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Prefacio

Es un privilegio presentar este número especial de la revista Investigación Operacional, dedicado a conmemorar dos hitos significativos en el ámbito científico: el 30º aniversario de la creación de la neutrosofía y la teoría plitogénica, así como el 70º cumpleaños de su destacado fundador, el Profesor Doctor Florentín Smarandache.

En el transcurso de estas tres décadas, la neutrosofía ha progresado de ser una teoría filosófica innovadora a un enfoque multidisciplinario de considerable impacto, aplicable en áreas tan variadas como la inteligencia artificial, la lógica, la matemática y las ciencias sociales. La teoría plitogénica, basada sobre los principios neutrosóficos, ha proporcionado herramientas sofisticadas para el análisis de sistemas complejos y la toma de decisiones in condiciones de incertidumbre.

Este número especial no solo homenajea la significativa contribución del Prof. Smarandache a la ciencia contemporánea, sino que también pretende ser un vehículo para la divulgación de los últimos avances en estas teorías. A través de los artículos recopilados, se investigan nuevas fronteras en la investigación neutrosófica y plitogénica, subrayando la relevancia de estas teorías en el contexto académico y profesional contemporáneo.

Es especialmente relevante que esta cifra coincida con la reciente visita del Prof. Smarandache a Cuba in 2024, un acontecimiento que enfatiza los vínculos de cooperación entre la Universidad de La Habana y los avances científicos en el ámbito de la neutrosofía. Los autores que participan en este número especial proceden de diversas instituciones internacionales , algo que evidencia el carácter global de la influencia de estas teorías.

Anticipamos que esta publicación no solo funcione como un homenaje al legado del Prof. Smarandache, sino también como una fuente de inspiración para investigadores, estudiantes y profesionales interesados en explorar los amplios horizontes que brinda la neutrosofía y sus aplicaciones.

Los Editores

NEUTROSOPHIC MULTI-CRITERIA ANALYSIS OF LEGAL AND SOCIAL BARRIERS TO MARRIAGE EQUALITY IN MERCOSUR

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ABSTRACT.

The present study analyzes the status of the legalization of same-sex marriage in Mercosur member countries, using a multicriteria approach based on neutral logic. This work addresses a critical problem in the region: the remarkable disparity in the recognition and protection of LGBTIQ+ rights between the different Member States, despite the international commitments assumed. Through a systematic analysis, the study identifies how legal frameworks, cultural dynamics, and political positions impact the evolution of these rights. Although existing literature has explored individual aspects, such as social perceptions or public policies, no approaches that simultaneously capture the multiple dimensions of this complex phenomenon have been integrated. The applied methodology combines neutral tools and multicriteria evaluation techniques to analyze key indicators such as current regulations, political support, social activism, and citizen perception. The results highlight that, although some countries show significant advances, structural and cultural barriers persist that slow down progress in others. This study contributes to the literature by offering a holistic approach to understanding the legalization of equal marriage in complex regional contexts, also providing concrete recommendations to overcome identified barriers. Ultimately, this research not only expands the theoretical framework on human rights and public policies but also provides practical tools to promote more equitable and sustainable progress in the recognition of LGBTIQ+ rights in the Mercosur region.

KEYWORDS: neutrosophic, multicriteria, policies, public, disparity, frames, legal, dynamics, cultural, activism, perception, citizenship, barriers, structural.

MSC: 03B52, 62P20, 90B50

RESUMEN

El presente estudio analiza el estado de la legalización del matrimonio entre personas del mismo sexo en los países miembros del MERCOSUR, utilizando un enfoque multicriterio basado en la lógica neutrosófica. Este trabajo aborda un problema crítico en la región: la notable disparidad en el reconocimiento y la protección de los derechos LGBTIQ+ entre los distintos estados miembros, a pesar de los compromisos internacionales asumidos. A través de un análisis sistemático, el estudio identifica cómo los marcos legales, las dinámicas culturales y las posturas políticas impactan en la evolución de estos derechos. Aunque la literatura existente ha explorado aspectos individuales, como las percepciones sociales o las políticas públicas, no se han integrado enfoques que capturen simultáneamente las múltiples dimensiones de este fenómeno complejo. La metodología aplicada combina herramientas neutrosóficas y técnicas de evaluación multicriterio para analizar indicadores clave como la normativa vigente, el apoyo político, el activismo social y la percepción ciudadana. Los resultados destacan que, aunque algunos países muestran avances significativos, persisten barreras estructurales y culturales que ralentizan el progreso en otros. Este estudio contribuye a la literatura al ofrecer un enfoque holístico para comprender la legalización del matrimonio igualitario en contextos regionales complejos, brindando además recomendaciones concretas para superar las barreras identificadas. En última instancia, esta investigación no solo amplía el marco teórico sobre derechos humanos y políticas públicas, sino que también provee herramientas prácticas para fomentar un progreso más equitativo y sostenible en el reconocimiento de los derechos LGBTIQ+ en la región del MERCOSUR.

PALABRAS CLAVE: Neutrosófico, Multicriterio, Políticas, Públicas, Disparidad, Marcos, Legales, Dinámicas, Culturales, Activismo, Percepción, Ciudadanía, Barreras, Estructurales.

1. INTRODUCTION

The legalization of same-sex marriage has emerged as a critical issue in the fight for human rights in the 21st century. Despite legislative progress in various countries, the situation within the MERCOSUR member states reveals significant disparities, reflecting complex legal, cultural, and social dynamics. These differences, often overlooked in comparative studies, have crucial implications for equality and regional cohesion. Recent research has explored individual aspects of this issue, such as social acceptance or local regulations, yet there remains a need for integrative approaches that capture the multidimensionality of the problem [1][2].

Historically, the legislation surrounding marriage equality has evolved unevenly. While countries like Argentina took the lead in the region by enacting inclusive laws in 2010 [3], other MERCOSUR nations have adopted more conservative stances, creating a patchwork of regulations across the bloc. This context highlights not only divergences in societal values but also the influence of political structures and local leadership. Therefore, understanding the interplay of these factors requires a systematic analysis that transcends purely legal perspectives and considers cultural and social dynamics [4].

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The central problem driving this study lies in the absence of a comprehensive analytical framework to evaluate the conditions and current status of same-sex marriage legalization in MERCOSUR countries. This issue can be summarized in the following question: how can the state of such legislation be effectively analyzed, considering the normative, political, and cultural diversity of the region? This methodological gap serves as a barrier to the development of policies that promote greater equality within the bloc [5].

In response to this, the study employs a multi-criteria neutrosophic approach, an innovative analytical tool designed to address uncertainty and ambiguity inherent in complex social problems. This method, which combines mathematical techniques with subjective evaluations, is particularly suited for analyzing phenomena where multiple factors converge. The goal is not only to generate a clear diagnosis of the current legislative status but also to propose strategies to foster progress in this domain [6][7].

The primary objective of this article is to develop a comprehensive methodology for analyzing and comparing the status of marriage equality across MERCOSUR countries. Additionally, it seeks to identify critical factors hindering legislative progress in some nations while highlighting best practices that could be replicated within the regional context. On a broader level, this study aims to contribute to the academic literature by offering a replicable methodological framework for regions with similar characteristics.

Finally, this work has significant practical and theoretical implications. From a practical perspective, the findings can inform the creation of inclusive public policies and guide the design of strategies that promote equal rights in the region [8]. Theoretically, the use of a neutrosophic approach expands methodological possibilities for analyzing complex problems in contexts of high uncertainty, showcasing its applicability beyond the specific case under study.

In conclusion, this research addresses an urgent and relevant issue in the context of human rights and regional politics. By integrating multiple dimensions into a systematic analysis, the study seeks not only to illuminate the current state of marriage equality legislation within MERCOSUR but also to provide practical and conceptual tools for advancing equality and social justice in the region. This multidisciplinary approach bridges the gap between theory and practice, fostering sustainable and equitable solutions for the future.

2. MULTI-CRITERIA NEUTROSOPHIC METHOD.

To achieve the proposed objectives, the study used the multi-criteria decision-making method (MCDM). MCDM allows the development of procedures that take very complex real situations and make decisions with simplifications in certain situations. In this way, the original problem reaches a solvable state.

Several MCDM methods have been developed to solve problems arising in various areas of life and society. However, traditional methods often use explicit values to evaluate alternatives. Due to the complexity of the environment and human subjectivity, MCDM problems often involve uncertainty, so the information provided to solve them is often confusing or verbal.

Decision-making typically involves the use of human language or, commonly, linguistic parameters. Arguments simply represent words or concepts used in human language. Therefore, this linguistically variable approach is a suitable way for decision-makers to express their evaluation. Basic levels can be expressed using linguistic variables. Linguistic variables can be represented in SVNS, as shown in Table 1.

Definition	SVNS
Extremely preferred (ExP)	(1,0,0)
Very Very Preferred (VVP)	(0.9, 0.1, 0.1)
Highly 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 little preferred (VNP)	(0.20,0.85,0.80)
Very little preferred (VVNP)	(0,10,0,90,0,90)
Extremely Not Preferred (ENP)	(0,1,1)

Table 1: Parameters and Single-Valued Neutrosophic Numbers [SVNN]. Source: [13]

Given a set of options $G = [G_1, G_2, \dots, G_n]$ and $A = [A_1, \dots, A_m]$ a collection of properties. Let be $W = [w_1, w_2, \dots, w_n]$ the weight of the attribute, where

$$O \leq w_j \leq 1 \text{ y } \sum_{j=1}^{n} w_j = 1 \quad (1).$$

Let a_{ij} with $i = 1, 2,\dots,m$ and $j = 1, 2,\dots, n$, be the value of the selection attribute A_i associated with the attribute Gj. Then

$$A = [a_{ij}]_{m\times n} = \langle (T_{ij}, I_{ij}, F_{ij}) \rangle_{mxn} \quad (2)$$

be the SVNN matrix. Here, T_{ij}, $I_{ij,}$ and F_{ij} are the membership degree and the degree of uncertainty in membership. The diagnosis procedure is as follows:

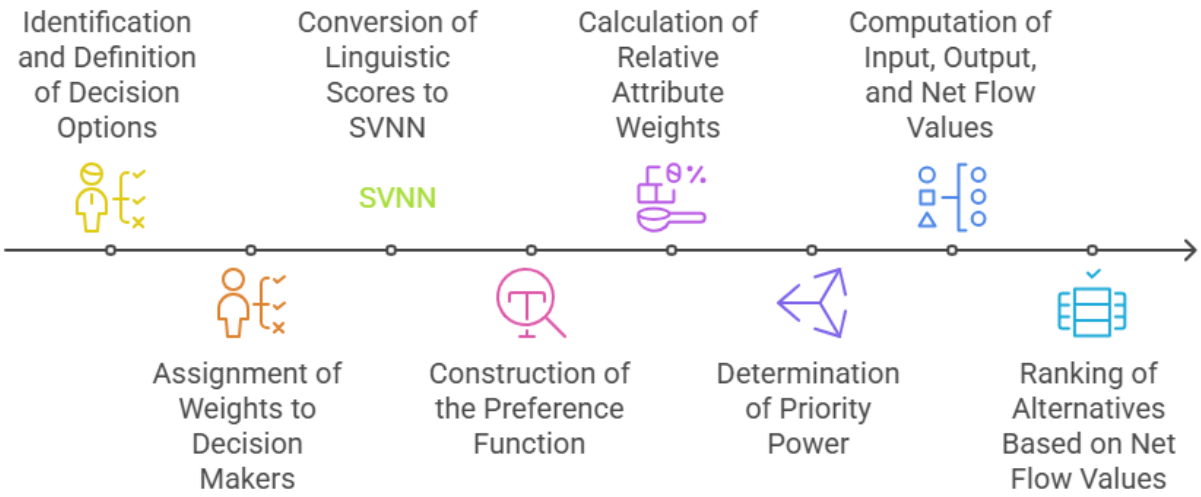

Figure1. Decision-Making Process

Step 1 Identification and Definition of Decision Options

Multicriteria decision-making methods are analytical frameworks designed to address complex problems by evaluating multiple, often conflicting, objectives. Central to these methods is the explicit definition of options (potential solutions) and criteria (measurable factors used to assess those solutions), such as cost-effectiveness, environmental sustainability, or social impact. This structured approach not only enhances transparency but also mitigates biases, ensuring decisions align with strategic goals.

Step 2 Assignment of Weights to Decision Makers

The logic of the method allows each decision-maker to receive unique and different ratings from the other decision-makers. This is because each rating is given based on each expert's level of knowledge about the decision issue under discussion. The relative weight of each determinant is considered a language variable and an input to the SVNN, which is then defined by Equation 1.

Step 3: Conversion of Linguistic Scores to Single Valued Neutrosophic Numbers (SVNN).

The language scores provided by the experts are converted to the SVNN. From the clear and precise individual matrices obtained according to expert judgment, the individual neutrosophic decision-making matrix is constructed as shown in Table 1. The initial relationship matrix is obtained for options *A* and G see (2)

Equation (2) is used to calculate the member score, undetected member score, and non-member score. In the fifth step, the information about the solution is combined. This means that we normalize.

$$A = [a_{ij}]_{m\times n} \quad B = [b_{ij}]_{m\times n} \tag{3}$$

If the decision is a cost factor, the decision information must be changed to an additional set using equation [3], but if the decision is an efficiency factor, it cannot be changed.

To provide greater context on the subject, decision-making plays a vital role across all domains, whether in personal, professional, or academic settings. In the academic realm, students regularly encounter choices that range from selecting courses to deciding on research topics. Utilizing structured methodologies, like the approach outlined, enables students to make well-informed and thoughtful decisions by taking into account multiple factors and the insights of experts.

Furthermore, the use of matrices and equations provides a quantitative framework for evaluating options, which can be especially useful in situations where decisions are influenced by multiple variables. However, it is important to note that while methods can provide structure and clarity, it is also critical to consider the specific context and individual needs when making decisions. Therefore, the application of these methods must be complemented by careful analysis.

Step 4: Construction of the Preference Function.

Use [5] to build the preference function $P_j\,[B_i\,,\,B_r]$ to replace B_i with B_r with the characteristic G_j.

$$P_j(B_i, B_r) = \begin{cases} 0\ , d \le p \\ \frac{d-p}{q-p}\ , p < d < q \\ 1\ , d \ge q \end{cases} \tag{4}$$

Step 5: Calculation of Relative Attribute Weights

Calculate the relative weight of attribute w_{jr}, which is the relative weight of G_r concerning G_j. here

$$w_{jr} = \frac{w_j}{w_r} = [j, r = 1,2, \dots, n] \tag{5}$$

Step 6: Determination of Priority Power.

Determine priority power $\pi[B_i, Br]$ of circuit B_i for Br using the following formula:

$$\pi(B_i, B_r) = \frac{\sum_{j=1}^{n} w_{jr} P_j(B_i, B_r)}{\sum_{j=1}^{n} w_{jr}} \tag{6}$$

Step 7: Computation of Input, Output, and Net Flow Values.

Calculate the input $\Phi^{+}[B_i]$, output $\Phi[B_i]$ and net input $\Phi[B_i]$ as follows:

$$\Phi^{+}(B_i) = \frac{\sum_{r=1}^{m} \pi(B_i, B_r) - \min\limits_{1 \le i \le m} \{\sum_{r=1}^{m} \pi(B_i, B_r)\}}{\max\limits_{1 \le i \le m} \{\sum_{r=1}^{m} \pi(B_i, B_r)\} - \min\limits_{1 \le i \le m} \{\sum_{r=1}^{m} \pi(B_i, B_r)\}} \tag{7}$$

$$\Phi^{-}(B_i) = \frac{\sum_{r=1}^{m} \pi(B_r, B_i) - \min\limits_{1 \le i \le m} \{\sum_{r=1}^{m} \pi(B_r, B_i)\}}{\max\limits_{1 \le i \le m} \{\sum_{r=1}^{m} \pi(B_r, B_i)\} - \min\limits_{1 \le i \le m} \{\sum_{r=1}^{m} \pi(B_r, B_i)\}} \tag{8}$$

$$\Phi(B_i) = \Phi^{+}(B_i) - \Phi^{-}(B_i) \tag{9}$$

Step 8: Ranking of Alternatives Based on Net Flow Values.

Sort all options by value $\Phi(B_i)$. The higher the value, $\Phi(B_i)$, the better the option.

3. RESULTS

Below, we analyze step by step the neutrosophic multicriteria process used to evaluate the equality of marital status between persons of the same sex in MERCOSUR.

A total of seven experts were consulted, whose opinions were used to determine the appropriate endpoints for this study. The criteria obtained from this consultation are presented in Table 2.

In	Evaluation criteria
F1	Equal rights in marriage are evaluated based on whether same-sex couples have the same opportunities as heterosexual couples to formalize their unions. This assessment examines the extent to which legal, administrative, or social obstacles may hinder equal access, highlighting potential disparities in the ability of same-sex couples to enjoy the same rights and recognition.
F2	Legal protection and recognition are crucial factors in assessing whether married same-sex couples enjoy the same safeguards and rights as heterosexual couples. This includes evaluating their access to property rights, tax benefits, social security, adoption opportunities, and other legal privileges associated with marriage.
F3	Non-discrimination and respect for gender identity are key aspects to consider when evaluating the treatment of same-sex couples by both the government and society. This includes ensuring that these couples are not subjected to discriminatory practices and that their gender identities are acknowledged and respected throughout the marriage process.
F4	Education and awareness-raising: it also includes education and awareness-raising initiatives on marriage equality and the specific rights and issues faced by same-sex couples. This may include educational programs, information campaigns, and training for professionals in different fields.

Table 2: Indicators that evaluate respect for equal marriage in MERCOSUR.

This paper adopts a horizontal approach to assign weighting vectors to the indicators used to assess the equality of marital status for same-sex couples within MERCOSUR. This methodology forms the foundation for deriving informed conclusions about the level of equality achieved. The results of these weighting vectors, which quantify the relative importance of each indicator, are detailed below and summarized in Table 3.

Evaluation criteria	Neutrosophic weight
F1	(0.9, 0.1, 0.1)
F2	(1 0 0)
F3	(0.8,0.15,0.20)
F4	(1 0 0)

Table 3: Weights related to the indicators.

To obtain the results of the proposed method, people use a neutrosophic scale, more precisely the linguistic scale S, where $v_{kj} \in S$, and $S = \{s_1, \dots, s_g\}$ is a set of terms. The language is defined to evaluate the characteristics of CK using the

Single-Evaluate Neutrosophic Count (EN) method. This approach facilitates the analysis of the resulting linguistic terms. The range of linguistic terms employed in this evaluation is presented in Table 4.

Linguistic terms	SVN Number
Extremely high (EH)	(1 0 0)
Very very high (VVH)	(0.9, 0.1, 0.1)
Very high (VH)	(0.8,0.15,0.20)
High (H)	(0.70,0.25,0.30)
Medium High (MH)	(0.60,0.35,0.40)
Medium (M)	(0.50,0.50,0.50)
Medium Low (ML)	(0.40,0.65,0.60)
Low (VL)	(0.30,0.75,0.70)
Very low (VL)	(0.20,0.85,0.80)
Very very low (VVL)	(0,10,0,90,0,90)
Extremely Low (EL)	(0,1,1)

Table 4. Scale of linguistic terms.

Based on the results obtained, the Neutrosophic tool was used to quantify the status of same-sex marriage in Mercosur. The analysis was carried out using a scale of linguistic terms; the results are presented in Table 5.

Evaluation criteria	Linguistic terms	Neutrosophic value
F1	Very very high (VVH)	(0.9, 0.1, 0.1)
F2	Extremely high (EH)	(1 0 0)
F3	Very high (VH)	(0.8,0.15,0.20)
F4	Extremely high (EH)	(1 0 0)

Table 5. The scale determines the current state of equal rights in marriage and adoption of same-sex couples in MERCOSUR

Based on the proposed linear neutrosophic weighting method, a calculation was performed to determine the equal marital status of same-sex couples in Mercosur. Table 6 presents the data and processing results obtained from the calculation of Equation 3.

Evaluation criteria	Preferred neutrosophic value	Neutrosophic weight vector	Calculation
F1	(0.70,0.25,0.30)	(0.9, 0.1, 0.1)	(0.8,0.15,0.20)
F2	(0.40,0.65,0.60)	(1 0 0)	(0.7,0.25,0.30)
F3	(0.40,0.65,0.60)	(0.8,0.15,0.20)	(0.60,0.35,0.40)
F4	(0.20,0.85,0.80)	(1 0 0)	(0.60,0.35,0.40)
Results			(0.67,0.35,0.40)

Table 6: Processing results.

The results indicate that the status of same-sex marriage within MERCOSUR achieves a favorable assessment, reflected in an index score of 0.67, signifying a "very good" level of progress.

Below are the results of a survey conducted to gather information and verify the results of the method developed, as well as to assess the need for its use. The survey was conducted with 15 lawyers from the countries of Ecuador and MERCOSUR. The results are as follows:

Question 1: Do you support the legalization of same-sex marriage in MERCOSUR?

Option	Total	Percent
Yes	13	88%
No	2	12%
Total	**15**	**100%**

Table 7: Results of Question 1.

Regarding question 1, we found that among all respondents, 88% support the legalization of same-sex marriage in MERCOSUR, while 18% oppose the measure.

Question 2: Do you think same-sex couples can marry in the country?

Option	Total	Percent
Yes	12	86.6%
No	3	13.4%
Total	**15**	**100%**

Table 8: Results of Question 2.

Analyzing the results of the question, 86.6% support this option, while 13.4% oppose it.

Question 3: Do you think that the HOMOSEXUAL community in Mercosur is advancing in terms of rights and acceptance in society?

Option	Total	Percent
Yes	11	80%
No	4	20 %
Total	**15**	**100%**

Table 9: Results of Question 3.

According to the analysis, 80% of respondents believe that Mercosur is making progress in the rights of LGBTIQ+ groups and 20% believe that there is no progress in this regard in society.

Question 4: Are additional legal measures necessary to guarantee equal rights for same-sex couples in matters of marriage in MERCOSUR?

