travel times," Evol. Intell., no. 0123456789, 2021, doi: 10.1007/s12065-021-00648-0.
17. Z. Shao, S. Gao, and S. Wang, "A Hybrid Particle Swarm Optimization Algorithm for Vehicle Routing Problem with Stochastic Travel Time," in FUZZY INFORMATION AND ENGINEERING, VOL 1, 2009, vol. 54, pp. 566–574.
18. B. Xie and S. An, "Applying genetic algorithm to vehicle routing problem with stochastic travel times," Dyn. Contin. Discret. Impuls. Syst. A-MATHEMATICAL Anal., vol. 13, no. 2, S, pp. 693–697, 2006.

19. J. Oyola, “The capacitated vehicle routing problem with soft time windows and stochastic travel times,” Rev. Fac. Ing. Univ. Pedagog. Y Tecnol. Colomb., vol. 28, no. 50, pp. 19–32, 2019, doi: 10.19053/01211129.v28.n50.2019.8782.
20. A. Gutierrez, L. Dieulle, N. Labadie, and N. Velasco, “A multi population memetic algorithm for the vehicle routing problem with time windows and stochastic travel and service times,” IFAC-PapersOnLine, vol. 49, no. 12, pp. 1204–1209, 2016, doi: 10.1016/j.ifacol.2016.07.673.
21. D. M. Miranda, J. Branke, and S. V. Conceição, “Algorithms for the multi-objective vehicle routing problem with hard time windows and stochastic travel time and service time,” Appl. Soft Comput. J., vol. 70, pp. 66–79, 2018, doi: 10.1016/j.asoc.2018.05.026.
22. S. I. A. Aal, M. M. A. Abd Ellatif, and M. M. Hassan, “Two ranking methods of Single Valued Triangular Neutrosophic Numbers to rank and evaluate Information Systems Quality,” Neutrosophic Sets Syst., vol. 19, pp. 133–143, 2018.
23. Uber, “Uber Movement,” 2022. https://movement.uber.com/.
24. R. Kumar, S. A. Edaltpanah, S. Jha, S. Broumi, and A. Dey, “Neutrosophic shortest path problem,” Neutrosophic Sets Syst., vol. 23, pp. 5–15, 2018.

Received: September 15, 2022. **Accepted:** October 31, 2022

Information about the journal

Neutrosophy provides elements to strengthen Latin American philosophy on solving social problems and on a new rebirth of philosophy, science and art in the continet. This special issue serves as a sample of the advances of neutrosophy in the continent in resolving social problems and the results of the Latin American Association of Neutrosophics Sciences.

Editors-in-Chief of this Neutrosophic Sets and Systems Special Issue: *Neutrosophic in Latin America, progress and perspectives*, Vol.SI 52, 2022:

Prof. Dr. Florentin Smarandache, Postdoc, Mathematics Department, University of New Mexico, Gallup, NM 87301, USA, Email: smarand@unm.edu.
Dr. Mohamed Abdel-Basset, Faculty of Computers and Informatics, Zagazig University, Egypt,
Email: mohamed.abdelbasset@fci.zu.edu.eg.
Prof. Dr. Maikel Leyva Vazquez, Autonomous Regional University of the Andes (UNIANDES Ambato), Ecuador,
Email: mleyvaz@gmail.com.
Dr. Said Broumi, Laboratory of Information Processing, Faculty of Science Ben M'Sik, University of Hassan II, Casablanca, Morocco, Email: s.broumi@flbenmsik.ma.

ISSN 2331-6055 (print)
ISSN 2331-608X (online)

23316055