Option	Total	Percent
Yes	10	73.3%
No	5	26.7%
Total	**15**	**100%**

Table 10: Results of Question 4.

Regarding this question, most of the responses were in favor (73.3%) and only 26.7% were against.

Question 5: In your opinion, should same-sex couples enjoy the same rights as opposite-sex couples?

Option	Total	Percent
Yes	14	93.3%
No	1	6.7%
Total	**15**	**100%**

Table 11: Results of Question 5

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Analyzing the issue, it can be seen that 93.3% of respondents support homosexual couples having the same rights as heterosexual couples. However, 6.7% believe that they should not have the same rights but rather specific rights for each group.

Question 6: Do you think it is necessary to improve and simplify processes in MERCOSUR?

Option	All	Percent
Yes	15	100%
No	0	0%
Total	**15**	**100%**

Table 12: Results of Question 6.

Respondents were 100% in agreement on the importance of improving and optimizing processes within MERCOSUR to enhance the well-being of children and adolescents.

Question 7: Do you agree that the law should guarantee equal opportunities for all couples, regardless of their sexual orientation?

Option	Total	Percent
Yes	13	87%
No	2	13%
Total	**15**	**100%**

Table 8: Results of Question 7.

On this issue, 87% of respondents agreed that the law guarantees equal opportunities for couples to adopt children regardless of their sexual orientation, while only 13% disagreed with adoption.

The study reveals that the status of same-sex marriage within MERCOSUR is assessed at a favorable level, achieving an index score of 0.67, which signifies a "very good" degree of progress. This quantitative evaluation provides a strong foundation for understanding the current situation while highlighting areas requiring further attention. Below, the results

of a survey conducted with 15 lawyers from Ecuador and MERCOSUR are presented to corroborate these findings and assess the necessity of the developed methodology. Regarding **Question 1**, which asked participants if they supported the legalization of same-sex marriage in MERCOSUR, **88% of respondents expressed support**, while **12% opposed the measure** (Table 7). These results suggest a high level of approval for legalizing same-sex marriage across the surveyed legal professionals, reflecting progressive attitudes toward equality. For **Question 2**, respondents were asked if they believed same-sex couples could legally marry in their country. **86.6% responded affirmatively**, whereas **13.4% stated otherwise** (Table 8). This indicates that most respondents perceive the availability of marriage rights for same-sex couples as a reality, though a minority highlighted persisting legal or practical barriers. In **Question 3**, participants were queried about societal progress regarding the rights and acceptance of the LGBTQ+ community in MERCOSUR. **80% acknowledged advancements**, while **20% felt there had been no significant progress** (Table 9). This feedback underscores the perception of ongoing improvement, although a notable portion of respondents still views societal acceptance as insufficient.

When asked in **Question 4** whether additional legal measures are necessary to ensure equal rights for same-sex couples in marriage, **73.3% of respondents agreed**, compared to **26.7% who disagreed** (Table 10). This finding highlights the perception that further legislative efforts are required to fully guarantee equality. **Question 5** addressed whether same-sex couples should enjoy the same rights as opposite-sex couples. **An overwhelming 93.3% supported this**, while **6.7% favored specific rights tailored to each group** (Table 11). This data reflects a strong consensus toward equal treatment, with only a small minority advocating for differentiated approaches. In **Question 6**, all respondents (100%) agreed on the necessity of improving and simplifying processes within MERCOSUR to enhance the well-being of children and adolescents (Table 12). This unanimity suggests widespread recognition of the importance of administrative efficiency and inclusivity in fostering better outcomes for all families. Finally, **Question 7** explored whether the law should guarantee equal opportunities for all couples, regardless of sexual orientation, in matters such as adoption. **87% supported this**, while **13% disagreed** (Table 8). This finding underscores significant support for equality in family-related rights, with only a small minority dissenting.

The survey results, supported by a robust methodological framework, reveal a generally favorable perception of progress in marriage equality within MERCOSUR. However, they also highlight critical areas requiring legal and societal improvements, particularly in ensuring comprehensive equality and removing residual barriers to full recognition.

4. DISCUSSION.

The results of this study reveal that the status of same-sex marriage within MERCOSUR is assessed at a favorable level, with an index score of 0.67 indicating a "very good" degree of progress. Additionally, the survey results demonstrate strong support among legal professionals for marriage equality and highlight the need for further legislative and administrative improvements to ensure full equality across the region. These results underscore significant strides in the recognition of same-sex marriage rights within MERCOSUR. The high levels of support for legalization (88%) and equal rights (93.3%) among respondents suggest a shifting societal and professional consensus in favor of inclusivity. This progress may be attributed to growing advocacy, regional legal precedents, and increasing awareness of LGBTQ+ rights. The unanimous agreement (100%) on the necessity of improving administrative processes further emphasizes the demand for systemic efficiency to enhance the implementation of rights. Comparing these results with prior studies, the findings align with research indicating regional disparities in LGBTQ+ rights recognition but also highlight an overarching trend toward equality in Latin America. For instance, countries like Argentina have pioneered same-sex marriage legalization, influencing neighboring nations. However, contrasting perspectives remain, particularly in more conservative contexts within the bloc, where societal resistance and political inertia continue to hinder progress. This divergence mirrors findings from previous studies that emphasize the role of cultural and political factors in shaping marriage equality outcomes.

Despite these promising results, the study is not without limitations. The survey sample, consisting of 15 legal professionals, may not fully capture the diversity of opinions within the broader population. Additionally, the geographic focus on MERCOSUR, while providing valuable regional insights, limits the generalizability of the findings to other contexts. These constraints should be addressed in future research through larger, more diverse samples and comparative analyses across different regions. The implications of these findings are substantial for both future research and practical application. For researchers, the study highlights the importance of adopting holistic, multi-criteria methodologies to evaluate complex social and legal phenomena. Future studies could expand on this approach by incorporating perspectives from policymakers, activists, and the general public. Practically, the findings emphasize the need for targeted legislative reforms and public awareness campaigns to address remaining barriers to equality, particularly in countries lagging behind in recognizing same-sex marriage. Anomalous results, such as the 13.4% of respondents who indicated that same-sex marriage is not yet recognized in their country, despite legal precedents in some cases, suggest gaps in public understanding or inconsistencies in enforcement. These discrepancies warrant further investigation to uncover underlying causes, such as regional administrative challenges or misinformation. These findings contribute valuable evidence to the ongoing discourse on marriage equality, demonstrating significant progress while emphasizing areas requiring further attention. The study not only highlights the advancements in LGBTQ+ rights within MERCOSUR but also provides a framework for addressing remaining inequalities. By integrating data-driven analysis with practical insights, this research sets the stage for more inclusive and equitable policies in the future.

5. CONCLUSION.

This study provides valuable insights into the status of same-sex marriage within MERCOSUR, highlighting significant progress while identifying areas that require further attention. The favorable index score of 0.67 and the strong support for marriage equality among legal professionals underscore a growing consensus for inclusivity and equal rights in the region. These findings reveal a shifting cultural and legal landscape that increasingly embraces LGBTQ+ rights. The practical importance of these results lies in their ability to guide policymakers, advocates, and legislators in creating and implementing reforms that address persistent inequalities. By identifying critical gaps in societal acceptance and administrative processes, this research equips stakeholders with actionable data to promote more effective and inclusive policies. One of the key contributions of this study is its application of a multi-criteria neutrosophic approach to analyze the complex interplay of cultural, legal, and administrative factors influencing marriage equality. This methodology not only provides a nuanced understanding of the current status but also offers a replicable framework for assessing similar issues in other regions. The study bridges theoretical insights with practical implications, making it a significant step forward in the field of social and legal equity research. However, the research is not without limitations. The small sample size of 15 legal professionals, while providing valuable insights, restricts the generalizability of the findings to broader populations. Furthermore, the focus on MERCOSUR, while regionally relevant, may not fully capture the nuances present in other geopolitical or cultural contexts. These factors should be considered when interpreting the results and their implications. Future studies could expand on this work by incorporating larger and more diverse samples, including perspectives from activists, policymakers, and the general public. Additionally, exploring complementary methodologies, such as Fuzzy Logic or Artificial Intelligence, could enhance the analytical depth and accuracy of future assessments. Further investigation into the administrative and cultural barriers identified in this study is essential for sustaining the progress observed and addressing areas where disparities remain. In summary, this research underscores both the advancements and challenges in achieving marriage equality within MERCOSUR. It lays a foundation for continued dialogue and action, providing tools and insights that can drive meaningful change. By addressing the limitations and exploring new avenues of inquiry, future research can build on this work to foster greater equity and justice in the region and beyond.

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ASSESSING LEGAL SECURITY IN ECUADOR'S ABBREVIATED CRIMINAL PROCEDURE: A NEUTROSOPHIC DELPHI APPROACH

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ABSTRACT
The study analyzes deficiencies in Article 636 of the Comprehensive Organic Penal Code of Ecuador, which lacks clarity in determining the penalty in the summary procedure and affects the legal certainty of the defendants. The objective of the work is to carry out a critical legal analysis that identifies ambiguities and gaps in Article 636 of the COIP, as well as to propose solutions to strengthen legal certainty in the abbreviated procedure. Through the Neutrosophic Delphi method, consultations with experts, comparative analysis with foreign legislation, and review of judgments, ambiguities in the process are identified. It was found that certain international legislations emphasize the need to ensure a fair and proportionate trial in these cases, which is essential for safeguarding fundamental rights, and reform is proposed to incorporate clear and objective criteria, inspired by international practices and principles of justice and human rights, to improve the legal certainty and effectiveness of the Ecuadorian penal system.
KEYWORDS: Neutrosophic Delphi, penal system, fundamental rights, principles of justice.
MSC: 03B70, 68T37, 91D10, 03C90, 93A30

RESUMEN
El estudio analiza las deficiencias del Artículo 636 del Código Orgánico Integral Penal (COIP) de Ecuador, el cual carece de claridad en la determinación de la pena en el procedimiento abreviado, afectando la seguridad jurídica de los acusados. El objetivo del trabajo es realizar un análisis jurídico crítico que identifique las ambigüedades y vacíos en el Artículo 636 del COIP, así como proponer soluciones para fortalecer la seguridad jurídica en el procedimiento abreviado. A través del método Delphi Neutrosófico, consultas con expertos, análisis comparativo con legislaciones extranjeras y revisión de sentencias, se identifican ambigüedades en el proceso. Se encontró que ciertas legislaciones internacionales enfatizan la necesidad de garantizar un juicio justo y proporcional en estos casos, lo cual es esencial para la protección de los derechos fundamentales. Se propone una reforma para incorporar criterios claros y objetivos, inspirados en prácticas internacionales y principios de justicia y derechos humanos, con el fin de mejorar la seguridad jurídica y la eficacia del sistema penal ecuatoriano.
PALABRAS CLAVE: Delphi Neutrosófico, sistema penal, derechos fundamentales, principios de justicia.

1. INTRODUCTION

The criminal justice system is a cornerstone of any society seeking to maintain order, fairness, and the protection of its citizens. It represents the mechanism through which the state exercises its *ius puniendi*, that is, the right to apply sanctions and penalties to those who have committed criminal actions. At the same time, it has the important mission of safeguarding the individual rights of persons subject to criminal proceedings [9].

In the specific context of Ecuadorian criminal justice, the Comprehensive Organic Penal Code (COIP) represents a pivotal milestone in the country's legal system evolution. Since its implementation, efforts have been made to establish a more comprehensive, updated, and coherent legal framework that adapts to the needs and realities of Ecuadorian society.

One of the procedural instruments introduced with the COIP is the abbreviated procedure, conceived as a tool to expedite and simplify the resolution of criminal conflicts. This procedure aims to accelerate the judicial process by reducing the time and costs associated with a regular trial. Additionally, it seeks to encourage collaboration among the involved parties, thus favoring the speed and effectiveness of sentences. However, its application has faced significant challenges related to the clarity of its norms, especially concerning the imposition of penalties. The lack of precision in Article 636 of the COIP has led to various and sometimes contradictory interpretations, affecting the legal certainty of the accused.

On the other hand, legal certainty is an essential principle in the Rule of Law, ensuring that individuals have certainty about the rules governing their conduct and the legal consequences of their actions [17]. When legal norms are unclear or leave room for ambiguous interpretations, uncertainty, and vulnerability are created for citizens undergoing judicial processes.

Therefore, it is essential to address these issues in the application of the abbreviated procedure and work on solutions that ensure coherence, predictability, and protection of the fundamental rights of the accused. Clarity and precision in the regulations, as well as the incorporation of procedural safeguards, are key aspects to guarantee a more efficient and fair criminal justice system in Ecuador. Only in this way can an adequate balance be achieved

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between procedural expediency and respect for human rights, thus strengthening society's confidence in its justice system.

Throughout this article, the nature and purpose of the abbreviated procedure will be analyzed, as well as the regulatory framework in which it is found in the COIP. The critical points in the application of this procedural figure will be identified, and how the lack of clarity in Article 636 can lead to divergent interpretations and unpredictable consequences for the accused.

In addition to pointing out existing issues, this critical-legal analysis will propose concrete and well-founded solutions to address the ambiguity of Article 636 and ensure coherence and security in the imposition of penalties in the abbreviated procedure. These proposals will be supported by solid legal arguments and ethical considerations, thus seeking to strengthen the Ecuadorian criminal justice system and safeguard the rights of those involved in this process.

The results obtained from contrasting the provisions of Article 636 of the COIP with other national and international legislations related to criminal law and human rights were enlightening in identifying good practices and potential solutions that could be applied in the Ecuadorian context.

Firstly, it was found that some legislations in neighboring countries and the region have more detailed and clear provisions regarding the determination of the penalty in the abbreviated procedure [6]. These legislations include explicit lists of mitigating circumstances and establish objective criteria for their assessment. Additionally, some of these legislations allow for greater flexibility in reducing the penalty, provided that the principle of proportionality between the committed offense and the imposed sanction is respected. These practices could be considered to improve the wording of Article 636 of the COIP and avoid ambiguous interpretations that affect the legal security of the defendant.

For example, in the criminal legislation of Colombia, the "proceso abreviado" (abbreviated process) is similar to the abbreviated procedure of the COIP. However, Article 356 of the Colombian Code of Criminal Procedure establishes limits for determining the penalty in this procedure. It states that in no case shall the agreed penalty exceed two-thirds of the minimum penalty established for the offense [2].

In Chile, Law No. 20,931, which reformed the criminal procedural system, also contains more precise provisions regarding the penalty in the abbreviated procedure [5]. Article 406 of the Chilean Code of Criminal Procedure establishes that, in this procedure, the agreed penalty shall not exceed half of the minimum penalty established for the offense. Likewise, in Peru, the Code of Criminal Procedure establishes in Article 468 that, in the abbreviated procedure, the agreed penalty shall not exceed half of the minimum penalty set for the offense [3,10].

These examples show that in neighboring countries and the region, greater precision has been foreseen in determining the penalty in the abbreviated procedure. These clear and detailed provisions provide greater legal security for both the defendant and judicial operators, thus avoiding subjective interpretations and ensuring a more uniform application of the law. In this sense, the COIP could benefit from implementing similar modifications to ensure a more effective and equitable criminal justice system.

Secondly, it was observed that certain international legislations related to human rights, such as the International Covenant on Civil and Political Rights and the American Convention on Human Rights, emphasize the importance of guaranteeing the right to equality before the law and to a fair trial in all types of criminal proceedings, including the abbreviated procedure. In this regard, the need to ensure that the penalty imposed in this procedure is not disproportionate and complies with the standards of justice and human rights became evident.

Based on these observations, it is proposed that the COIP consider modifying Article 636 to establish clear and objective limits on determining the penalty in the abbreviated procedure. It is essential to set specific and proportional criteria to guide judicial operators in their application, thus avoiding possible ambiguous interpretations that affect the legal security of the defendant. By considering the good practices of other national and international legislations and respecting the principles of justice and human rights, legal security in the Abbreviated Procedure of the COIP can be strengthened, advancing toward a more equitable and effective criminal system.

Ultimately, it is expected that this article will contribute to constructive debate in the legal community and contribute to the development of a more transparent, predictable, and respectful justice system of the fundamental rights of the defendant in the context of the abbreviated procedure. The importance of legal security in the criminal field is crucial to ensure impartial, equitable justice that provides certainty to both society and individuals involved in the process.

This article aims to design a critical legal analysis that addresses the problem of the lack of clarity in Article 636 of the Comprehensive Organic Penal Code regarding the imposition of the penalty in the abbreviated procedure through the modeling of the Delphi method. It seeks to demonstrate how this normative ambiguity can undermine the fundamental principle of legal security and affect the rights and guarantees of the individuals involved in the process.

2. PRELIMINARIES

2.1. Delphi Neutrosophic Method

The Delphi Method is a research technique that involves collecting opinions from a panel of experts through a series of questionnaires or surveys, to reach a consensus or make predictions on a particular topic. It is commonly used in various fields such as information systems research and decision-making to identify and prioritize issues and factors affecting a specific area of interest [11,12]. The Delphi Method is a structured communication technique, developed as an interactive systematic. It is a prediction method, based on an expert panel, see [13]. Its objective is to achieve consensus through discussion 3,8].

Neutrosophy is a branch of philosophy that studies the origin, nature, and scope of neutralities, as well as their interactions with different ideological spectra. In mathematics and logic, the most important concept is the neutrosophic set that generalizes the fuzzy sets of Zadeh and the fuzzy intuitionist sets of Atanassov, in the following these definitions are formally defined [1,15]

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]*.

Definition 2: The Single-Valued Neutrosophic Set (SVNS) *N* over *U* is $A = \{\langle x;\ TA(x),\ IA(x),\ FA(x)\rangle : x \in U$ [12], *where* $TA: U \to [0,\ 1]$, $IA: U \to [0,\ 1]$, and $FA: U \to [0,\ 1]$, $0 \leq TA(x) + IA(x) + FA(x) \leq 3$. 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:

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

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & otherwise \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{(x-a_2+\gamma_{\tilde{a}}(a_3-x))}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & otherwise \end{cases} \quad (3)$$

where, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ 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, [3,7,15]

The model proposed in this article is described below. Table 1 contains the scale for measuring criterion weights and Table 1 summarizes the scale of evaluations associated with single-valued triangular neutrosophic numbers (SVTNN).

Linguistic terms	SVTNN
Extremely important (EI)	⟨(0,0, 1); 0.00, 1.00, 1.00⟩
Very important (VI)	⟨(0, 1, 3); 0.20, 0.75, 0.80⟩
Important (I)	⟨(1, 3,5); 0.30, 0.80, 0.60⟩

Medium (M)	⟨(3, 5,7); 0.50, 0.50, 0.50⟩
Not important (NI)	⟨(5, 7,9); 0.60, 0.25, 0.35⟩
Not very important (NVI)	⟨(7, 9, 10);0.85, 0.15, 0.20⟩
Extremely unimportant (EU)	⟨(9, 10, 10); 1.00, 0.00, 0.00⟩

Table 1. Linguistic terms for evaluations associated with SVTNN. Source: [4,5,15]

3. MATERIALS AND METHODS

This study employs the Neutrosophic Delphi Method to evaluate the legal certainty of Article 636 of the Comprehensive Organic Penal Code (COIP) in Ecuador's abbreviated criminal procedure. Given the complexity of legal interpretations and the need for expert-driven insights, this method provides a structured framework to achieve consensus among specialists. The research followed a systematic process, ensuring that the ambiguities and legal inconsistencies identified were analyzed rigorously and methodically.

Research Steps

The study was conducted in five structured steps, each contributing to the development of a robust legal analysis:

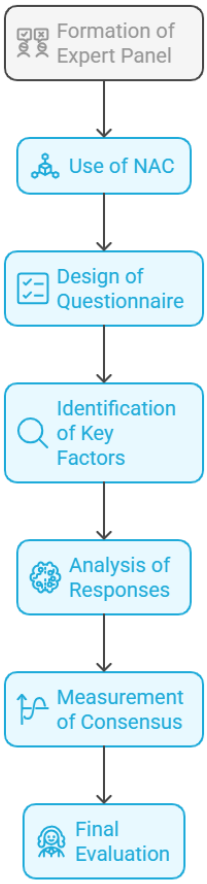

Figure 1. Process of Evaluating Article 636 of the COIP

Expert Selection

A panel of eleven experts was formed, including jurists, legal academics, and legislative specialists. The Neutrosophic Argumentation Coefficient (NAC) was used to ensure the relevance and reliability of the expert's opinions. Experts remained anonymous to avoid bias.

Questionnaire Design

A structured survey with five key questions was developed to assess the legal security factors influencing Article 636 of the COIP. Questions focused on the identification, evaluation, and effectiveness of current strategies to improve legal certainty.

Selection of Key Factors

Experts analyzed ambiguities and deficiencies in Article 636, identifying five key factors that affect the abbreviated procedure:

C1: Diversity of Interpretations – Different judicial interpretations cause inconsistencies.

C2: Procedural Agility vs. Human Rights – Balancing efficiency with fair trial rights.
C3: Room for Ambiguities – Lack of clarity in sentencing rules.
C4: Legal Insecurity – Uncertainty for defendants due to vague legislation.
C5: Application Challenges – Regulatory issues hindering practical implementation.

Analysis of Expert Responses

Expert responses were analyzed using Neutrosophic Logic, which quantifies truth (T), indeterminacy (I), and falsity (F). This allowed the study to measure levels of agreement and highlight areas needing further clarification.

Consensus Measurement and Final Evaluation

The Concordance Coefficient (Cc) was calculated to determine the level of agreement among experts. A consensus threshold of 75% was set to validate the findings. The results showed high agreement on the need for clearer sentencing guidelines in Article 636 of the COIP.

This methodology provides a quantitative and qualitative foundation for evaluating legal certainty in the abbreviated procedure. The findings offer a data-driven approach to support future legislative reforms and judicial improvements in Ecuador's criminal justice system.

3. RESULTS

To model the Delphi method, especially in complex contexts such as the issue of the lack of clarity in Article 636 of the Comprehensive Organic Penal Code (COIP) regarding the imposition of penalties in the expedited procedure, the following steps should be followed:

Step 1: Expert Selection

- Eleven experts (E1, E2, E3, ..., E11) were selected. None of them know the identity of the others. They include jurists, academics specializing in international law, experts in law formulation, and other professionals. To properly select these specialists, the Neutrosophic Argumentation Coefficient is used, which is based on evaluating the strength of experts' opinions through a weighted aggregation of values obtained from various Influence Factors.

Step 2: Questionnaire Design

The moderator distributes the survey with the following questions:

1. Determine what factors or criteria affect the legal security of the accused.
2. Evaluate the importance of each of the given criteria on the linguistic scale.
3. How would you assess the relative frequency of the current implemented strategies?
4. What factor do you consider most effective?
5. From your perspective, do you consider the strategies useful for overcoming current challenges?

Step 3: Selection of factors

Code	Criteria	Dimensions
C1	Diversity of Interpretations	The ambiguity of Article 636 has given rise to varied and sometimes contradictory interpretations among justice operators, which directly affects the legal security of the defendants.
C2	Balance between Procedural Agility and Human Rights	The importance of finding an adequate balance between speed in the judicial process and respect for the fundamental rights of the defendants is highlighted, which requires clear rules and well-defined procedures.
C3	Room for Ambiguities	To ensure an efficient and fair criminal justice system, it is crucial to address clarity and precision in regulations, ensuring consistency and predictability in the imposition of sentences.
C4	Legal Insecurity	The lack of regulatory clarity generates uncertainty and vulnerability for citizens subject to judicial processes, undermining the principle of essential legal security in a rule of law.
C5	Application Challenges	The abbreviated procedure, although designed to expedite the judicial process, faces significant obstacles in its effective application due to regulatory imprecision, especially in the imposition of sentences.

Table 2: Selection of factors. Source: own elaboration.

Step 4: Analysis of the Responses

Analyzing the responses to identify areas of consensus and discrepancy. Prepare a summary of the responses and include statistics when possible.

Experts	C1	C2	C3	C4	C5

Exp2	⟨(5, 7,9); .60, .25, .35⟩	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(7, 9, 10); .85, .15, .2⟩	⟨(0,0, 1); .00, 1., 1.⟩	⟨(1, 3,5); .30, .80, .60⟩
Exp13	⟨(7, 9, 10); .85, .15, .20⟩	⟨(5, 7,9); .60, .25, .35⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(1, 3,5); .30, .80, .60⟩	⟨(5, 7,9); .60, .25, .35⟩
Exp26	⟨(5, 7,9); .60, .25, .35⟩	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(5, 7,9); .60, .25, .35⟩
Exp34	⟨(7, 9, 10); .85, .15, .20⟩	⟨(5, 7,9); .60, .25, .35⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(5, 7,9); .60, .25, .35⟩	⟨(3, 5,7); .50, .50, .50⟩
Exp52	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(3, 5,7); .50, .50, .50⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(3, 5,7); .50, .50, .50⟩
Exp59	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(5, 7,9); .60, .25, .35⟩	⟨(0,0, 1); .00, 1.0, 1.0⟩	⟨(3, 5,7); .50, .50, .50⟩	⟨(7, 9, 10); .85, .15, .20⟩
Exp67	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(0,0, 1); .00, 1.00, 1.00⟩
Exp71	⟨(5, 7,9); .60, .25, .35⟩	⟨(1, 3,5); .30, .80, .60⟩	⟨(5, 7,9); .60, .25, .35⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(5, 7,9); .60, .25, .35⟩
Exp78	⟨(5, 7,9); .60, .25, .35⟩)	⟨(7, 9, 10); .85, .15, .20⟩	⟨(3, 5,7); .50, .50, .50⟩	⟨(0,0, 1); .00, 1.00, 1.00⟩	⟨(3, 5,7); .50, .50, .50⟩
Exp79	⟨(1, 3,5); .30, .80, .60⟩	⟨(5, 7,9); .60, .25, .35⟩	⟨(3, 5,7); .50, .50, .50⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(1, 3,5); .30, .80, .60⟩
Exp80	⟨(1, 3,5); .30, .80, .60⟩	⟨(7, 9, 10); .85, .15, .20⟩	⟨(0,0, 1); .00, 1.0, 1.0⟩	⟨(3, 5,7); .50, .50, .50⟩	⟨(0,0, 1); .00, 1.00, 1.00⟩

Table 3. Validation of criteria. Source: own elaboration.

Factors	**(0.92,0.1,0.12)**	**(0.7,0.2,0.25)**	**(0.50,0.55,0.5)**	**(0.3,0.75,0.80)**	**(0.10,0.90,0.95)**
C1	0.2222	0.3333	0.5556	0.6667	1,0000
C2	0.0000	0.3333	0.4444	0.5556	0.8889
C3	0.1111	0.2222	0.3333	0.7778	1,0000
C4	0.1111	0.3333	0.6667	0.7778	1,0000
C5	0.0000	0.1111	0.4444	0.6667	1,0000

Table 4: Relative Frequency. Source: own elaboration.

Average	**N - Avg.**	**SVNN**
0.58	**-1.79**	(0.7,0.2,0.25)
-0.54	**-0.67**	(0.10,0.90,0.95)
0.37	**-1.58**	(0.50,0.55,0.5)
0.61	**-1.82**	(0.7,0.2,0.25)
-0.19	**-1.02**	(0.3,0.75,0.80)
-3.50	**2.29**	(0.10,0.90,0.95)
-3.50	**2.29**	(0.10,0.90,0.95)

Table 5: Calculation of the neutrosophic indicator scale. Source: own elaboration.

For determining the consensus among the participants of the Expert Panel, the Coordinating Group considered the consensus level achieved when the Concordance Coefficient Cc obtains a value higher than 75%, thus concluding the process.

Expert	**C1**	**C2**	**C3**	**C4**	**C5**
Exp2	YES	YES	YES	YES	YES
Exp13	YES	YES	YES	YES	YES

Exp26	NO	YES	YES	NO	YES
Exp34	YES	YES	YES	YES	YES
Exp52	YES	YES	YES	YES	YES
Exp59	YES	YES	NO	YES	YES
Exp67	YES	YES	YES	YES	NO
Exp71	YES	YES	YES	YES	YES
Exp78	YES	YES	YES	YES	YES
Exp79	YES	YES	YES	YES	YES
Exp80	YES	YES	YES	YES	YES
Coefficient	**90,91**	**100**	**90,91**	**90,91**	**90,91**

Table 6. Final evaluations of the criteria. Source: own elaboration

4. DISCUSSION

The analysis of Article 636 of the COIP reveals significant ambiguities regarding the determination of penalties in the abbreviated procedure, which can lead to inconsistent judicial interpretations. Experts highlight that the lack of clear limits on penalty reduction creates uncertainty for both legal operators and defendants. The article states that the penalty reduction should not be less than one-third of the minimum penalty, but it fails to specify whether this reduction applies to the minimum penalty itself or the imposed sentence, leading to legal insecurity. Additionally, the absence of standardized criteria for evaluating mitigating circumstances further complicates judicial decisions, potentially resulting in disproportionate or arbitrary penalties.

To address these issues, experts propose reforming Article 636 by establishing precise guidelines for penalty determination, incorporating objective criteria for assessing mitigating factors and aligning the regulation with international human rights standards. Moreover, ensuring that defendants receive clear information and legal guidance throughout the process is crucial to prevent coercion and guarantee informed decision-making. Other key recommendations include limiting judicial discretion, incorporating proportionality principles, and implementing training programs for judicial operators to enhance uniformity in sentencing. These measures aim to strengthen legal security in the abbreviated procedure, fostering a fairer and more transparent criminal justice system.

5. CONCLUSION

The critical-legal analysis of article 636 of the Comprehensive Organic Penal Code (COIP) in the context of the Abbreviated Procedure has revealed the existence of ambiguities and gaps in its wording, representing a significant challenge to the legal security of the defendant. The lack of clarity in determining the penalty in this procedural figure can generate uncertainty and inequality in the treatment of criminal cases, which goes against the fundamental principles of a fair and equitable criminal justice system.

Comparison with legislation from neighboring countries and the region has shown that there are more detailed and clear provisions regarding the determination of the penalty in the abbreviated procedure. These legislations could serve as models to improve Article 636 of the COIP and strengthen the legal security of the defendant. The Ecuadorian criminal justice system must constantly seek to improve and perfect its processes to ensure respect for the fundamental rights of citizens and the equitable application of the law.

The neutrosophic Delphi method defines the criteria by level of importance and intensity within the analyzed field of study, based on the selection of experts according to the coefficient of expert competence. From the results obtained, it is defined that the criteria with the greatest relevance directly favored the legal security and effectiveness of the abbreviated procedure in the Ecuadorian criminal justice system.

To address this issue, various recommendations have been proposed. Firstly, it is suggested to reform Article 636 to make the determination of the penalty in the abbreviated procedure clearer and more precise, by establishing specific criteria and setting maximum and minimum limits to guide judicial operators in its application. Furthermore, emphasis is placed on the importance of ensuring that the defendant has access to clear and understandable information about the abbreviated procedure and their rights. For this purpose, it is essential to ensure adequate legal advice and provide the necessary guidance for the defendant to make informed decisions.

The implementation of mechanisms that promote a better understanding of the terms and conditions of the agreement, through the use of accessible language and graphic resources, is also a relevant measure to reinforce the legal security of the defendant. With these proposals and recommendations, the aim is to contribute to strengthening legal security in the Abbreviated Procedure of the COIP and to advance towards a more transparent, equitable, and respectful criminal justice system.

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APPLICATION OF NEUTROSOPHIC AHP IN THE ANALYSIS OF SHARED CUSTODY: A STUDY OF FAMILY LAW

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ABSTRACT
The study addresses a critical issue in family law: the evaluation of shared custody decisions using a systematic and quantifiable framework. Traditional approaches to custody determinations cannot often incorporate multiple, conflicting criteria, such as the emotional well-being of the child, the financial stability of the parents, and the logistical feasibility of shared arrangements. This research aims to bridge this gap by applying a Neutrosophic Analytic Hierarchy Process (AHP) model, which allows for the incorporation of uncertainty and subjectivity inherent in custody decisions. By introducing mathematical rigor to a field often dominated by qualitative assessments, the study offers a pathway to more balanced and transparent decision-making. The results demonstrate the utility of the Neutrosophic AHP method in handling complex, multi-criteria evaluations in family law. Key findings include the identification of weighting vectors that prioritize the child's welfare while addressing practical considerations for both parents. The integration of linguistic terms with neutrosophic numbers, such as truth (T), indeterminacy (I), and falsity (F), provides a structured mechanism to capture the nuances of judicial discretion. This innovative approach contributes not only to the theoretical advancement of decision-making methodologies in legal contexts but also offers practical implications for policymakers and legal practitioners seeking to enhance fairness and clarity in shared custody rulings.
KEYWORDS: Neutrosophic AHP, shared custody, family law, multi-criteria analysis, decision-making, uncertainty.

MSC: 62P25, 91D10, 68T37, 93A30, 03B70

RESUMEN
El estudio aborda un tema crítico en el derecho de familia: la evaluación de las decisiones de custodia compartida utilizando un marco sistemático y cuantificable. Los enfoques tradicionales de las determinaciones de custodia a menudo carecen de la capacidad de incorporar criterios múltiples y conflictivos, como el bienestar emocional del niño, la estabilidad financiera de los padres y la viabilidad logística de los arreglos compartidos. Esta investigación tiene como objetivo cerrar esta brecha aplicando un modelo de proceso de jerarquía analítica neutrosófica (AHP), que permite la incorporación de la incertidumbre y la subjetividad inherentes a las decisiones de custodia. Al introducir el rigor matemático en un campo a menudo dominado por evaluaciones cualitativas, el estudio ofrece una vía de toma de decisiones más equilibrada y transparente. Los resultados demuestran la utilidad del método AHP neutrosófico en el manejo del manejo de evaluaciones complejas de criterios múltiples en el derecho de familia. Los hallazgos clave incluyen la identificación de vectores de ponderación que priorizan el bienestar del niño al tiempo que abordan consideraciones prácticas para ambos padres. La integración de los términos lingüísticos con números neutrosóficos, como la verdad (t), la indeterminación (I) y la falsedad (F), proporciona un mecanismo estructurado para capturar los matices de la discreción judicial. Este enfoque innovador contribuye no solo al avance teórico de las metodologías de toma de decisiones en contextos legales, sino que también ofrece implicaciones prácticas para los responsables políticos y profesionales legales que buscan mejorar la equidad y la claridad en las decisiones de custodia compartida.
PALABRAS CLAVE: AHP neutrosófico, custodia compartida, derecho de familia, análisis de criterios múltiples, toma de decisiones, incertidumbre.

1. INTRODUCTION

Shared custody has emerged as a crucial yet underexplored concept in the realm of family law. It involves the joint responsibility of parents to ensure the proper upbringing of minors, focusing on equitable sharing of time, financial obligations, and emotional care. While shared custody aligns with the principles of equality and co-responsibility enshrined in Ecuador's Constitution [13], its implementation faces significant challenges, particularly due to the absence of clear legal guidelines and the limited capacity of judicial systems to enforce agreements effectively. Historically, shared custody has been conceptualized as a modern response to evolving family dynamics. Originating in Sweden, this legal institution gained momentum across Europe, with France introducing more comprehensive legislation by 2002 that allowed children to maintain dual residences with both parents [6]. In Latin America, countries like Chile, Argentina, and Mexico have incorporated shared custody into their legal

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frameworks, recognizing its potential to mitigate the emotional and psychological impact of parental separation on children [7]. Ecuador, however, remains at a crossroads, with shared custody only enforceable through parental agreement and judicial approval, leaving significant gaps in its practical application. The core problem addressed in this study is the limited implementation of shared custody in Ecuador despite its alignment with the constitutional principle of the child's best interest. How can a framework be developed to ensure equitable co-responsibility while respecting the individual rights of all family members? This question drives the research, seeking to uncover the legal, social, and institutional barriers to shared custody and propose actionable solutions to address them.

Ecuador's current legal framework presents both opportunities and obstacles. The recognition of parental co-responsibility and the right of children to maintain relationships with both parents are foundational principles [18]. Yet, the judicial system lacks the authority to unilaterally impose shared custody without a mutual parental agreement, which can hinder its broader adoption [9]. Additionally, societal perceptions and logistical challenges further complicate its implementation, emphasizing the need for a systematic analysis to bridge these gaps. This research leverages the Neutrosophic Analytic Hierarchy Process (AHP) to provide a structured methodology for evaluating shared custody. By incorporating linguistic terms and mathematical tools, the study captures the complexity of factors influencing custody decisions. These include parental cooperation, the psychological well-being of children, and the capacity of judicial systems to enforce equitable arrangements. This innovative approach allows for the simultaneous consideration of conflicting criteria, offering a balanced framework for decision-making.

Preliminary findings reveal that shared custody has the potential to positively impact children's development when parents maintain amicable relationships [15.21]. However, the lack of comprehensive legislation and judicial discretion often results in outcomes that fail to align with the best interest of the child. By addressing these shortcomings, the study aims to contribute to the development of a more robust legal framework that ensures equitable parental co-responsibility while prioritizing the child's welfare. The objectives of this research are twofold: first, to identify the key factors that influence the successful implementation of shared custody in Ecuador; and second, to propose a decision-making model that integrates the principles of family law with mathematical rigor. This model not only offers a pathway for fairer custody decisions but also establishes a foundation for future legal reforms. Ultimately, this study seeks to bridge the gap between theory and practice in family law. Applying a Neutrosophic AHP framework, it provides a novel approach to understanding and addressing the complexities of shared custody. The results have the potential to inform policymakers, legal practitioners, and families, contributing to a more equitable and effective legal system that aligns with the best interests of children and adolescents.

2. PRELIMINARIES

2.1 Saaty's Analytic Hierarchy Process (AHP)

It is one of the most widespread methods for solving multi-criteria decision-making problems. This technique models the problem leading to the formation of a hierarchy representative of the associated decision-making scheme. This hierarchy presents at the upper level the objective pursued in solving the problem, and at the lower level, it includes the different alternatives from which a decision must be made. The intermediate levels detail the set of criteria and attributes considered [20, 21].

The AHP is theory-oriented toward the decision-maker and serves to identify the best alternative according to the allocated resources. This method can be applied to situations involving technical, economic, political, social, and cultural factors. That is, it aims to be a scientific tool to address those aspects that are difficult to quantify but sometimes require a unit of measurement.

Some authors suggest that the AHP has not been well understood, as it goes beyond being a simple methodology for choice situations. It is then proposed that the best way to understand the method is by describing its three basic functions: structuring complexity, measuring on a scale, and synthesizing. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the following levels [19]. The steps are:

1. Prioritization of the elements of the hierarchical model.
2. Binary comparison of the elements.
3. Evaluation of the elements by assigning weights.
4. Ranking of the alternatives according to the given weights.
5. Synthesis and sensitivity analysis.

The AHP, proposed by Thomas Saaty in 1980, is one of the most widespread methods for solving multi-criteria decision-making problems. This technique outlines the process for building a hierarchical structure that reflects the decision-making framework. At the top level, the hierarchy defines the main objective to be achieved in addressing the problem. The bottom level contains the various alternatives among which a decision must be made.

The intermediate levels serve to organize the criteria and attributes that influence the decision-making process. To fully explain the method, it is essential to introduce the following definitions.

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 $]-0, 1+[$ 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 $A = \{\langle x; TA(x), IA(x), FA(x)\rangle : x \in U\}$, 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

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a\_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, & otherwise \end{cases} \quad (1)$$

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

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

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:

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

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

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* $a_1, a_2, a_3, a_4 \neq 0$.

Multiplication by a scalar number:

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

Definitions 3 and 4 pertain to single-valued triangular neutrosophic numbers under the condition $a_2=a_3$. To streamline the process, the linguistic scale of triangular neutrosophic numbers, as illustrated in Table 1, is employed and compared to the predefined scale therein. The importance levels or weights assigned to the criteria are calculated through paired comparisons, allowing for a systematic estimation of their relative significance.

$$S = \left\{\frac{1}{9}, \frac{1}{7}, \frac{1}{5}, \frac{1}{3}, 1,3,5,7,9\right\} \quad (5)$$

Through the use of the theory of AHP technique in a neutrosophic framework (Neutrosophic AHP, or NAHP for short), the indeterminacy of decision-making can be modeled.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (6)$$

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

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (7)$$

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

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 7 and 8:

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: [13]

3. METHODS

The study began with a comprehensive bibliographic review, employing a mixed qualitative-quantitative methodology [11, 12]. A detailed literature search was conducted to deepen the understanding of shared custody, focusing on its challenges and potential improvements. Additionally, input was gathered from 20 specialists with extensive experience in family law, who were asked to identify the most common causes threatening the proper functioning of shared custody. Their expertise allowed them to provide insights aimed at safeguarding the well-being of minors and enhancing the effectiveness of shared custody arrangements.

To analyze the identified causes of non-compliance, a Pareto diagram was employed, highlighting the most significant issues contributing to shared custody challenges. The proposed solutions, generated through expert consensus, were then evaluated using the Analytic Hierarchy Process (AHP) method in its neutrosophic version, which accounts for uncertainty and subjectivity in decision-making [13, 19]. The methodology followed in this research is detailed in the subsequent sections.

Theoretical methods

✓ Analytical Synthetic Method: The analytical method allows the decomposition of the whole into specific aspects to understand and comprehend the structure; it facilitates observance to better understand the components. In this context, this method implies synthesis, that is, the union of dispersed elements to form a total component. This is put into practice through the review of the bibliography, which emphasizes what is necessary to argue the research and the topic of analysis.

✓ Inductive Deductive Method: This research method allows logical reasoning. While the inductive method starts from specific premises to reach general aspects, the deductive method is the opposite, as it starts from general to reach particular aspects. However, both methods are essential in the construction of knowledge. For this research, these methods allowed to understand the problem and propose possible solutions.

✓ Historical Logical Method: These methods allow the construction of research based on historical elements, to understand the essential elements of the same and its historical evolution.

Methods for Information Processing

✓ Pareto Diagram: it was used for the selection of criteria. It was introduced by J.M. Jurán in his Quality Control Handbook based on what was described in 1909 by V. Pareto under the principle of "the vital few and the trivial many." This diagram is based on problem analysis and is used to present data, drawing attention to the causes of greatest incidence in the problem in question [14,20]. Its objective is to determine 20% of the causes that provoke 80% of the problems.

Its main advantages are:

✓ It allows focusing on the aspects whose improvement will have the most impact, thus optimizing efforts.

✓ It provides a simple and quick view of the relative importance of problems.

✓ It helps prevent some causes from worsening while trying to solve others that are less significant.

✓ Its graphical view of the analysis is easy to understand and stimulates the team to continue with the improvement.

For its development, the following algorithm is executed:

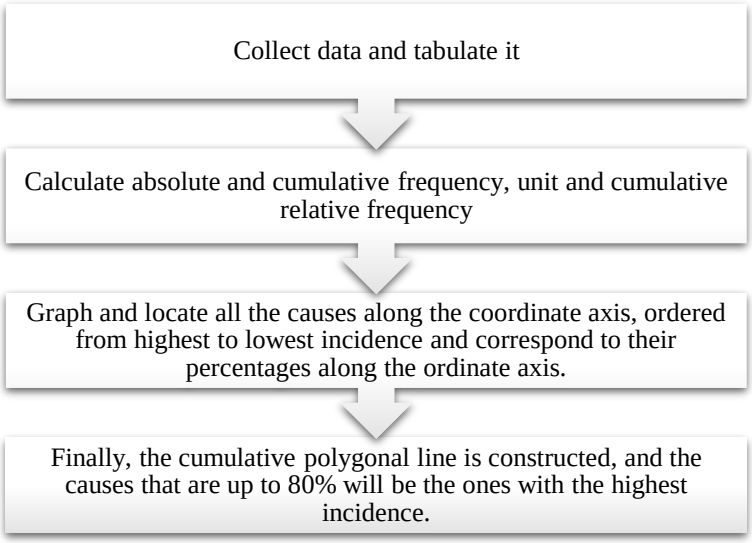

Figure 1. Algorithm for executing the Pareto Diagram. Source: own elaboration.

Neutrosophic AHP

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 is 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 to a deterministic matrix using Equations 9 and 10. To get the score and the accuracy degree of $\tilde{a}_{ji}$ the following equations are used:

$$S(\tilde{a}_{ji}) = {}^{1}\Big/_{S(\tilde{a}_{ij})} \tag{9}$$

$$A(\tilde{a}_{ji}) = {}^{1}\Big/_{A(\tilde{a}_{ij})} \tag{10}$$

With compensation by the accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \tag{11}$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

Note that Step 3 refers to considering the use of the calculation 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 equation:

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{12}$$

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

$$CR = \frac{CI}{RI} \tag{13}$$

RI is given in [13]. If $CR \leq 0.1$, it indicates that the experts' evaluation is sufficiently consistent, allowing for the application of NAHP. This procedure is then applied to matrix "A" in Equation 12.

4. RESULTS

Among the reasons identified for the non-compliance with the functioning of shared custody as argued by consulted family lawyers and judges are the following:

1. Failure to comply with and irregularity in the routines and life schedule of the minor.
2. Parental alienation syndrome.
3. Instability in fulfilling responsibilities granted by either parent.
4. Wrongful retention of children.
5. Lack of follow-up by the assigned team of social workers and prosecution.
6. Difficulties in communication between parents regarding the established dynamics and functioning that generate conflicts and high tension.
7. Resistance or refusal by one of the parents to accept shared custody.
8. Emotional or psychological stress that affects the ability to comply with custody.
9. Logistic problems such as lack of an adequate location for the custody of the minor or respect for their privacy.
10. Significant differences in parental skills.
11. Presence of alcohol and drug use among the parents.
12. Disregard of the children's opinions.
13. Lack of social support or resources to maintain shared custody by one of the parents.
14. Failure to comply with prior agreements due to resentment or desires for revenge.
15. Interference from relatives or third parties in the relationship between the child and one of the parents.

These causes were subjected to further analysis using the Pareto diagram, and the results obtained are reflected in the following figure:

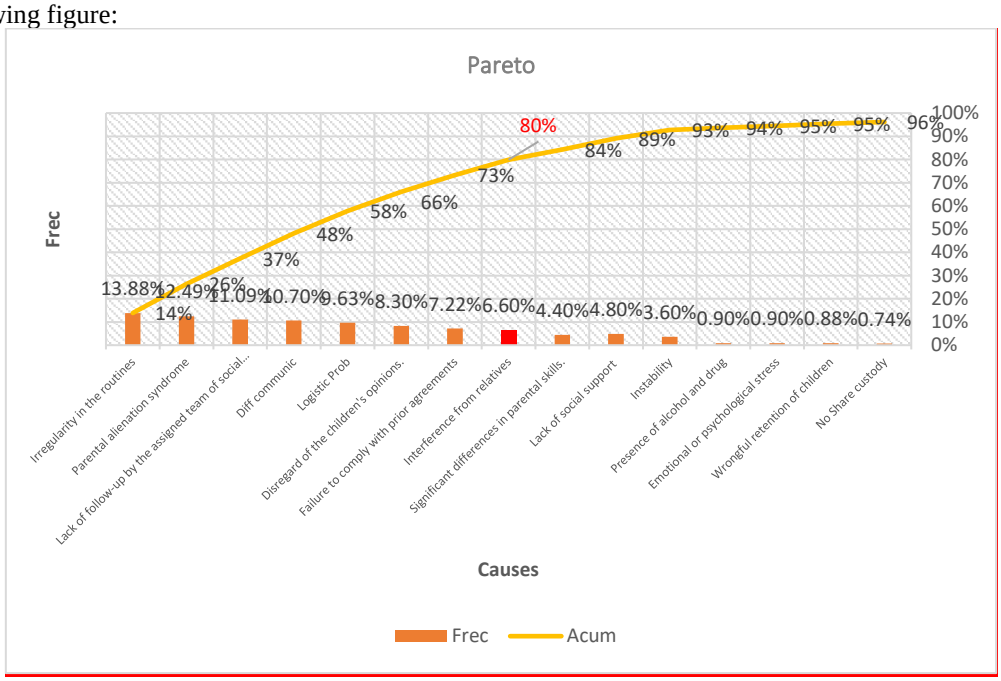

Figure 2. Pareto diagram. Source: consultations with family lawyers and judges.
Source: own elaboration.

From the causes mentioned earlier, according to the Pareto diagram analysis, those that frequently impact the problem of non-compliance with shared custody measures are:

1. Failure to comply with and irregularity in the routines and life schedule of the minor.
2. Parental alienation syndrome.
3. Lack of follow-up by the assigned team of social workers and the prosecutor's office.
4. Communication difficulties among parents regarding the established dynamics and operation that generate conflicts and high tension.
5. Logistic problems such as lack of an adequate location for the custody of the minor or respect for their privacy.
6. Disregard of the children's opinions.
7. Failure to comply with prior agreements due to resentment or desires for revenge.

8. Interferences from relatives or third parties in the relationship between the child and one of the parents.

For these situations that frequently occur and threaten the proper functioning of shared custody, the following measures or alternatives are proposed:

1. Continuous monitoring. (Maintain regular monitoring of the case to ensure compliance with agreements and take action in cases of non-compliance) (C1)
2. Education on co-parenting. (Provide resources and guidance to parents on how to develop a healthy co-parenting relationship, which can reduce conflicts and non-compliance) (C2)
3. Psychological counseling. (Through therapy, help parents understand how non-compliance can emotionally affect their children and convey knowledge on how to deal with the situation they face) (C3)
4. Flexible negotiation. (In some cases, it may be necessary to review and adjust the terms of the agreement to accommodate the changing needs of the parents, as long as this does not affect the well-being of the minor) (C4)
5. Request modification. (If circumstances change significantly for one of the parents, the agreement can be modified) (C5)
6. Formal notification. (In case of persistent non-compliance, the lawyer can send a formal letter to the non-compliant parent reminding them of their obligations and the possible legal consequences in case of further non-compliance) (C6)
7. Suggest mediation. (This can be used as a possible way to resolve disputes. A neutral mediator could help conflicting parents reach beneficial solutions for both parties and fundamentally for the minor) (C7)
8. Enforcement of sanctions. (If the parent continues to not comply, the lawyer can request the enforcement of sanctions such as fines or compensatory time for the affected parent) (C8)

From the analysis through the multi-criteria decision method, the following results were obtained, as stated in the tables below.

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
C1	Equally influential	⟨(6,7,8); .90,.10,.10⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(6,7,8); .90,.10,.10⟩	⟨(6,7,8); .90,.10,.10⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(6,7,8); .90,.10,.10⟩
C2	1/⟨(6,7,8); . 90, .10, .10⟩	Equally influential	⟨(2,3,4); .30,.75,.70⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(2,3,4); .30,.75,.70⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(4,5,6); .80,.15,.20⟩
C3	1/(4,5,6); .80,.15,.20⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	Equally influential	⟨(2,3,4); .30,.75,.70⟩	⟨(2,3,4); .30,.75,.70⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(4,5,6); .80,.15,.20⟩	⟨(4,5,6); .80,.15,.20⟩
C4	1/ ⟨(6,7,8); .90,.10,.10⟩	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	Equally influential	⟨(1,1,1); .50,.50,.50⟩	⟨(2,3,4); .30,.75,.70⟩	⟨(2,3,4); .30,.75,.70⟩	⟨(2,3,4); .30,.75,.70⟩
C5	1/ ⟨(6,7,8); .90,.10,.10⟩	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	1/ ⟨(1,1,1); .50,.50,.50⟩	Equally influential	⟨(1,1,1); .50,.50,.50⟩	⟨(2,3,4); .30,.75,.70⟩	⟨(2,3,4); .30,.75,.70⟩
C6	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	1/ ⟨(1,1,1); .50,.50,.50⟩	Equally influential	⟨(1,1,1); .50,.50,.50⟩	⟨(1,1,1); .50,.50,.50⟩
C7	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	1/ ⟨(1,1,1); .50,.50,.50⟩	Equally influential	⟨(1,1,1); .50,.50,.50⟩
C8	1/ ⟨(6,7,8); .90,.10,.10⟩	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(4,5,6); .80,.15,.20⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	1/ ⟨(2,3,4); .30,.75,.70⟩	1/ ⟨(1,1,1); .50,.50,.50⟩	1/ ⟨(1,1,1); .50,.50,.50⟩	Equally influential

Table 2. Saaty's scale translated to a neutrosophic triangular scale. Source: [13]

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**Weight**
C1	0.49	0.76	0.50	0.40	0.38	0.25	0.21	0.27	0.41
C2	0.07	0.11	0.30	0.28	0.27	0.15	0.21	0.19	0.20
C3	0.10	0.04	0.10	0.17	0.16	0.25	0.21	0.19	0.15
C4	0.07	0.02	0.03	0.06	0.05	0.15	0.13	0.12	0.08
C5	0.07	0.02	0.03	0.06	0.05	0.05	0.13	0.12	0.07
C6	0.10	0.04	0.02	0.02	0.05	0.05	0.04	0.04	0.04
C7	0.10	0.02	0.02	0.02	0.02	0.05	0.04	0.05	0.04
C8	0.07	0.02	0.02	0.02	0.02	0.05	0.04	0.04	0.03

Table 3. Weights of the criteria using the Neutrosophic AHP method. Source: own elaboration.

Factors	F1	F2	F3	F4	F5	F6	F7	F8

Approximate eigenvalues	10.404963	9.82341749	8.73584877	8.30751768	8.5296233	8.70069562	7.99317717	8.46685733

Table 4. Analysis of the consistency of the paired matrix. Source: own elaboration.

The consistency of the exercise was smaller than or equal to 0.10, with an eigenvalue of 8.87026, with CI= 0.12 and CR= 0.09, demonstrating effectiveness in decisions. As a result, the most successful decision alternative according to experts was number 1, followed by the others at subsequent levels. The consulted family lawyers and judges considered that proper follow-up on cases assigned under shared custody would prevent non-compliance. In case of non-compliance, the remaining alternatives are available, provided that the welfare of the child and the right of the parents to provide them with a safe and stable life from the economic, emotional, and emotional point of view is taken into account.

1. Continuous monitoring. (Maintain regular monitoring of the case to ensure compliance with agreements and take action in cases of non-compliance)
2. Education on co-parenting. (Provide resources and guidance to parents on how to develop a healthy co-parenting relationship, which can reduce conflicts and non-compliance)
3. Psychological counseling. (Through therapy, help parents understand how non-compliance can emotionally affect their children and convey knowledge on how to deal with the situation they face)

4. CONCLUSIONS

This study demonstrates that the application of the neutrosophic AHP method effectively supports decision-making in complex family law scenarios, particularly in cases of shared custody. The results indicate a consistency ratio (CR) of 0.09 and an eigenvalue of 8.87026, reflecting a robust and reliable evaluation process. The most effective decision alternative identified by experts was continuous monitoring, followed closely by education on co-parenting and psychological counseling. These findings underscore the importance of proactive measures to ensure compliance and prioritize the well-being of children. From a practical perspective, these results provide valuable insights for family lawyers, judges, and policymakers. Continuous monitoring offers a mechanism to address non-compliance promptly, while education on co-parenting equips parents with tools to foster healthier relationships and reduce conflict. Psychological counseling further complements these measures by addressing the emotional dimensions of shared custody, ensuring a comprehensive approach that safeguards the interests of children and supports parents in their roles. The study's contributions lie in its integration of neutrosophic logic with the AHP framework, a novel methodological approach in the context of family law. This combination allows for nuanced decision-making that accounts for uncertainty and subjectivity, advancing the theoretical understanding of shared custody while offering actionable recommendations. By bridging the gap between qualitative legal principles and quantitative decision-making models, the research contributes to more effective and equitable custody arrangements. However, the study is not without limitations. The reliance on expert opinions, while valuable, introduces potential bias and restricts generalizability across different jurisdictions or cultural contexts. Additionally, the focus on a limited set of alternatives may overlook other innovative solutions that could address compliance challenges. Expanding the analysis to include a broader range of options and incorporating input from diverse stakeholders could enhance the study's applicability.

Future research should explore additional methods, such as fuzzy logic or machine learning, to further refine the evaluation process. Investigating the long-term outcomes of implementing these alternatives, particularly in varying socio-economic contexts, would provide deeper insights into their effectiveness. Moreover, expanding the scope to include input from families directly affected by shared custody decisions could enrich the understanding of practical challenges and potential solutions. In conclusion, this research highlights the critical role of structured decision-making frameworks in addressing the complexities of shared custody. By prioritizing continuous monitoring, co-parenting education, and psychological counseling, the study emphasizes the need for a holistic approach that balances the rights of parents with the paramount interest of the child. These findings lay the groundwork for future studies and practical applications that aim to enhance fairness and stability in family law.

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APPLICATION OF THE NEUTROSOPHIC PROMETHEE METHOD TO ENHANCE THE SAFEGUARDING OF THE PRESUMPTION OF INNOCENCE IN DRUG TRAFFICKING CASES IN AMBATO

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ABSTRACT
This study examines the challenges faced by attorneys when defending drug trafficking cases, with a specific focus on preserving the presumption of innocence. By employing the neutrosophic PROMETHEE method, the primary obstacles were identified and prioritized: the defendant's prior reputation, pressure for plea deals, and difficulty in proving a lack of knowledge. These challenges underscored the complexity of ensuring a fair trial, emphasizing the importance of meticulous evidence analysis and the need for due process. Solutions such as legal reforms, ethical training, and strengthening investigative resources were proposed to comprehensively address these challenges. Thus, this holistic approach aims to enhance effective defense and bolster the preservation of the presumption of innocence. The findings suggest that these strategies, if properly implemented, can have a significant impact on the criminal justice system and the legal practice of drug trafficking cases. They ensure equitable treatment for defendants and uphold high standards of justice and professional ethics. Furthermore, they provide a valuable foundation for future improvements in legal defense and underscore the need for coordinated action to address the inherent challenges in these cases.
KEYWORDS: Neutrosophic PROMETHEE, presumption of innocence, drug trafficking, multi-criteria decision-making, legal uncertainty
MSC Codes: 62P25, 03B52, 91D10, 93A30, 68T37

RESUMEN
Este estudio examina los desafíos que enfrentan los abogados al defensor de casos de tráfico de drogas, con un enfoque específico en la preservación de la presunción de inocencia. Utilizando el método neutrosófico PROMETHEE, se identificaron y priorizaron los principales obstáculos: la reputación previa del acusado, la presión para aceptar acuerdos de culpabilidad y la dificultad para probar la falta de conocimiento. Estos desafíos subrayan la complejidad de garantizar un juicio justo, enfatizando la importancia de un análisis meticuloso de la evidencia y la necesidad de un debido proceso. Se propusieron soluciones como reformas legales, capacitación ética y fortalecimiento de los recursos de investigación para abordar de manera integral estos desafíos. Así, este enfoque holístico tiene como objetivo mejorar la defensa efectiva y fortalecer la preservación de la presunción de inocencia. Los hallazgos sugieren que estas estrategias, si se implementan adecuadamente, pueden tener un impacto significativo en el sistema de justicia penal y en la práctica legal de los casos de tráfico de drogas. Aseguran un trato equitativo para los acusados y mantienen altos estándares de justicia y ética profesional. Además, proporciona una base valiosa para futuras mejoras en la defensa legal y subrayan la necesidad de una acción coordinada para abordar los desafíos inherentes a estos casos.
PALABRAS CLAVE: PROMETHEE neutrosófico, presunción de inocencia, tráfico de drogas, toma de decisiones multicriterio, incertidumbre legal.

1. INTRODUCTION

This study focuses on applying the neutrosophic PROMETHEE method to enhance the safeguarding of the presumption of innocence in drug trafficking cases in Ambato, Ecuador. This topic holds critical relevance not only in the legal domain but also in social and ethical contexts, as the presumption of innocence is a fundamental principle of criminal law, recognized as a cornerstone of democratic judicial systems [3]. In a context where criminal justice systems face growing challenges related to handling uncertainty and subjectivity, the implementation of advanced tools such as the neutrosophic approach offers novel perspectives for objective and equitable decision-making.

Historically, the fight against drug trafficking has been characterized by a punitive approach, marked by strict policies that often sacrifice fundamental rights in favor of efficiency [5]. Particularly in Latin America, the criminalization of drug trafficking has resulted in frequent violations of the presumption of innocence, exacerbated by structural biases and negative societal perceptions of defendants [10]. Recently, technological and methodological advancements, such as multi-criteria decision-making systems, have begun to be applied in the

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legal domain to minimize these violations. However, their implementation remains limited and lacks a comprehensive consideration of the uncertainty inherent in judicial cases [20].

In this context, a key question arises that guides the present research: How can the presumption of innocence in drug trafficking cases be safeguarded, considering the multiple dimensions of uncertainty and subjectivity? This problem extends beyond the legal dimension and reflects an underlying ethical tension in justice administration. The difficulty of objectively evaluating the guilt or innocence of an accused person, especially in cases where evidence may be ambiguous or subject to various interpretations, presents a complex challenge that remains unresolved [15].

The neutrosophic approach, grounded in the theory of neutrosophic sets, allows for managing high levels of uncertainty and ambiguity—characteristics inherent in human perceptions and decision-making processes. Meanwhile, the PROMETHEE method, widely utilized in multi-criteria analysis, facilitates the structured evaluation of alternatives in complex scenarios. Integrating both approaches represents an innovative proposal to address the identified problem by enabling a balanced analysis of both objective evidence and subjective perceptions.

The main objective of this study is to analyze the effectiveness of the neutrosophic PROMETHEE method in promoting more objective and equitable decisions in the context of drug trafficking cases. To this end, the study seeks, first, to develop a methodological model that integrates neutrosophic principles and the PROMETHEE method. Second, it aims to apply this model to real cases in the city of Ambato, assessing its impact on protecting the presumption of innocence principle. Finally, it aspires to generate practical recommendations that can be implemented in other judicial contexts with similar characteristics.

Throughout this article, it will be demonstrated how this approach has the potential to redefine judicial procedures by incorporating advanced analytical tools that consider both the indeterminacy inherent in human perceptions and the technical and legal criteria. By contributing to mitigating biases and errors in judicial decision-making, this study aligns with the global effort to strengthen criminal justice systems and ensure respect for human rights.

In the following sections, the theoretical framework underpinning this research is detailed, followed by a methodological description and the results obtained. This innovative approach is expected not only to provide practical solutions to the posed problem but also to inspire new applications of neutrosophic multi-criteria analysis in other areas of criminal law and social justice [18].

2. PRELIMINARIES

The evaluation or decision matrix is established after defining the criteria and assigning weights to the linguistic terms utilized within the Single-Valued Neutrosophic Set (SVNS). This matrix functions as a systematic tool for assessing alternatives, integrating the criteria's significance and the inherent uncertainty expressed through the SVNS linguistic terms. The decision-maker can give, for each of the considered criteria and each alternative, a value within the neutrosophic choice set [9]. Therefore, the following guidelines are defined to be taken into account:

- To establish the weights of the criteria k_j, y_{ij} is defined as a point within the SVNS. In the Neutrosophic CRITIC method, the linguistic terms used to represent the weight of importance are outlined in Table 1. These terms provide a structured way to express the relative significance of each criterion, incorporating the uncertainty and imprecision inherent in human judgment within the neutrosophic framework.
- To establish the weights of the alternatives A_i, g_{ij} is defined as a point within the SVNS. Therefore, the linguistic terms to represent the weights of importance for the Neutrosophic PROMETHEE method are proposed in Table 2.
- For *X* from the universe of discourse, the Single-Valued Neutrosophic Number (SVNN) over *A* is defined as an object in the representation.

$$g_A = \{\langle x, \vartheta_A(x), \eta_A(x), \delta_A(x)\rangle : x \in X\}$$
$$y_A = \{\langle x, \vartheta_A(x), \eta_A(x), \delta_A(x)\rangle : x \in X\}$$

similarly, where $\vartheta_A(x), \eta_A(x), \delta_A(x)$ meet the following condition

$$0 \leq \vartheta_A(x), \eta_A(x), \delta_A(x) \leq 3, \text{ for all } x \in X.$$

Linguistic scale	**SVNN**(h, i, j)
Very Important (VI)	(0.95, 0.15, 0.10)
Important (I)	(0.75,0.30,0.25)
Medium (M)	(0.50,0.45,0.50)
Not Important (NI)	(0.25,0.85,0.75)
Very Not Important (VNI)	(0.15,0.90,0.95)

Table 1: Linguistic terms representing the weight of importance of the criteria. Own elaboration

Criterion	SVNN
Extremely High	(1,0,0)
Very Very High	(0.9,0.07,0.11)
Very High	(0.8,0.17,0.21)
High	(0.7,0.27,0.31)
Slightly Moderate	(0.6,0.37,0.41)
Moderate	(0.5,0.47,0.51)
Moderately Low	(0.4,0.57,0.61)
Low	(0.3,0.67,0.71)
Very Low	(0.2,0.77,0.81)
Very Very Low	(0.1,0.87,0.91)
Extremely Low	(0,0.97,1)

Table 2: Relationship between measurement ranges and neutrosophic scales. Source: Own elaboration.

This table allows an intuitive interpretation of how different challenges can be evaluated under the framework of the neutrosophic PROMETHEE method, integrating the indeterminacy inherent to each situation. Analysts and lawyers can strategically use this methodology to priorize challenges and resources, based on a deeper understanding of the underlying dynamics and the relative probabilities of their impact on the defense process. The application of these neutrosophic scales emphasizes the importance of considering all aspects of each challenge, including those that cannot be clearly classified as true or false. Thus, it reflects the neutrosophic environment in legal practice in drug trafficking cases.

2.1. CRITIC Neutrosophic Method.

The CRITIC (Criteria Importance Through Intercriteria Correlation) method was proposed by Diakoulaki, Mavrotas, and Papayannakis in 1995. The CRITIC method is a multicriteria analysis technique used for decision-making in situations where multiple alternatives must be evaluated and compared based on various criteria. The Neutrosophic CRITIC method is based on assigning neutrosophic weights to the relevant criteria (k_n) and comparing the alternatives based on these weights to make decisions that include indetermination information [11]. Below are the steps for modeling the method:

Step 1: Define the decision matrix by including the weight of the criterion (see Figure 1).

$$\begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccccc} k_1 & k_2 & \dots & k_j & \dots & k_n \\ w_1 & w_2 & \dots & w_j & \dots & w_n \end{array} \\ \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1j} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2j} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ y_{i1} & y_{i2} & \cdots & y_{ij} & \cdots & y_{in} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mj} & \cdots & y_{mn} \end{bmatrix} \end{array}$$

Figure 1. Decision matrix. Source: own elaboration.

Step 2: Normalize the values of each criterion by the range. Analysis of the elements of the neutrosophic decision matrix:

The decision criteria $k_n = k_1, k_2, k_{Qj}, \dots, k_{Qn}$ can be defined as the conditions or parameters that allow for the discrimination of alternatives and the establishment of the decision-maker's importance preferences. The criteria for making decisions about each alternative are evaluated based on the linguistic terms in Single-Valued Neutrosophic Numbers (SVNNs) according to the scales shown in Table 1.

$$L_{ij} = \frac{y_{ij} - y_{jmax}}{y_{jmax} - y_{jmin}} \tag{1}$$

Step 3: Calculate the standard deviation of each criterion.

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{m} \left[l_{ij} - \left(\frac{\sum_{i=1}^{m} l_{ij}}{m} \right) \right]^2}{m-1}} \tag{2}$$

Step 4: Calculate the correlation between each pair of criteria.

$$r_{jk} = \frac{cov\,(j,k)}{\sigma_j - \sigma_k} \tag{3}$$

Step 5: Calculate the weight of each criterion.

$$w_j = \sigma_j \cdot \sum_{k=1}^{n} \left(1 - r_{jk}\right) \tag{4}$$

Step 6: Weighting each criterion.

$$w_j' = \frac{w_j}{\sum_{j=1}^{n} w_j} \tag{5}$$

A criterion with greater weights means that its variance (standard deviation) is higher and that the information it provides is more different compared to other criteria (lower correlation coefficient between criteria).

2.2 Neutrosophic PROMETHEE Method.

The Neutrosophic PROMETHEE Method enriches the original PROMETHEE method by incorporating the principles of neutrosophy and offering an advanced approach to handling indeterminacy in decision-making [11]. This integration significantly improves the analysis of options against multiple criteria in complex contexts, where information can be imprecise, indeterminate, or incomplete [12,17].

The Neutrosophic PROMETHEE Method represents a significant advancement in the ability to evaluate complex decisions. Thus, it provides a more robust and versatile tool to face the challenges inherent in decision-making in uncertain and dynamic environments. Below are the steps of the method [13,18]:

Step 1: Define the decision matrix with the respective weights of each criterion (see Figure 2).

$$\begin{array}{c} \\ \\ A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccccc} k_1 & k_2 & \dots & k_j & \dots & k_n \end{array} \\ \begin{array}{ccccccc} w_1 & w_2 & \dots & w_j & \dots & w_n \end{array} \\ \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1j} & \cdots & g_{1n} \\ g_{21} & g_{22} & \cdots & g_{2j} & \cdots & g_{2n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ g_{i1} & g_{i2} & \cdots & g_{ij} & \cdots & g_{in} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ g_{m1} & g_{m2} & \cdots & g_{mj} & \cdots & g_{mn} \end{bmatrix} \end{array}$$

Figure 2: Decision Matrix. Source: own elaboration.

where $A = [g_{ij}]$, where each element g_{ij} represents the relative importance of criterion i for criterion j, with $i, j = 1,2,\dots,n_{ij}$. While k_n corresponds to the established criteria.

Step 2: Define the generalized criteria associated with each k_j (see Table 3).

Generalized criterion		
Criterion maximization $P_j(a,b) = F_j[d_j(a,b)]$	+	The set of g_{ij} evaluations $i = 1,\dots,m$
Criterion minimization $P_j(a,b) = F_j[-d_j(a,b)]$		

Table 3. Generalized Criterion. Source: Own elaboration

Generalized criteria are defined based on the determination of parameters p (threshold of strict preference), q (threshold of indifference), and/or s (an intermediate value between q and p).

Step 3: Pairwise comparison of alternatives (calculation of $P_j(a,b)$ and $P_j\,(b,a)$).

Step 4: Calculation of the aggregated preference indices $\pi(a,b)$, $\pi(b,a)$.

$$\Pi(a,b) = \sum_{j=1}^{n} P_j(b,a)\, w_j \tag{6}$$

$$\Pi(b,a) = \sum_{j=1}^{n} P_j(b,a)\, w_j \tag{7}$$

Step 5: Calculation of the flows φ^+ (Positive), φ^- (Negative), and φ (Net).

$$\varphi^+ = \sum \pi\,(a,b) \tag{8}$$

$$\varphi^- = \sum \pi\,(b,a) \tag{9}$$

$$\varphi = \varphi^+ - \varphi^- \tag{10}$$

Step 6: Obtaining the ranking of alternatives based on φ. For this, the following conditions must be analyzed:

- $aPb\ (a\ surpasses\ b)\ if\ \varphi(a) > \varphi(b)$.
- $aIb\ (a\ and\ b\ are\ indifferent)\ if\ \varphi(a) = \varphi(b)$

3. METHODS

This study employed a mixed-methods approach, combining qualitative and quantitative techniques to analyze the challenges faced by defense attorneys in drug trafficking cases in Ambato, Ecuador. The research framework integrated expert consultations with a mathematical decision-making model, leveraging the Neutrosophic PROMETHEE method for a structured evaluation of challenges and their impact on the presumption of innocence.

3.1. Data Collection and Expert Consultation

To gain insights into the complexities of legal defense in drug trafficking cases, semi-structured interviews were conducted with a purposive sample of 20 experienced defense attorneys. These professionals, with an average of 8 years of experience, were selected based on their expertise in criminal law and their direct involvement in cases related to drug trafficking. The interviews focused on identifying key obstacles in the legal process and exploring strategies employed to preserve the presumption of innocence. The responses were categorized into eight major challenges, as outlined in Table 4 in the results section.

Additionally, secondary data was reviewed, including legal frameworks, case law, and academic literature on judicial decision-making in drug-related offenses. This background information provided a contextual foundation for the study, ensuring that the identified challenges aligned with broader legal and socio-political dynamics.

3.2. Application of Neutrosophic Multi-Criteria Decision-Making (MCDM) Methods

To systematically assess and prioritize the identified challenges, a Neutrosophic Multi-Criteria Decision-Making (MCDM) approach was applied. The methodology involved the following key steps(Figure 1):

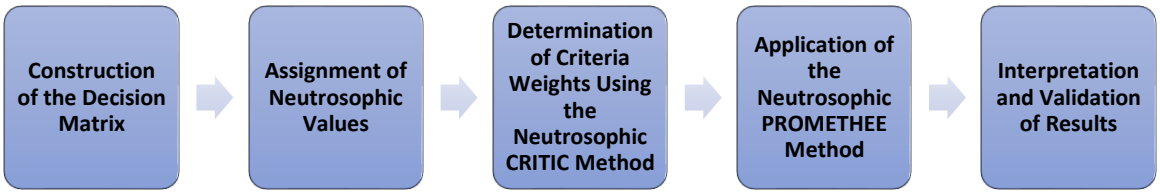

Figure 1. Neutrosophic Multi-Criteria Decision-Making approach

Step 1: Construction of the Decision Matrix

A decision matrix was formulated, incorporating the eight identified challenges as alternatives (D1 to D8) and five evaluation criteria (k1 to k5) representing critical aspects influencing legal defense (Table 5). The criteria were selected based on expert input and literature review, covering aspects such as impact on defense strategy, public perception, legal complexity, resource requirements, and case outcomes.

Step 2: Assignment of Neutrosophic Values
Each challenge was evaluated against the five criteria using Single-Valued Neutrosophic Numbers (SVNNs). These numbers captured the degrees of truth (T), indeterminacy (I), and falsity (F) associated with each evaluation, reflecting the inherent uncertainty in legal decision-making. The linguistic scale employed for the assignment of values is detailed in Tables 6 to 9.

Step 3: Determination of Criteria Weights Using the Neutrosophic CRITIC Method
The Criteria Importance Through Intercriteria Correlation (CRITIC) method was adapted to a neutrosophic environment to assign weights to the evaluation criteria. This involved:
- Standardizing the decision matrix values.
- Calculating the standard deviation of each criterion to assess its variability.
- Computing the correlation coefficients between criteria to identify dependencies.
- Determining the final weight of each criterion based on its relative importance in the decision-making process (Table 8).

Step 4: Application of the Neutrosophic PROMETHEE Method
The PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) method was used to rank the challenges based on their impact on legal defense. The process included:
- Pairwise comparisons of challenges using preference functions.
- Calculation of aggregated preference indices (π) to assess the dominance of each alternative.
- Computation of positive (φ^+), negative (φ^-), and net (φ) preference flows to establish the final ranking of challenges (Table 11).

Step 5: Interpretation and Validation of Results
The ranked challenges were analyzed to identify priority areas for intervention. The top-ranked challenges, including "previous reputation of the accused," "pressure for plea deals," and "difficulty in proving lack of knowledge," were highlighted as critical obstacles affecting the presumption of innocence (Figure 3). The findings were validated through expert review, ensuring alignment with real-world legal practice.

3.3. Development of Strategic Recommendations
Based on the ranking of challenges, targeted strategies were proposed to enhance the preservation of the presumption of innocence in drug trafficking cases. These strategies, outlined in Table 12, included legal reforms, ethical training for lawyers, public awareness campaigns, and enhanced investigative resources. Each recommendation was assessed for feasibility, impact, and implementation timeframe, providing a structured roadmap for legal practitioners and policymakers.

3.4. Ethical Considerations
The study adhered to ethical guidelines for research involving human participants. Informed consent was obtained from all interviewed attorneys, ensuring confidentiality and anonymity. The research focused solely on systemic challenges without discussing specific cases, safeguarding the integrity of the legal process.

3.5. Limitations
While the study provides a structured evaluation of legal defense challenges, certain limitations must be acknowledged:
- The findings are specific to Ambato, Ecuador, and may not fully generalize to other jurisdictions.
- The reliance on expert opinions introduces a degree of subjectivity, despite efforts to mitigate bias through mathematical modeling.
- The study does not account for real-time judicial decisions, as it focuses on retrospective analysis and expert perceptions.

Despite these limitations, the integration of qualitative insights with neutrosophic MCDM techniques provides a novel and robust framework for analyzing legal complexities. Future research could expand this approach to other legal contexts and incorporate real-time case data to enhance predictive accuracy.

By systematically identifying and ranking the challenges in defending drug trafficking cases, this methodological framework offers practical tools for legal professionals and policymakers seeking to uphold the principles of fairness and justice in criminal proceedings.

4. RESULTS.

The research on the experience of lawyers specializing in drug trafficking cases in Ambato, Ecuador, sheds light on the challenges and tactics employed in defending these cases. The lawyers, with an average of 8 years of experience, identify key challenges that affect the process (see Table 4).

Challenges	Challenge name	Description	Intrinsic obstacles
D1	Complexity of laws and regulations.	The difficulty arises from the constant evolution and complexity of drug trafficking laws.	The need for constant updating and understanding can overwhelm the defense's capacity, affecting the fairness of the trial.
D2	Limited resources for investigation.	The lack of resources to conduct a thorough investigation in defense.	Limits the lawyer's ability to build a strong defense, potentially compromising the presumption of innocence.
D3	Interference from external factors.	The influence of external elements unrelated to the case, such as politics or public opinion, on the trial.	Can bias the legal process and the perception of the accused's innocence by introducing factors unrelated to the evidence.
D4	Pressure for quick results.	The judicial system's urgency to resolve cases quickly.	This may lead to rushed judgments without full consideration of all evidence, affecting the justice of the process.
D5	Previous reputation of the accused.	How the accused's background can negatively influence the perception of their innocence.	Stigmatization based on history can predispose those involved in the trial against the accused, undermining the presumption of innocence.
D6	Pressure to obtain plea deals.	The tendency to resolve cases through plea deals under undue pressure.	Compromises the accused's ability to fully exercise their right to a fair trial, pushing them to accept possibly unjustified guilt.
D7	Negative publicity and media bias.	The creation of a bias in public opinion through negative media coverage.	Affects the objectivity of the judicial process by influencing the perception of judges, juries, and society, eroding the presumption of innocence.
D8	Difficulty in proving lack of knowledge.	The challenge of proving that the accused had no knowledge of the illegal activity.	Requires solid and convincing evidence, which is often difficult to obtain, affecting the ability to establish an effective defense.

Table 4: Main challenges provided by the interviewed lawyers. Source: Own elaboration.

Table 4 shows cases of the diversity and complexity of the challenges that lawyers face in preserving the presumption of innocence in drug trafficking cases. Each challenge presents unique obstacles in the legal process, highlighting the importance of adaptive and ethical strategies in legal defense (see Table 5).

Criterion	Criterion name	Description	Neutrosophic Environment
k1	Impact on Defense.	Evaluates how the challenge affects the lawyer's ability to effectively defend the accused.	Effectiveness of Legal Defense.
k2	Public Perception.	Considers the effect of the challenge on public opinion and media regarding the case and the accused.	Influence on Public Perception.

k3	Legal Complexity.	Measures the legal and technical difficulty presented by the challenge to be addressed.	Difficulty of Management within the Legal Framework.
k4	Required Resources.	Assesses the amount of resources (time, money, personnel) required to overcome the challenge.	Resource Demand.
k5	Impact on the Result.	Analyzes how the challenge may affect the outcome of the case.	Influence on the Case Verdict.

Table 5: Evaluation criteria and associated neutrosophic scales. Source: Own elaboration.

This table facilitates the implementation of the neutrosophic PROMETHEE method by providing a detailed framework for evaluating challenges in defending drug trafficking cases. The inclusion of neutrosophic scales allows for addressing the indeterminacy associated with each criterion, offering a more flexible and adaptive tool for analyzing indeterminate decisions in the legal field. By assigning these scales to the measurement ranges, the precision of the evaluation is improved, and the identification of priority areas for strategic action is facilitated. Therefore, the determination of weights is proceeded with using the Neutrosophic CRITIC method (see Tables 6 to 9).

Challenges	**Impact on Defense**	**Public Perception**	**Legal Complexity**	**Required Resources**	**Impact on the Result**
	k1	**k2**	**k3**	**k4**	**k5**
D1	(0.5,0.47,0.51)	(0,0.97,1)	(0.3,0.67,0.71)	(0.5,0.47,0.51)	(0.7,0.27,0.31)
D2	(0,0.97,1)	(0.5,0.47,0.51)	(0.4,0.57,0.61)	(0.5,0.47,0.51)	(0.6,0.37,0.41)
D3	(0.3,0.67,0.71)	(0.4,0.57,0.61)	(0.2,0.77,0.81)	(0.6,0.37,0.41)	(0,0.97,1)
D4	(0,0.97,1)	(0.4,0.57,0.61)	(0.3,0.67,0.71)	(0.6,0.37,0.41)	(0.5,0.47,0.51)
D5	(0.3,0.67,0.71)	(0.6,0.37,0.41)	(0.5,0.47,0.51)	(0.4,0.57,0.61)	(0.7,0.27,0.31)
D6	(0,0.97,1)	(0.4,0.57,0.61)	(0.3,0.67,0.71)	(0.2,0.77,0.81)	(0.6,0.37,0.41)
D7	(0.5,0.47,0.51)	(0.8,0.17,0.21)	(0.5,0.47,0.51)	(0,0.97,1)	(0.7,0.27,0.31)
D8	(0.4,0.57,0.61)	(0.5,0.47,0.51)	(0,0.97,1)	(0.2,0.77,0.81)	(0,0.97,1)
X_{max}	**(0.5,0.47,0.51)**	**(0.8,0.17,0.21)**	**(0.5,0.47,0.51)**	**(0.6,0.37,0.41)**	**(0.7,0.27,0.31)**
X_{min}	**(0,0.97,1)**	**(0,0.97,1)**	**(0,0.97,1)**	**(0,0.97,1)**	**(0,0.97,1)**

Table 6: Decision Matrix. Own elaboration.

Criteria	**k1**	**k2**	**k3**	**k4**	**k5**
k1	(1,0,0)	(0,0.97,1)	(0,0.97,1)	(0,0.97,1)	(0,0.97,1)
k2	(0,0.97,1)	(1,0,0)	(0.3,0.67,0.71)	(0,0.97,1)	(0,0.97,1)
k3	(0,0.97,1)	(0.3,0.67,0.71)	(1,0,0)	(0,0.97,1)	(0.8,0.17,0.21)
k4	(0,0.97,1)	(0,0.97,1)	(0,0.97,1)	(1,0,0)	(0,0.97,1)
k5	(0,0.97,1)	(0,0.97,1)	(0.8,0.17,0.21)	(0,0.97,1)	(1,0,0)
σ_j	**0.090**	**0.058**	**0.034**	**0.065**	**0.074**

Table 7: Calculate the standard deviation and correlation between each pair of criteria. Source: own elaboration

Criteria	**k1**	**k2**	**k3**	**k4**	**k5**	w_j	w'_j
σ_j	**0.090**	**0.058**	**0.034**	**0.065**	**0.074**		
Total	**(0.5,0.47,0.51)**	**(0.3,0.67,0.71)**	**(0,0.97,1)**	**(0.4,0.57,0.61)**	**(0.4,0.57,0.61)**	**1,301**	
k1	(0,0.97,1)	(1,0,0)	(1,0,0)	(1,0,0)	(1,0,0)	0.407	**(0.7,0.35,0.25)**
k2	(1,0,0)	(0,0.97,1)	(0.5,0.47,0.51)	(1,0,0)	(0.8,0.17,0.21)	0.238	**(0.25,0.7,0.75)**
k3	(1,0,0)	(0.5,0.47,0.51)	(0,0.97,1)	(1,0,0)	(0,0.97,1)	0.098	**(0,0.95,1)**
k4	(1,0,0)	(1,0,0)	(1,0,0)	(0,0.97,1)	(1,0,0)	0.324	**(0.50,0.55,0.5)**
k5	(1,0,0)	(0.8,0.17,0.21)	(0,0.97,1)	(1,0,0)	(0,0.97,1)	0.234	**(0.25,0.7,0.75)**

Table 8: Correlation matrix, standard deviations, and weightings of each criterion. Source: own elaboration.

SVNN	**Linguistic term**	**Criteria**
(0.95,0.15,0)	Extremely Important (EI)	-
(0.7,0.35,0.25)	Very Important (VI)	**k1**
(0.50,0.55,0.5)	Important (I)	**k4**
(0.25,0.7,0.75)	Not So Important (NSI)	**k2,k5**
(0,0.95,1)	Not Important (NI)	**k3**

Table 9: Linguistic terms and corresponding weight of importance for each criterion. Source: own elaboration.

The results obtained from the modeling of the neutrosophic CRITIC method represent the criterion *Impact on Defense* with a classification of *Very Important* when evaluating each challenge in the defense of drug trafficking

cases. Meanwhile, *k4* shares a classification of *Important*, and the rest of the criteria fall below the neutrosophic average. Therefore, once the neutrosophic weights are defined, the PROMETHEE model is developed using the 8 challenges and the 5 defined criteria. Consequently, a decision matrix is constructed (see Table 10). Each challenge is evaluated according to the established criteria using the provided neutrosophic scales to obtain the flows φ^+, φ^- and φ for each alternative (see Table 11).

Alternatives / Criteria	**Impact on Defense**	**Public Perception**	**Legal Complexity**	**Required Resources**	**Impact on the Result**
	k1	**k2**	**k3**	**k4**	**k5**
w	**(0.7,0.35,0.25)**	**(0.25,0.7,0.75)**	**(0,0.95,1)**	**(0.50,0.55,0.5)**	**(0.25,0.7,0.75)**
Min/Max	**max**	**max**	**min**	**max**	**max**
D1	(0.5,0.47,0.51)	(0.5,0.47,0.51)	(0.8,0.17,0.21)	(0.7,0.27,0.31)	(0.6,0.37,0.41)
D2	(0.3,0.67,0.71)	(0.3,0.67,0.71)	(0.5,0.47,0.51)	(0.8,0.17,0.21)	(0.4,0.57,0.61)
D3	(0.4,0.57,0.61)	(0.6,0.37,0.41)	(0.5,0.47,0.51)	(0.6,0.37,0.41)	(0.5,0.47,0.51)
D4	(0.6,0.37,0.41)	(0.6,0.37,0.41)	(0.6,0.37,0.41)	(0.5,0.47,0.51)	(0.7,0.27,0.31)
D5	(0.9,0.07,0.11)	(0.8,0.17,0.21)	(0.7,0.27,0.31)	(0.7,0.27,0.31)	(0.8,0.17,0.21)
D6	(0.8,0.17,0.21)	(0.8,0.17,0.21)	(0.7,0.27,0.31)	(0.6,0.37,0.41)	(0.8,0.17,0.21)
D7	(0.7,0.27,0.31)	(0.8,0.17,0.21)	(0.7,0.27,0.31)	(0.6,0.37,0.41)	(0.7,0.27,0.31)
D8	(0.8,0.17,0.21)	(0.7,0.27,0.31)	(0.7,0.27,0.31)	(0.6,0.37,0.41)	(0.8,0.17,0.21)

Table 10: Define the decision matrix. Source: Own elaboration.

Challenges	φ	φ^+	φ^-
D5	0.7400	0.8700	0.1300
D6	0.3800	0.6900	0.3100
D8	0.2371	0.6186	0.3814
D7	0.1029	0.5514	0.4486
D1	-0.3114	0.3443	0.6557
D4	-0.3114	0.3443	0.6557
D2	-0.3400	0.3300	0.6700
D3	-0.4971	0.2514	0.7486

Table 11: Calculation of the flows φ^+, φ^-, and φ. Source: own elaboration.

This method has enabled the prioritization of these challenges based on their neutrosophic importance. This ranking identifies "previous reputation of the accused," "pressure to secure plea deals," and "difficulty in proving lack of knowledge" as the most significant obstacles impeding the protection of the presumption of innocence (refer to Figure 3).

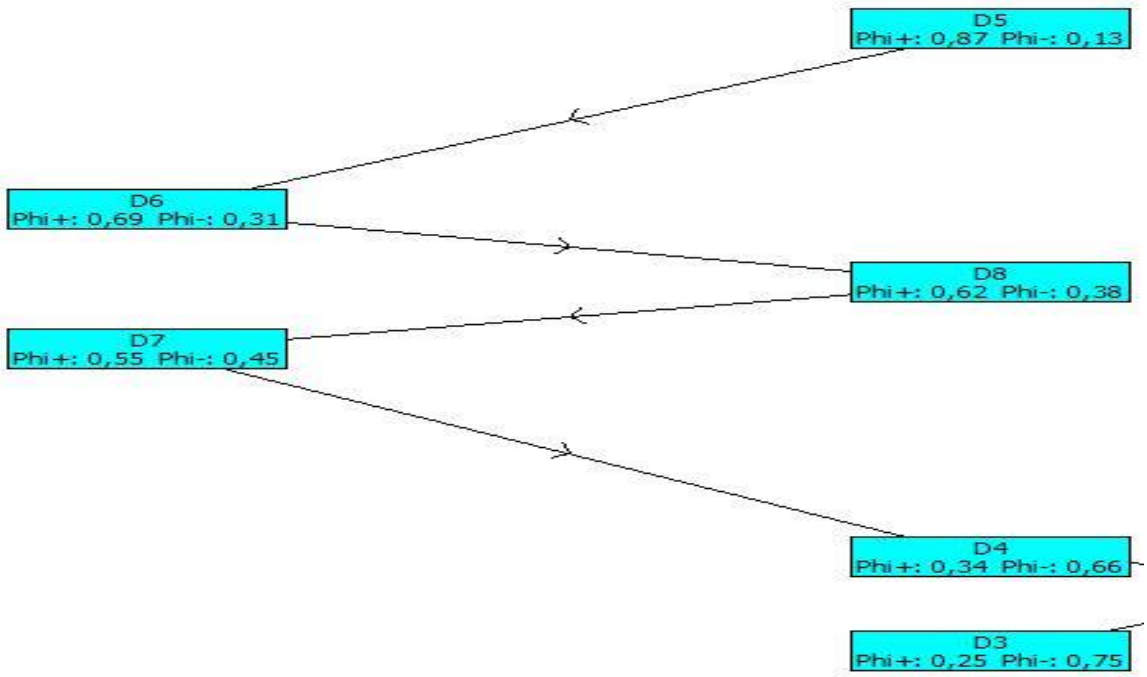

Figure 2: Ranking of alternatives based on φ. Source: Own elaboration.

This research underscores the complexity of ensuring the presumption of innocence in the current judicial context, highlighting both systemic obstacles and the need for meticulous and well-informed defense to overcome them. It also emphasizes the critical importance of the lawyer-client relationship in building tailored and effective defenses. This fact shows the need for substantial improvements in how the principle of the presumption of innocence is applied. General strategies for addressing these challenges include:

- Legal reforms: A call for reform is highlighted to achieve fairer and more equitable procedures, reflecting a critique of current legislation or its application.
- Strengthening of ethical training: An emphasis on the importance of ethical standards in legal practice to ensure effective defense and maintain the integrity of the judicial process.
- Public awareness: A strategy aimed at educating society about the presumption of innocence to mitigate social and media biases.
- Adaptation to changes in drug control policies: An acknowledgment of the need to continuously adapt to legislative and regulatory changes in the field of drug control.

However, to address the main challenges identified in neutrosophic modeling, among which the *prior reputation of the accused* stands out as dominant, it is proposed to expand strategies that adopt a comprehensive and multidimensional approach. Below, Table 12 proposes strategies for protecting the presumption of innocence in drug trafficking cases.

Challenge	**Proposed Measures**	**Scope**	**Time**	**Benefits**	**Impact on the Preservation of the Presumption of Innocence**
The previous reputation of the accused	Awareness campaigns on the presumption of innocence. Media training for lawyers.	National	6-12 months	Improves public perception of the accused. Equip lawyers with tools to manage the public narrative.	Reinforces the principle that everyone is innocent until proven guilty by minimizing the impact of the defendant's record.
Pressure for plea deals	Training workshops on negotiation and ethics for lawyers. Development of judicial protocols.	Judicial/ Legal	3-6 months	Strengthens lawyers' negotiation and ethical skills. Ensures fairness of plea agreements.	Ensures that plea agreements are based on informed and voluntary decisions by protecting the right to a fair trial.

Difficulty demonstrating a lack of knowledge	Investments in investigative and forensic resources. Training in defense techniques.	Legal/ Scientific	6-12 months	Improves the ability to present exculpatory evidence. Increases the effectiveness of defenses based on technical evidence.	Facilitates the demonstration of innocence in complex cases by improving the chances of a fair verdict.

Table 12: Expanded strategies to mitigate challenges. Source: Own elaboration.

The scope of the measures shows their level of implementation, whether it be national, within the judicial/legal sector, or in the scientific/forensic community, indicating the required breadth. The estimated time for implementation allows for strategic planning and the allocation of appropriate resources. The expected benefits include improvements in public perception and capacity strengthening. Thus, it contributes to reinforcing the presumption of innocence in drug trafficking cases by improving defense capabilities. It also supports ensuring fair decision-making processes and facilitates the presentation of key evidence.

These recommendations highlight the need for a multifaceted approach that combines legal reforms, professional ethics, public awareness, and adaptability to changes in drug control policies. In a way that helps to improve the fairness of the legal process and strengthen the protection of the presumption of innocence in drug trafficking cases.

5. CONCLUSION

In this research, the challenges faced by lawyers in drug trafficking cases to preserve the presumption of innocence and the strategies they employ were explored. The challenges identified, such as the influence of media biases and the pressure for plea deals, highlighted the complexity of ensuring a fair trial in drug trafficking cases. These obstacles suggest that there are external factors that can compromise the presumption of innocence and fairness in the legal process. However, factors like the previous reputation of the accused are elements that can be managed in many different ways depending on professional ethics.

The application of the Neutrosophic PROMETHEE Method allowed for the ranking of challenges, placing previous reputation and pressure for plea deals in priority positions within the analyzed neutrosophic set. This provides a guide for focusing efforts and resources on mitigating the most significant obstacles. The main strategies indicate the need for legal reforms and ethical strengthening in legal defense in drug trafficking cases. These suggestions aim to address structural problems and maintain high standards of professional conduct to ensure the protection of the presumption of innocence. Solutions involving legal and ethical reforms can influence future improvements in the application of the presumption of innocence and the quality of the legal defense process in this area. These outcomes may influence future enhancements in the application of the presumption of innocence and the legal defense process in drug trafficking cases.

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EVALUATION OF THE CASE METHODOLOGY IN LEGAL EDUCATION: AN APPLICATION OF PLITHOGENIC LOGIC.

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ABSTRACT
The study focused on analyzing the perception and satisfaction of senior Law students at Universidad de los Andes regarding the use of the case method as a didactic tool. A mixed methodology that involved indeterminate Likert scales to assess various educational dimensions was implemented. Effectiveness, ease of learning, professional preparation, development of critical skills, and methodological preference were some of the considered dimensions. Data collected from 81 students were translated into TRINS matrices and processed using the $\gamma(V)$ function, leading to the acquisition of Refined Plithogenic Probabilities and Neutrosophic Plithogenic Probabilities. The results showed a positive trend towards the case method, highlighting its value in learning and professional preparation. However, the presence of indeterminate responses indicated the need for future research to better understand areas of ambiguity and improve teaching methodology. The study underscores the importance of the case method in legal education and suggests ongoing examination of pedagogical practices to enrich the educational experience of future legal professionals.
KEYWORDS: legal education; plithogenic logic; case methodology; student satisfaction

MSC: 97K80, 68T37, 91C20

RESUMEN
El estudio se centró en analizar la percepción y satisfacción de los estudiantes de Derecho de la Universidad de los Andes respecto al uso del método del caso como herramienta didáctica. Se implementó una metodología mixta que involucró escalas Likert indeterminadas para evaluar diversas dimensiones educativas, incluyendo efectividad, facilidad de aprendizaje, preparación profesional, desarrollo de habilidades críticas y preferencia metodológica. Los datos recopilados de 81 estudiantes se tradujeron en matrices TRINS y se procesaron utilizando la función $\gamma(V)$, culminando en la adquisición de Probabilidades Plitogénicas Refinadas y Probabilidades Plitogénicas Neutrosóficas. Los resultados mostraron una tendencia positiva hacia el método del caso, destacando su valor en el aprendizaje y la preparación profesional. Sin embargo, la presencia de respuestas indeterminadas indicó la necesidad de futuras investigaciones para comprender mejor las áreas de ambigüedad y mejorar la metodología de enseñanza. El estudio subraya la importancia del método del caso en la educación legal y sugiere un examen continuo de las prácticas pedagógicas para enriquecer la experiencia educativa de los futuros profesionales del derecho.
PALABRAS CLAVE: educación legal; lógica plitogénica; metodología del caso; satisfacción estudiantil.

1. INTRODUCTION

The legal education landscape, and particularly the application of the case method in training future legal professionals, has taken on unprecedented significance in today's academic discourse. This pedagogical approach not only fosters a more dynamic and practical learning environment but also challenges traditional paradigms by weaving real-world scenarios and critical debates into the classroom fabric [1]. Indeed, the escalating demand for analytical and problem-solving skills in the legal realm compels educators to transcend mere knowledge transmission, situating them at the confluence where theory and practice converge to deliver high-quality education [2]. Scholars emphasize that adopting such methodologies represents a transformative shift, one that can catalyze profound improvements in pedagogical outcomes and student preparedness.

Throughout the last few decades, the case method has evolved into a cornerstone of legal teaching, enabling students to engage with complex legal issues and hone essential critical thinking abilities. Its historical trajectory is anything but linear; it has been marked by pedagogical breakthroughs, curricular shifts, and continuous revisions of study materials to mirror societal and technological changes [3, 14]. Universities worldwide have witnessed significant transformations in their pedagogical strategies, integrating active learning techniques that strive to involve students more deeply than the traditional lecture format ever allowed [4].

One cannot overstate the importance of tracing the origins of the case method to fully appreciate its intrinsic value and why it has become an indispensable resource in modern legal education. Since its early adoption in law schools, this method has continuously adapted to meet the evolving needs of each generation, offering novel solutions to persistent educational challenges [5,15]. Early resistance and criticisms have gradually given way to

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widespread recognition of its ability to simulate professional environments, thus fostering active, collaborative learning experiences that mirror real-life legal dilemmas.

Academic discussions today often revolve around the efficacy of the case method within an increasingly interconnected and complex world. The advent of emerging technologies and new forms of social interaction has rendered legal scenarios more dynamic and challenging, demanding continuous adaptation of teaching strategies [6]. Far from being a hindrance, this dynamic climate provides a unique opportunity for innovation, encouraging educators to enrich legal training by embracing methods that respond adeptly to real-world complexities and uncertainties. Such educational agility is essential in preparing students for the multifaceted challenges they will face as practitioners.

However, despite the multitude of advantages reported in literature and observed in practice, questions and gaps remain regarding students' perceptions and satisfaction with this teaching approach. Observers wonder how effectively students are adapting to this style of learning and how they perceive its impact on their professional preparation and development of critical skills. While many studies extol its benefits quantitatively, the subjective experiences of students and the nuances of their sometimes ambiguous responses have not been thoroughly integrated into a comprehensive evaluation.

The crux of this research lies in addressing the absence of holistic approaches that adequately consider the subjective and indeterminate dimensions of evaluating the case method. Previous investigations have often highlighted measurable benefits but frequently neglected the personal and ambiguous facets of the student experience. How can we accurately assess and improve law students' perceptions of the case method when subjective factors and personal variability introduce layers of uncertainty and complexity that standard methodologies fail to capture?

To confront these challenges, this study proposes an innovative application of the neutrosophic Delphi method as a novel tool for capturing the inherent complexity within student opinions. By employing this approach, the research seeks to navigate uncertainty and ambiguity, offering a more nuanced and detailed evaluation of the case method's impact on legal education. The introduction of neutrosophic techniques allows for addressing the subjectivity and variability in student feedback, laying a robust foundation for future pedagogical enhancements that marry technological innovation with human-centered inquiry.

The primary objectives of this research are, first and foremost, to analyze law students' perceptions and satisfaction with the case method, employing neutrosophic tools to obtain a detailed and refined understanding of their opinions. Secondly, it aims to identify areas of ambiguity and develop concrete recommendations for optimizing teaching methodologies, thereby enhancing learning effectiveness and professional preparedness. These objectives align closely with the central research question and set a clear path for enriching educational practices within the legal domain.

2. PRELIMINARIES

2.1. Neutrosophic and refined neutrosophic set

Neutrosophic, developded by Smarandache (2005) [7,16], studies a perception or event or entity, "A" in relation to its opposite, "Anti- *A*" and not *A*, "Non- *A*", and as neither " *A*" nor "Anti*A*", denoted by "Neut- *A*".

Let us denote *X* as a metric space, where individual entities within *X* are symbolized by *x*. In this context, a single-valued neutrosophic set (SVNS) A within space *X* is defined by the following membership functions: the truth function $T_{A(x)}$, the indeterminacy function $I_{A(x)}$, and the falsity function $F_{A(x)}$. For an arbitrary point *x* in *X*, the values of $T_{A(x)}$, $I_{A(x)}$, and $F_{A(x)}$ are confined to the closed interval $[0, 1]$, fulfilling the condition

$$0 \leq T_{A(x)} + I_{A(x)} + F_{A(x)} \leq 3 .$$

The SVNS A is thus represented as

$$A = \{ x, T_{A(x)}, I_{A(x)}, F_{A(x)} \big| x \in X \}, \text{ see [8]}$$

According to the refined neutrosophic logic as formulated by Smarandache, we have the following:[9]

Definition 1: The concept of truth *T* is fractionated into distinct subclasses $T_1, T_2, \dots, T_p$; similarly, indeterminacy I is categorized into $I_1, I_2, \dots, I_r$, and falsity F into $F_1, F_2, \dots, F_s$. Here, *p*, *r*, *s* are all positive integers such that $p + r + s = n$.

Triple Refined Indeterminate Neutrosophic Sets (TRINS) further refine the notion of indeterminacy into three distinct memberships, enhancing both precision and applicability to contexts like the Likert scale. TRINS have been applied in areas such as personality classification. In contrast, a double-valued neutrosophic set (DVNS) bifurcates the concept of indeterminacy into two components.

Definition 2: A TRINS A in X, as previously outlined, is identified by five membership functions, namely positive $P_{A(x)}$, indeterminate $I_{A(x)}$, negative $N_{A(x)}$, positively indeterminate $IP_{A(x)}$, and negatively indeterminate $IN_{A(x)}$, each accompanied by a respective weight $w_m \in [0, 5]$. For every $x \in X$, we stipulate:

$$P_A(x), IP_A(x), I_A(x), IN_A(x), N_A(x) \in [0, 1]$$

and their weighted equivalents:

$$w_m P(P_A(x)), w_m IP(IP_A(x)), w_m I(I_A(x)), w_m IN(IN_A(x)), w_m N(N_A(x)) \in [0,5]$$

subject to the constraint:

$$0 \leq P_A(x) + IP_A(x) + I_A(x) + IN_A(x) + N_A(x) \leq 5$$

The TRINS A is thus notated as:

$$A = \{x, P_A(x), IP_A(x), I_A(x), IN_A(x), N_A(x) | x \in X\}$$

Let's consider two Triple Refined Indeterminate Neutrosophic Sets (TRINS), designated *A* and *B*, defined in the metric space *X*. The intersection of *A* and *B* produces a third TRINS C, expressed as $C = A \cap B$. The formulation of the membership of *C* in terms of truth, indeterminacy towards truth, indeterminacy, indeterminacy towards falsehood, and falsehood is determined by the following functional relations based on the corresponding membership values of *A* and *B*:

$$T_{C(x)} = \min(T_{A(x)}, T_{B(x)})$$
$$IT_{C(x)} = \min(IT_{A(x)}, IT_{B(x)})$$
$$I_{C(x)} = \min(I_{A(x)}, I_{B(x)})$$
$$IF_{C(x)} = min(IF_{A(x)}, IF_{B(x)})$$
$$F_{C(x)} = \max(F_{A(x)}, F_{B(x)})$$

In the context of refined Neutrosophic, the fourth definition is introduced for the calculation of the generalized weight, which synthesizes the influence of all membership functions within the framework of the Triple Refined Indeterminate Neutrosophic Set (TRINS). This definition is crucial for assessing the relevance and contribution of each membership function to the overall value of a neutrosophic set. The generalized weighting for a TRINS A, symbolized by w_A, is mathematically defined as:

$$w_A = (\sum_{i=1}^{n} w^T T_{A(x_i)} + w^I IT_{A(x_i)} + w\, I_{A(x_i)} + w^F IF_{A(x_i)} + w^N F_{A(x_i)}) \quad (1)$$

Here, $w^T, w^I, w, w^F, y\, w^N$ represent the weights associated with the membership functions of truth, indeterminacy towards truth, indeterminacy, indeterminacy towards falsehood, and falsehood, respectively. These weights play a crucial role in evaluating the relevance of the various membership functions within the neutrosophic set and in determining their contribution to the broader theoretical construct of neutrosophic analysis.

2.2. Basic Notions on Plithogenic

According to F. Smarandache, Plithogenic refers to the birth, creation, formation, development, and evolution of new entities, emerging from the dynamic and organic fusion of old entities that may be contradictory, neutral, or non-contradictory [10,17]. This concept advocates for the integration and unification of theories and ideas across all disciplines. In this context, "entities" refer to knowledge encompassing various fields like the soft sciences, hard sciences, arts, and theoretical aspects of literature.

A Plithogenic Set is defined as a non-empty set *P*, where the elements within a specified domain $U(P \subseteq U)$ are distinguished by one or more attributes $A_1, A_2, \ldots, A_m, m \geq 1$. Each attribute can possess a range of potential values across a spectrum *S* of values (states), which may be finite, infinite, discrete, continuous, open, or closed. [11,18] Each element $x \in P$ is characterized by the entire range of potential values for the attributes contained within the set $V = \{v_1, v_2, \cdots, v_n\}$. An attribute's value has a degree of belonging $d(x, v)$ for an element *x* in set *P* based on a specific criterion. This degree of belonging can manifest as fuzzy, intuitionistic fuzzy, or neutrosophic, among other types.

This means that for every element x in the set *P*, there exists a function $d: PxV \rightarrow \wp([0,1]^z)$, as shown in equation (2), where $d(x, v) \subseteq [0,1]^z$ and $\wp([0,1]^z)$ represents the power set of $[0,1]^z$. Here, z indicates the degree of appurtenance, with $z = 1$ corresponding to the fuzzy degree, $z = 2$ to the intuitionistic fuzzy degree, and $z = 3$ to the neutrosophic degree of appurtenance.

$$\forall x \in P, d: PxV \rightarrow \wp([0,1]^z) \quad (2)$$

Furthermore, if the cardinality of *V* is greater than or equal to *1*, a function $c: V \times V \rightarrow [0,1]^2$ is termed as the attribute value contradiction degree function for any pair of attribute values v_a, v_b. This function adheres to the following axioms:

$c(v_a, v_a) = 0$, indicating no contradiction in the attribute value with itself.

$c(v_a, v_b) = c(v_b, v_a)$, denoting the symmetry in contradiction degree between any two attribute values.

The function *c*, as defined above, is represented by *c* to signify that it is a fuzzy attribute value contradiction degree function. It is also defined in other forms, such as $c_{IF}: V \times V \rightarrow [0,1]^2$ to denote a neutrosophic attributes value contradiction function, reflecting different levels of certainty or contradiction in the attribute values.

Consequently, the Plithogenic Set is delineated by (P, a, V, d, c), encompassed by the set *P*, the attribute set *A*, the value set *V*, the membership function *m*, and the function known as the value contradiction degree *k*. The contradiction function is pragmatically employed to evaluate the contradiction across all attributes relative to a predominant attribute, should such an attribute exist, which is deemed paramount in comparison to the others. [12]

In contrast, (U, a, V, d, c) is designated as Plithogenic Probability, wherein E represents the event space. Plithogenic Probability is defined as the likelihood of an event's occurrence across all random variables that influence it, each random variable may adhere to classical, *T, I, F*-neutrosophic, *I*-neutrosophic, *T, F*-intuitionistic fuzzy, *T, N, F*-picture fuzzy, *T, N, F*-spherical fuzzy, or other fuzzy extensions distribution functions. Thus, Plithogenic Probability extends the classical concept of multivariate probability. [13]

Moreover, Plithogenic Statistics encapsulates the analysis and insights derived via the methodologies of Plithogenic Probability. Plithogenic Statistics expands upon classical multivariate statistics. Refined Probabilities are fragmented into multiple elements of truth, indeterminacy, or falsehood, delineated as $T_1, \dots T_p, I_1, \dots I_p, F_1, \dots . F_r$, where at least one of the indices *p*, *q*, or *r* exceeds *1*.

3. METHOD

The present research falls within a quantitative, descriptive, and correlational study, which was conducted to evaluate the influence of the case method as a pedagogical tool and determine the level of satisfaction of Law students at the UNIANDES regarding this teaching methodology. To achieve this, a mixed methodology was applied that combined traditional statistical analysis with plithogenic logic, through the use of Plithogenic Neutrosophic Probabilities, allowing for a more detailed and nuanced approach to the perceptions and attitudes of the students.

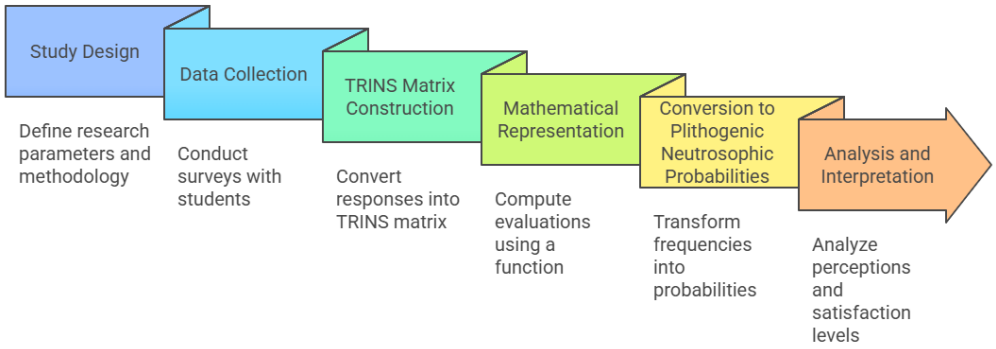

Figure 1. Research Methodology

Data collection was carried out through surveys applied to 81 senior Law students at UNIANDES. These surveys are designed to measure the students' perception of their satisfaction with the use of case studies as a teaching tool. Indeterminate Likert scales are used to evaluate specific elements of the surveys, seeking to identify indeterminacies in the students' responses.

After obtaining the results, the TRINS matrix is constructed for each respondent, categorizing each rating by statement on an indeterminate Likert scale ranging from (1) negative membership to (5) positive membership. This will allow determining the degree of acceptance of the statements by the students, expressing the responses in the form of TRINS, denoted as G_x.

For each student, their evaluation is represented by a vector in $[0, 1]^5$, where each component of the vector reflects an evaluation category from "Very High" to "Very Low". The function

$$\gamma(V) = 2v_1 + v_2 + 0.5v_3 - v_4 - 2v_5 \quad (3)$$

is used to analyze these data, calculating their relative frequency in percentages.

The frequency values are converted into Neutrosophic Plithogenic Probabilities to express the overall behavior of the studied dimensions. This is done through equation (3), representing the probabilities of each variable and its dimensions with values of the type (T, I, F), where T indicates the "strongly certain" probability that the dimension occurs adequately, I represents the "indeterminate" probability, and F the "totally certain" probability that the dimension does not occur adequately.

$$PNP = p_1 + p_2, pI, np_2 + np_1 \quad (4)$$

This methodological approach allows capturing the complexity and indeterminacy inherent to students' perceptions and satisfactions regarding the use of the case method as a pedagogical tool, using the framework of plithogenic logic and neutrosophic probabilities for a deeper and more nuanced analysis of the collected data.

4. RESULTS

The data collected were taken from final-year law students, as it was considered that they have a higher level of understanding of the analyzed pedagogical tool so that the results obtained would be significant for the study. Specific variables and their dimensions related to student satisfaction and the effectiveness of the case method as a pedagogical tool were analyzed. The selected study variables include the level of student satisfaction and the

level of appreciation/use of case studies as a teaching method. The dimensions to be evaluated for the second variable focused on:

- D11 Satisfaction with the Teaching Methodology,
- D12 Satisfaction with Classroom Interaction,
- D13 Satisfaction with the Learning Obtained for the first variable.

For the second variable, the dimensions of analysis proposed are:

- D21 Effectiveness of case studies,
- D22 Ease of learning,
- D23 Perception of preparation for professional practice,
- D24 Development of critical thinking and problem-solving,
- D25 Level of preference for the case study method.

Table 1 shows, as an example, the results corresponding to each dimension evaluated in the questionnaire through variable 1. The obtained values show the degree of agreement, the degree of indeterminacy with a tendency towards positive agreement, the degree of indeterminacy, the degree of indeterminacy with a tendency towards negative disagreement, and the degree of disagreement of each evaluated student, with respect to each dimension of the analyzed variables.

No	Satisfaction with the Teaching Methodology	Satisfaction with Class Interaction	Satisfaction with the Learning Obtained
1	(1; 1; .4; .6; .6)	(.6; .2; 0; 0; 1)	(1; 0; 0; .4; .4)
2	(1; .6; .2; .2; .2)	(.8; .6; .4; .4; .4)	(1; .4; 0; 0; .2)
3	(1; .4; 0; 0; .2)	(.6; .8; .2; .8; .6)	(1; .6; 0; 0; 0)
4	(.8; .2; 0; 0; 0)	(.6; 0; .6; 0; 1)	(1; .6; .4; 0; 0)
5	(.4; .2; 0; 0; 0)	(.6; .8; 0; 1; .8)	(.4;.4;.2; .2; 0)
6	(.6; .4; 0; 0; 0)	(.6; 0; 0; .6; .6)	(.6; .6; 0; 0; 0)
7	(1; 0; .4; .4; 0)	(.4; 0; .4; 1; .4)	(1; .2; .4;.4; 0)
8	(.6; .6;.6; .6; 0)	(0; 0; .2; .6; 1)	(.8;.6; .2; 0;.2)
9	(.8; .4; .2; 0; .2)	(.4; .4; 0; .4; 0)	(.6; 0;.6;.6; .4)
10	(1; .2; 0; 0; .2)	(.8; .6; 0; 0; .4)	(.4; .6; 0; 0;0)
11	(.8; .2; 0; 0; 0)	(.6; 1; .4; .4; .6)	(1; .4; 0; 0;.2)
12	(.6; .6; .6; .6; 0)	(.6; 0; .6; .8; 1)	(.8; .2; 0;0;0)
13	(.8; .4; .2; 0; .2)	(.6; .4; .2; .2; .6)	(.6; .6;.6;0;.6)
14	(1; .2; 0; 0; .2)	(.6; .6; 0; 0; .8)	(.4;1; 1;.4; .6)
15	(.8; .2; 0; 0; 0)	(0; .2; .4; .4; .4)	(.2;0; 0; .2; 1)
16	(.6; 0; 0; .4; 0)	(0; .6; .2; .2; 0)	(1; 0; 0; .4; .4)
17	(.4; .2; 0; 0; 0)	(.4; 0; .6; .6; 0)	(1; .4; 0; 0; .2)
18	(0; .6; 0; 0; 0)	(.8; .6; .8; .8; 1)	(1; .6; 0; 0; 0)
19	(.4; .4; .2; .2;.2)	(0; .4; 0; 0; .8)	(1; .6; .4; 0; 0)
20	(1; .6; .2; .2; .2)	(1; .6; .8; .8; .4)	(.4;.4; .2; .2;0)
21	(1; .4; 0; 0; .2)	(.8; .2; 0; 0; .6)	(.6; .6; 0; 0; 0)
22	(.8; .2; 0; 0; 0)	(.6; .4; 0; 0; 0)	(1;.2; .4; .4; 0)
23	(.4; .2; 0; 0; 0)	(.6; 0; .4; .4; .8)	(.8; .6;.2;0; .2)
24	(.6; .4; 0; 0; 0)	(1; .6; .6; .6; 0)	(.6;0;.6; .6; .4)
25	(1; 0; .4; .4; 0)	(.8; .4; 1; 1; .4)	(.4;.6; 0; 0; 0)
26	(.6; .6; .6; .6; 0)	(.6; .2; 0; 0; .2)	(1; .4; 0; 0; .2)
27	(.8; .4; .2; 0; .2)	(.6; 0; .2; .2; 0)	(.8; .2; 0; 0;0)
28	(1; .2; 0; 0; .2)	(.2; .2; .4;.4; .6)	(.4;.6;.6; .6;.4)
29	(.8; .2; 0; 0; 0)	(.6; .6; .2; .2; .2)	(1;.6; .8; .8; 0)
30	(.6; .6; .6; .6; 0)	(.4; 0; .6; .6; .4)	(.8; .4; 0; 0;.2)
31	(.8; .4; .2; 0; .2)	(0; .6; .8; .8; 0)	(1; 0; 0; .4; .4)
32	(1; .2; 0; 0; .2)	(.4; .4; 0; 0; .2)	(1; .4; 0; 0; .2)
33	(.8; .2; 0; 0; 0)	(.4; .6; .8; .8; .4)	(1; .6; 0; 0; 0)
34	(.6; 0; 0; .4; 0)	(.8; .2; 0; 0; .6)	(1; .6; .4; 0; 0)
35	(.4; .2; 0; 0; 0)	(0; .4; .2; .2; 0)	(.4;.4; .2;.2; 0)
36	(0; .6; 0; 0; 0)	(.6; .6; 0; 0; .8)	(0.6;.6; 0; 0;0)
37	(.4; .4; .2; .2; .2)	(.4; .2; .4; .4; .6)	(1; .2; .4; .4;0)
38	(.8; .6; 0; 0; 0)	(.6; .6; .2; .2; .2)	(.8;.6; .2; 0;.2)
39	(1; .6; .2; .2; .2)	(1; 0; .6; .6; .4)	(.6;0; .6;.6;.4)
40	(1; .4; 0; 0; .2)	(.6; .6; .8; .8; 0)	(.4; .6; 0; 0;0)
41	(.8; .2; 0; 0; 0)	(.4; .4; 0; 0; .2)	(1; .4; 0; 0; .2)
42	(.4; .2; 0; 0; 0)	(0; .6; .8; .8; .4)	(.8; .2; 0; 0;0)
43	(.6; .4; 0; 0; 0)	(.2; .2; 0; 0; .6)	(.6;.6;.8; .8;0)
44	(1; 0; .4; .4; 0)	(.4; .4; .2; .2; 0)	(.6; .2;0; 0;.2)
45	(.6; .6; .6; .6; 0)	(0; .6; 0; 0; .8)	(1; .4; 0; 0; 0)
46	(.8; .4; .2; 0; .2)	(.4; .2; .4; .4; 0)	(.6; 0; .4;.4;0)
47	(1; .2; 0; 0; .2)	(.8; .6; .2;.2; .4)	(1; 0; 0; .4; .4)
48	(.8; .2; 0; 0; 0)	(0; 0; .6; .6; .2)	(1; .4; 0; 0; .2)
49	(.6; .6; .6; .6; 0)	(.6; .4; .4; .4; 0)	(1; .6; 0; 0; 0)
50	(.8; .4; .2; 0; .2)	(.4; .2; .6; .6; 0)	(1; .6; .4; 0; 0)
51	(1; .2; 0; 0; .2)	(0; .6; 0; 0; 0)	(.4; .4; .2;.2;0)
52	(.8; .2; 0; 0; 0)	(.4; .4; .2; .2;.2)	(.6; .6; 0; 0; 0)
53	(.6; 0; 0; .4; 0)	(.8; .6; 0; 0; .6)	(1; .2; .4; .4;0)
54	(.4; .2; 0; 0; 0)	(0; .2; .4; .4; .6)	(.8; .6; .2;0;.2)
55	(0; .6; 0; 0; 0)	(1; .6; .2; .2; .2)	(.6; 0; .6;.6;.4)
56	(.4; .4; .2; .2;.2)	(.8; 0; .6; .6; .4)	(.4; .6; 0; 0; 0)
57	(.8; .6; 0; 0; 0)	(.6; .6; .8; .8; 0)	(1; .4; 0; 0; .2)
58	(0; .2; .4; .4; .6)	(.4; .4; 0; 0; .2)	(.8; .2; 0; 0; 0)
59	(1; .6; .2; .2; .2)	(.8; 0; .4; .4; 0)	(0; 0; .6; .6; 0)
60	(1; .4; 0; 0; .2)	(0; .6; .6; .6; 0)	(1; .6; .8; .8;0)
61	(.8; .2; 0; 0; 0)	(.6; .4; 1; 1; .4)	(.8; .4; 0;0; 0)
62	(.4; .2; 0; 0; 0)	(.4; .2; 0; 0; .6)	(.6;.6;.8; .8;0)
63	(.6; .4; 0; 0; 0)	(.8; 0; .2; .2; 1)	(.6;.2; 0; 0; 0)

64	(1; 0; .4; .4; 0)	(.4; .4; .4; .4; 0)	(1; .4; 0; 0; 0)
65	(.6; .6; .6; .6; 0)	(.8; .2;.6; .6; .2)	(.6;0; .4;.4; 0)
66	(.8; .4; .2; 0; .2)	(0; .6; 0; 0; .4)	(.4;.6;.6;.6; .2)
67	(1; .2; 0; 0; .2)	(.6; .4; .2;.2; .6)	(1; 0; 0; .4; .4)
68	(.8; .2; 0; 0; 0)	(.4; .6; 0; 0; 0)	(1; .4; 0; 0; .2)
69	(.6; .6; .6; .6; 0)	(0; .2; .4; .4; .2)	(1; .6; 0; 0; 0)
70	(.8; .4; .2; 0; .2)	(.6; .6; .2; .2; 0)	(1; .6; .4; 0; 0)
71	(1; .2; 0; 0; .2)	(.4; 0; .6; .6; .4)	(.4; .4; .2;.2;0)
72	(.8; .2; 0; 0; 0)	(.8; .6; .8; .8; .2)	(.6; .6; 0; 0; 0)
73	(.6; 0; 0; .4; 0)	(0; .4; 0; 0; .6)	(1; .2; .4; .4;0)
74	(.4; 0.2; 0; 0; 0)	(.6; .6; .8; .8; 0)	(.8;.6;.2; 0;.2)
75	(0; 0.6; 0; 0; 0)	(.4; 0.2; 0; 0; 0)	(.6; 0; .6;.6;.4)
76	(.4; .4; .2; .2;.2)	(.4; .4; 0; 0;.4)	(.4; .6; 0; 0;0)
77	(.8; 0.6; 0; 0; 0)	(.8; .4; 0; 0; .2)	(1; .4; 0; 0; .2)
78	(0; .2; .4; .4; .6)	(0;0; .4; .4; 0)	(.8; .2; 0;0; 0)
79	(1; .6; .2; .2; .2)	(.6; .6; .6; .6; 0)	(0; .2; .4; .4;0)
80	(.8; 0; .6;.6; .4)	(.4; .4; 1; 1; .4)	(.6; .6;.2;.2;.2)
81	(.6;.6;.8;.8;0)	(1; 0.2; 0; 0; 1)	(.2; 0.4;0;0;0)

Table 1: Evaluation of the dimensions corresponding to the variable Student Satisfaction Level
Source: own elaboration.

The acquirement of these evaluations allows for their adjustment using the function

$$\gamma(V) = 2v_1 + v_2 + 0.5v_3 - v_4 - 2v_5$$

to analyze this data, calculating their relative frequency in percentages. Those elements whose evaluation of $\gamma(V)$ is equal to or higher than 2 are categorized within the range "Strongly Agree (Str.Ag.)", while scores equal to or higher than 1 are considered "Agreement (Ag.)". Those that fall within the interval of -1 to 1 are classified as "Indeterminate (Ind.) 5", those between -2 and -1 as "Disagree (Disag.)", and those that score lower than -2 are assigned to the group of "Strongly Disagree (Str.Disag.)". Table 2 shows the absolute frequencies obtained from this analysis, as well as their percentages.

Variables	Dimensions		Str.Disag	Disag.	Ind.	Ag.	Str.Ag.
Influence of using the case of study method	Effectiveness of case studies in career learning	Af	0	1	29	38	13
		%	0.0%	1.2%	35.8%	46.9%	16.0%
	Ease of learning with this method	Af	0	3	16	41	21
		%	0.0%	3.7%	19.8%	50.6%	25.9%
	Perception of preparation for professional practice with this method	Af	0	2	11	52	16
		%	0.0%	2.5%	13.6%	64.2%	19.8%
	Development of critical thinking and problem-solving	Af	0	0	10	50	21
		%	0.0%	0.0%	12.3%	61.7%	25.9%
	Level of preference for the case study method over other methods	Af	0	0	17	3. 4	30
		%	0.0%	0.0%	21.0%	42.0%	37.0%
Student satisfaction level	Satisfaction with the Teaching Methodology	Af	0	2	13	54	12
		%	0.0%	2.5%	16.0%	66.7%	14.8%
	Satisfaction with Class Interaction	Af	1	3	51	24	2
		%	1.2%	3.7%	63.0%	29.6%	2.5%
	Satisfaction with the Learning Obtained	Af	0	1	17	33	30
		%	0.0%	1.2%	21.0%	40.7%	37.0%

Table 2: Absolute frequencies (Af) and percentages of the results obtained
Source: own elaboration.

The acquisition of this data facilitates the generation of Refined Plithogenic Probabilities (RPP) and Neutrosophic Plithogenic Probabilities (NPP) for all evaluated dimensions, as detailed in Table 3. This statistical derivation process allows for a deeper and more nuanced interpretation of the data sets, using advanced theoretical frameworks to reflect the complexity and multidimensionality of the evaluated perceptions. The application of RPP and NPP offers an innovative approach to analyzing and understanding variations and trends within the responses, thus allowing for a more holistic and detailed view of the underlying dynamics in the studied dimensions.

Variables	RPP	NPP

Effectiveness of case studies in career learning	(0.0; 1.23; 35.8; 46.91; 16.05)	(62.96; 35.80; 1.23)
Ease of learning with this method	(0.0; 3.7; 19.75; 50.62; 25.93)	(76.55; 19.75; 3.70)
Perception of preparation for professional practice with this method	(0.0; 2.47; 13.58; 64.2; 19.75)	(83.95; 13.58; 2.47)
Development of critical thinking and problem-solving	(0.0; 0.0; 12.35; 61.73; 25.93)	(87.66; 12.35; 0.00)
Level of preference for the case study method over other methods	(0.0; 0.0; 20.99; 41.98; 37.04)	(79.02; 20.99; 0.00)
Satisfaction with the Teaching Methodology	(0.0; 2.47; 16.05; 66.67; 14.81)	(81.48; 16.05; 2.47)
Satisfaction with Class Interaction	(1.23; 3.7; 62.96; 29.63; 2.47)	(32.10; 62.96; 4.93)
Satisfaction with the Learning Obtained	(0.0; 1.23; 20.99; 40.74; 37.04)	(77.78; 20.99; 1.23)

Table 3: Refined Plithogenic Probabilities (RPP) and Neutrosophic Plithogenic Probabilities (NPP)
Source: own elaboration.

Following the analysis and interpretation of the obtained data, it was inferred that there was a positive inclination toward the case of study method as a pedagogical tool among the surveyed students. The values of the Refined Plithogenic Probabilities indicated a generally favorable perception across various key dimensions. On one hand, the effectiveness of case studies in learning the profession received high scores in the 'Agree' and 'Strongly Agree' categories, suggesting that students found this particular teaching method especially beneficial for their academic formation. At the same time, the dimension of Ease of Learning with this method showed a significant percentage of students responding favorably, reflecting that the case method was perceived as accessible and understandable. Regarding the third variable, the high percentages in positive categories highlight that students felt well-prepared for their future profession. This finding is particularly significant as it suggests that the case method aligns effectively with the practical demands of a legal career. Moreover, satisfaction with the teaching methodology was overwhelmingly positive, with the majority of students expressing a high degree of satisfaction. This stands as an endorsement of the implementation of the case method by the Law faculty, supporting its continuity and possible expansion in the curriculum.

However, the data showed a distribution with a tendency towards neutral and indeterminate responses in terms of satisfaction with class interaction. This suggests that, although the methodology was generally well-received, there might be aspects in class that require review and improvement.

The Neutrosophic Plithogenic Probabilities (NPP) provided an additional layer of analysis, allowing for the incorporation of indeterminacies and degrees of uncertainty in the evaluation of student perceptions. The PNP values emphasized that despite the positive acceptance of the case method, areas of ambiguity remain that could benefit from a more detailed qualitative analysis to identify and address specific concerns or doubts of the students.

5. CONCLUSION

During the study, a quantitative and descriptive assessment of the influence of the case method on the legal education of senior students at Universidad de los Andes was undertaken. Surveys were designed using indeterminate Likert scales to capture the perceptions and satisfaction levels of students concerning this pedagogical tool. The data collection instruments focused on measuring specific aspects such as the effectiveness of learning, the ease of the method, the perception of professional preparation, the development of critical thinking skills, and the preference for this method over others.

Data from 81 participants were processed through the construction of TRINS matrices, allowing the responses to be translated into a format that reflected varying degrees of acceptance. The main conclusions derived from the study indicate a generally positive reception of the case method, with high percentages of students reporting elevated satisfaction levels and a positive valuation of the method's effectiveness in their academic and professional formation. However, a significant proportion of neutral responses was noted, suggesting areas of uncertainty and potential for methodological improvements. The plithogenic analysis offered a deeper perspective on student perceptions, highlighting the complexity of responses and the presence of indeterminacies that could be explored in future research to optimize educational practice in Law.

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EVALUATION OF WOMEN'S PROTECTION AND THEIR RIGHT TO LEGAL SECURITY AGAINST STREET HARASSMENT USING DELPHI AND NAHP+NSC METHODS.

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ABSTRACT.

This study addresses a major issue in the field of human rights and urban security: the assessment of legal protection measures and their effectiveness in ensuring women's safety from street harassment. Despite regulatory advances in various jurisdictions, a significant gap persists between legal provisions and their practical implementation, leaving many women in vulnerable situations. This paper identifies and analyses the limitations of traditional approaches to measuring the effectiveness of these policies, proposing an innovative methodology based on the combination of the Delphi and NAHP+NSC methods to address them. The results obtained highlight that the combined method allows for a more accurate assessment of the legal, social, and cultural factors that influence the effectiveness of policies against street harassment. Furthermore, they reveal that the lack of coordination between legal institutions and the ambivalent perception of the public regarding these measures are key obstacles. This study contributes to the field by providing a novel methodological approach that not only offers a more comprehensive analysis but also provides practical recommendations for designing more effective and contextualized policies. In a global context where women's rights continue to be a priority, this work is positioned as a significant step towards legal security.

KEYWORDS: Delphi and NAHP+NSC methods, street harassment, legal security, Ecuadorian law, gender-based violence, neutrosophic number.

MSC: 91D10, 93A30, 62P25, 03B52, 68T37

RESUMEN

El presente estudio aborda un problema de gran trascendencia en el ámbito de los derechos humanos y la seguridad urbana: la evaluación de las medidas de protección jurídica y su efectividad para garantizar la seguridad de las mujeres frente al acoso callejero. A pesar de los avances normativos en diversas jurisdicciones, persiste una brecha significativa entre las disposiciones legales y su implementación práctica, dejando a muchas mujeres en situaciones de vulnerabilidad. Este trabajo identifica y analiza las limitaciones de los enfoques tradicionales para medir la efectividad de estas políticas, proponiendo una metodología innovadora basada en la combinación de los métodos Delphi y NAHP+NSC para abordarlos. Los resultados obtenidos destacan que el método combinado permite una evaluación más precisa de los factores jurídicos, sociales y culturales que influyen en la efectividad de las políticas contra el acoso callejero. Además, revelan que la falta de coordinación entre las instituciones jurídicas y la percepción ambivalente del público respecto a estas medidas son obstáculos clave. Este estudio contribuye al campo proporcionando un enfoque metodológico novedoso que no solo ofrece un análisis más integral, sino que también aporta recomendaciones prácticas para diseñar políticas más efectivas y contextualizadas. En un contexto global donde los derechos de las mujeres continúan siendo una prioridad, este trabajo se posiciona como un avance significativo hacia la seguridad jurídica.

PALABRAS CLAVE: métodos Delphi y NAHP+NSC, acoso callejero, seguridad jurídica, derecho ecuatoriano, violencia machista, número neutrosófico.

1. INTRODUCTION.

Street harassment is a persistent problem affecting women from diverse cultures and socioeconomic backgrounds. This phenomenon not only violates the right to freedom of movement but also represents a serious obstacle to ensuring women's legal security in public spaces. According to the United Nations, street harassment is one of the most common forms of gender-based violence, with negative impacts on the mental, physical, and emotional health of victims [27]. Despite regulatory advances in different countries, the implementation of effective policies to address this problem remains a significant challenge. This study focuses on assessing women's legal protection against street harassment through an innovative methodological approach that integrates the Delphi and NAHP+NSC methods. Historically, initiatives against street harassment have evolved slowly, reflecting changes in social perceptions about gender-based violence and human rights. From the first feminist mobilizations in the 20th century to the adoption of specific legislation in recent decades, the recognition of street harassment as a form of violence has been a gradual process [20]. At the international level, instruments such as the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) have established legal frameworks, but the translation of these principles into practical and sustainable ones still faces obstacles [10]. This historical and normative context raises the need for more effective and contextualized approaches to address the problem.

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The central problem that this study addresses is the gap between legal provisions designed to protect women and their practical implementation in everyday reality. Why, despite having specific laws, do many women continue to be victims of street harassment without obtaining the necessary legal protection? This question highlights the need to evaluate not only the effectiveness of existing policies but also to analyze the factors that limit their applicability. In this context, the Delphi and NAHP+NSC methods offer a powerful tool to explore these issues, allowing us to capture the complexity of interactions between social actors, legal institutions, and cultural contexts. In the existing harassment literature, several studies have analyzed street harassment from legal, psychological, and sociological perspectives. However, few have adopted an interdisciplinary approach that considers both public perception and technical evaluation of policies [5]. Furthermore, previous research has mostly focused on specific cases, without offering a replicable methodological framework for varied contexts. This theoretical and methodological gap underlines the need for a more comprehensive analysis, which not only diagnoses the problem but also proposes practical and viable solutions [9]. The present study adopts a mixed approach, combining the Delphi and NAHP+NSC methods to analyze the effectiveness of legal protection measures against street harassment. The Delphi method allows collecting and synthesizing expert opinions through structured iterations, while NAHP+NSC facilitates the prioritization of complex factors through hierarchical and neutrosophic analysis. This approach allows for addressing both the uncertainty inherent in the problem and the multidimensionality of the data, providing a more robust and detailed analysis [1].

The main findings of this study reveal that deficiencies in the implementation of laws, lack of social awareness, and limited coordination between institutions are key factors limiting the effectiveness of policies against street harassment. At the same time, they highlight the importance of strengthening monitoring mechanisms and community participation in the design of these measures. These results offer a novel perspective on how to improve women's legal security and more effectively address street harassment in urban contexts. This work therefore contributes to the field of legal and social research by providing a replicable methodological framework for evaluating public policies in a highly complex context. Furthermore, its findings have significant practical implications, from improving legal strategies to promoting community initiatives that reinforce women's safety in public spaces [7]. In summary, the main objective of this study is to evaluate the legal protection of women against street harassment through the combined use of the Delphi and NAHP+NSC methods. It is expected that the results will not only contribute to theoretical progress in the field but will also offer concrete tools for the design of more effective and sustainable public policies.

2. PRELIMINARY

2.1. Street harassment: a deep-rooted social problem.

Street harassment, defined as any form of unwanted interaction that creates discomfort, intimidation, or fear in public spaces, is one of the most common manifestations of gender-based violence. This phenomenon has been perpetuated over time, finding support in cultural and social norms that grant disproportionate power to certain groups over others. Although it may seem trivial to some sectors of the population, the emotional, psychological, and social consequences for victims are profound and long-lasting. Despite efforts in different regions to raise awareness and combat this problem, street harassment remains normalized in many cultures. Acts such as inappropriate comments, leering, or even non-consensual physical contact are often minimized under the excuse of being "compliments" or "gestures of interest." This trivialization perpetuates a cycle of impunity that hinders the implementation of effective public policies to prevent this type of violence [26]. Victims, mostly women and girls, face multiple barriers when trying to report these incidents. These include the fear of not being believed, re-victimization in judicial spaces, and the absence of specific legal mechanisms to address street harassment. According to recent studies, only a low percentage of those affected believe that reporting will have any real impact on their safety [7]. This reflects a widespread distrust in institutions and an urgent need for structural reforms. One of the least addressed dimensions of street harassment is its impact on the perception of public spaces. For many women, walking down certain streets or using public transport at specific times becomes an anxiety-laden experience. This phenomenon not only limits mobility but also restricts equal access to the city. In other words, street harassment contributes to the construction of exclusionary urban environments that reinforce gender inequalities [8].

In legislative terms, progress has been uneven. While some countries have implemented specific laws that penalize street harassment, in others the problem is only just beginning to be recognized as a form of violence. These differences reflect both cultural particularities and the levels of development of social movements in each context. However, even in places with robust regulatory frameworks, the challenge lies in ensuring their effective application and in promoting education that dismantles cultural prejudices. Feminist movements and social campaigns have played a crucial role in the fight against street harassment. Through initiatives such as #MeToo or #NiUnaMenos, millions of women have been able to share their experiences, giving rise to a collective narrative that demands structural changes. These movements have not only allowed the problem to be made visible but have also generated pressure on institutions to take concrete measures. Street harassment cannot be analyzed in isolation, but rather as part of a system of interconnected violence that disproportionately affects women. Lack of equity in access to rights, wage differences, and media representations that perpetuate gender stereotypes are factors that fuel this problem. Addressing street harassment therefore requires a comprehensive approach that goes beyond punitive solutions and promotes sustained cultural changes. Public policies must focus not only on sanctioning but also on prevention. This involves implementing educational programs that promote respect and equality from an early age, as well as awareness campaigns aimed at

denormalizing these behaviors. Likewise, guaranteeing safe spaces and accessible mechanisms for reporting should be a priority for local and national governments. Finally, the role of civil society is irreplaceable. The fight against street harassment cannot fall solely on institutions; citizens must take an active role in building inclusive public spaces free of violence. This involves questioning their own and others' attitudes and participating in collective initiatives that promote equality and respect. In conclusion, street harassment represents a complex challenge that requires a multidimensional response. Although progress in terms of legislation and awareness is impressive, there is still a long way to go to eradicate this form of violence. Only through collaboration between institutions, social movements and citizens will it be possible to guarantee the right of all people to enjoy public spaces free from violence and intimidation.

2.2. Methodological Framework and Theoretical Foundations

Delphi Method: It is a forecasting and decision-making technique based on collecting and analyzing expert opinions on a specific topic through a series of iterative questionnaires. After each round of questionnaires, the information collected is compiled and summarized, providing feedback to all participants. They are then asked to reconsider and, if they wish, revise their previous responses based on the feedback received. This process is repeated over several rounds until a consensus is reached or a stabilization and convergence in responses is observed. The goal is to reach a consensus or common understanding on the topic in question, taking advantage of the collective knowledge and experience of experts. Statistical control employs means and standard deviations to summarize expert opinions and observe the convergence of opinions throughout the rounds.

Analytical Hierarchy Process (AHP): is a theory-oriented to decision makers that is used to identify the best alternative according to the resources assigned. It is a scientific tool to address aspects that are difficult to quantify but that sometimes require a unit of measurement. The hierarchical structuring of homogeneous problems and subproblems allows measurements of both subjective and objective factors based on numerical, verbal or graphical estimates, providing great flexibility and allowing a wide variety of applications in different fields. Its approach is entirely systemic, without ever losing sight of the general objective and the interdependencies existing between sets of factors, criteria, and alternatives; therefore, this method is focused on the global system, and the solution it presents is for the totality, not for the particularity.

Neutrosophic concepts

Definition 1 : ([21]) The neutrosophic set N is characterized by three membership functions, which are the truth membership function T_A, the indeterminacy membership function $I A$, and the falsity membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x)$, $I_A(x)$, and $F_A(x) \subseteq]^{-}0,1^{+}[$, $y^{-}0 \leq inf\, T_A(x) + inf\, I_A(x) + inf\, F_A(x) \leq sup\, T_A(x) + sup\, I_A(x) + sup\, F_A(x) \leq 3^{+}$. Note that by the definition, $T_A(x)$, $I_A(x)$, and $F_A(x)$ are standard or nonstandard real subsets of $]^{-}0, 1^{+}[$ and therefore $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of $[0, 1]$.

Definition 2 : The single-valued neutrosophic set (SVNS) N over U is $A = \{\langle x; TA(x), IA(x), FA(x)\rangle : x \in U\}$, where $TA: U \to [0, 1]$, $IA: U \to [0, 1]$, and $FA: U \to [0, 1]$, $0 \leq TA(x) + IA(x) + FA(x) \leq 3$. The Single-Value 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 in $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined in [21].

Definition 4 : Given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$two $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$single-valued trapezoidal neutrosophic numbers and λany nonzero number on the real line. Then the operations are defined in [21].

Definitions 3 and 4 refer to the *single-valued triangular neutrosophic number* 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.

Definition	Neutrosophic Triangular Scale
Equally influential	$\tilde{1} = \langle (1,1,1); 0.50, 0.50, 0.50 \rangle$
Slightly influential	$\tilde{3} = \langle (2,3,4); 0.30, 0.75, 0.70 \rangle$
Strongly influential	$\tilde{5} = \langle (4,5,6); 0.80, 0.15, 0.20 \rangle$
Very influential	$\tilde{7} = \langle (6,7,8); 0.90, 0.10, 0.10 \rangle$
Absolutely influential	$\tilde{9} = \langle (9,9,9); 1.00, 1.00, 1.00 \rangle$
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 scale translated into a neutrosophic triangular scale. Source [21]

For verification of the analytic hierarchy process model in a neutrosophic environment (N-AHP) methodology, see [21].

Neutrosophic social choice theory

This subsection summarizes the main concepts of the Neutrosophic Social Choice theory developed in [24].

Definition 5: ([24]) Let *a = (Ta, Ia , Fa)* be a single-valued neutrosophic number with truth value *Ta*, indeterminacy value *Ia* and falsity value *Fa*. *The distributed indeterminacy form* (DIF) of *a* is defined as $_{DIF}$ = *(Ta − TaIa , 0, Fa − FaIa).*

The DIF aims to distribute the result of the indeterminacy regarding truth and falsehood, thus, it measures the degree of affectation of truth and falsehood, when the indeterminacy varies.

Definition 6: ([24]) Let *a be* a single-valued neutrosophic number. A *precision function H* of *a* is:

$$H(a) = \frac{(1+T_a-I_a\,(1-T_a)-F_a(1-I_a)}{2} \quad (1)$$

Where for all *a*, $H_{(a)} \in [0, 1]$. H is an order relation representing an information accuracy score of *a*. If $H(a_1) = H(a_2)$, then $a_1 = a_2$, i.e., they have the same information, whereas, if $H(a_1) < H(a_2)$, then a_2 is greater than a_1. Let *S = {s1, s2, . . . , sn }* will be a set of alternatives and m will be a set of individuals. Each individual declares his preferences over *S*, which are represented by an individual neutrosophic preference relation *Rk* , where *N* R_k*: S × S → [0,1] × [0,1] × [0,1]* and matrix $R_k = [r_{ij}^k]$, *j= 1,2,3,..., n; k = 1,2,3, . . . , m*, where r_{ij}^k= N $R_k(r_i^k, r_j^k)$.

$$R_k = \begin{matrix} (0.5, 0.5, 0.5) \\ r_{21}^k \\ r_{n1}^k \end{matrix}$$

The function H (called *the neutrosophic index* or *neutrosophic hesitation function*) maps each a_{ij} neutrosophic value to a number in [0, 1]. Thus, the *neutrosophic index* or *neutrosophic hesitation function* is defined as follows:

$$H(a) = \frac{(1+T(a_{ij})-I\,(a_{ij})\,(1-T(a_{ij}))-F(a_{ij})(1-I(a_{ij}))}{2} \quad (2)$$

The matrix $R_k^H = [H(r_{ij}^k)]$, *i, j = 1,2,3, . . , n; k = 1, 2, 3, ..., m.* R_k^H is *quasi-reciprocal* if and only if $H(r_{ij}^k) \leq 1 - H(r_{ij}^k)$. If R_k^H it is not quasi-reciprocal, we call a_k an *irrational individual* . Other definitions are stated in [27].

Definition 7: ([24]) *:* $S_i \in W$ is called *a consensus winner* if and only if $\forall S_j \neq S_i$: $r_{ij} > 0.5$, where $r_{ij} \in H_\pi$.

Definition 8: ([24]) The *average social aggregation function C* is defined to calculate the order of S_i in the group to the extent that individuals are not against the option yes, using the following equation:

$$C(S_i) = \frac{1}{m-1}\sum_{i \neq j} r_{ij} \quad (3)$$

where *i, j = 1, 2, ⋯, m*.

3. MATERIAL AND METHODS

In this section, the proposed NAHP+NSC method for the analysis of the object of study in the article is presented.

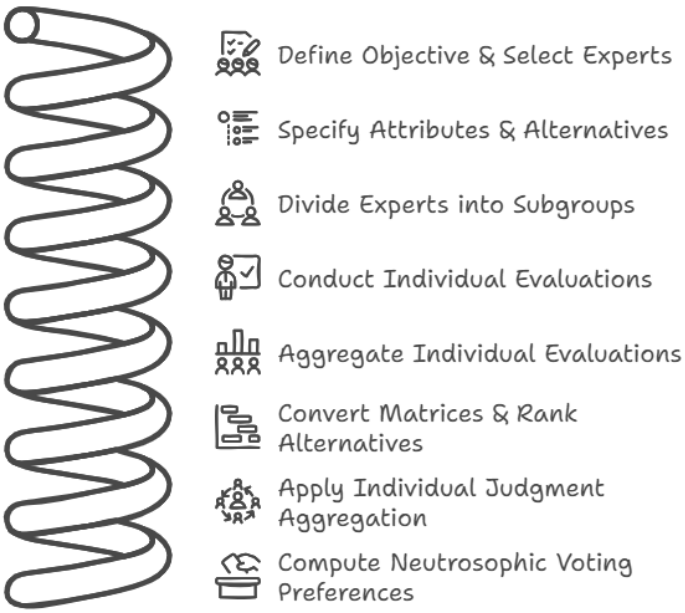

Figure 1. Evaluation and Alternative Prioritization Process

The first element is defined for any neutrosophic triangular number ã as the triangular precision function of $\tilde{a}$ = *‹(a1, a2, a3); αa, βa, γa ›,* which is the *TA* function defined as follows:

$$TA(\tilde{a}) = A(\langle(a1, a2, a3);\ DIF((\alpha a, \beta a, \gamma a))\rangle) \quad (4)$$

This is the degree of accuracy of Equation 6 calculated for the DIF of the neutrosophic number contained in ã. The inclusion of DIF follows the idea of [24], where the accuracy function H calculates the effect of Indeterminacy on truth and falsity.

It can be seen that the reciprocal or quasi-reciprocal properties in NSC theory are similar to the reciprocal property in NAHP, from the perspective of the rationality of the decision maker.

The method analyzed consists of the following steps:

1. The objective of the problem is established and the group of experts is selected accordingly. Attributes, sub-attributes and alternatives are then specified.
2. The expert group is divided into M interest subgroups, denoted by $IG = \{IG_1, IG_2, \cdots, IG_M\}$. In the analysis, it is assumed that the members of each subgroup form a homogeneous decision group.
3. Each expert evaluates his/her own NAHP. However, for each IG_i, the equivalent matrices of the subgroup members are aggregated using formula 5.

Given $\{\tilde{A}i1, Vi2, \ldots, \tilde{A}\ in_i\}$ as a set of n_i SVTNN representing the evaluation of each member of the i- th subgroup, where $\tilde{A}_{ij} = \langle (a_{ij}, a_{ij}, a_{ij}); \alpha\ \tilde{a}_{ij}, \beta\ \tilde{a}_{ij}, \gamma\ \tilde{a}_{ij} \rangle\ (i = 1, 2, \ldots, M)(j = 1, 2, \ldots, n_i)$, the weighted average of the SVTNN is calculated using the following equation:

$$\tilde{A}_i = \sum_{j=1}^{n_i} \lambda_{ij}\, \tilde{A}_{ij} \tag{5}$$

where λ_{ij} is the weight of $\tilde{A}_{ij}$, $\lambda_{ij} \in [0,1]$ and $\sum_{j=1}^{n_i} \lambda_{ij} = 1$.

Note that λ_{ij} measures the relative importance of the *j-th* expert in the *i-th* subgroup.

Each $\tilde{A}_i$ represents the pairwise comparison matrix of the NAHP method in IGi , to aggregate the pairwise comparison matrices of criteria, subcriteria and alternatives.

$\tilde{A}_i$ is converted to $\tilde{A}_i$ using Equation 13. This process can be repeated until the results are consistent according to the Consistency Index of the NAHP method. According to this method, a preference vector of the alternatives is obtained.

Individual Judgment Aggregation (IJA) is used here because there is interest in measuring the subgroup judgments as a synergistic unit.

Let us denote $O_i = \{O_{i1}, O_{i2}, \ldots, O_{iN}\}$ the position of each alternative as evaluated by the members of the i-th subgroup. For example, $O1 = \{1, 1, 3, 5, 4\}$ means that according to the first subgroup, alternatives 1 and 2 are equally preferred, while the next alternatives are the third, fifth, and fourth alternatives, in that order.

4. For each $S_{il}\ (l = 1, 2, \ldots, N)$, the V_{il} following triplet $P_{il} = card\ (k \neq l: S_{il}$ is formed = (, where P_{il}, I_{il}, N_{il}) is strictly preferable to S_{ik}}), I_{il}= card ({$k \neq l: S_{il}$ is equally preferred to S_{ik}}), and N_{il}= card ({k ≠ $l: s_{ik}$ is strictly preferred over s_{il}}).

It is observed that, $V_{il} \in [0, N-1] \times [0, N-1] \times [0, N-1]$ and $P_{il} + I_{il} + N_{il} = N - 1$.

Finally, $V_l \in [0, 1] \times [0, 1] \times [0, 1]$, $V_l = (P_l, I_l, N_l)$, sums the lth alternative preference for all subgroups,

where $P_l = \frac{\sum_{i=1}^{M} P_{il}}{M(N-1)}, I_l = \frac{\sum_{i=1}^{M} I_{il}}{M(N-1)}$, and $N_l = \frac{\sum_{i=1}^{M} N_{il}}{M(N-1)}$.

Please note that this is a neutrosophic voting method.

5. $H(V_l)\ (l = 1,2, \cdots, N)$ and the alternatives are ranked by preference, such that $V\,l_1$ is preferable to $V\,l_2$ if and only if $H(V\,l_1) > H(V\,l_2)$. When $H(V\,l_1) = H(V\,l_2)$, it is said that "$V\,l_1$ is equally preferable to $V\,l_2$". (See [24])

4. RESULTS AND DISCUSSION

This study used Delphi and NAHP+NSC methods to assess women's protection and legal security against street harassment. Through an iterative process of data collection and analysis, the most influential factors in the effectiveness of public policies aimed at combating this problem were identified and prioritized. The factors considered were:

1. Effective legal implementation.
2. Social awareness.
3. Access to reporting mechanisms.
4. Policy monitoring and evaluation.
5. Institutional training and capacity building.
6. Inter-institutional coordination.

Delphi Analysis

In the first phase, a panel of 15 experts, including lawyers, sociologists and activists, assessed the relevance of these factors using the Delphi method. After three rounds, consensus was reached on the results, as presented in Table 2.

Factors	Round 1	Round 2	Round 3	Final Average	Standard deviation
Effective legal implementation	8	9	9	8.67	0.47
Social awareness	7	8	8	7.67	0.47

Factors	Round 1	Round 2	Round 3	Final Average	Standard deviation
Access to reporting mechanisms	9	9	10	9.33	0.47
Policy monitoring and evaluation	8	8	8	8.00	0.00
Institutional training and capacity building	7	8	8	7.67	0.47
Inter-institutional coordination	6	7	8	7.00	0.82

Table 2: Delphi results

The **most relevant factor** according to the consensus was access to complaint mechanisms, with a final average of 9.33, followed by effective legal implementation. The lowest standard deviation was 0.00, indicating full agreement among experts regarding policy monitoring and evaluation.

Pairwise Comparison Matrix (N-AHP)

The next step involved applying the NAHP+NSC method to calculate the relative importance of each factor. A pairwise comparison matrix based on the triangular neutrosophic scale was used, as shown in **Table 3**.

Factors	Legal Implementation	Social Awareness	Access to Complaint	Political Monitoring	Institutional Training	Interinstitutional Coordination
Effective legal implementation	⟨ 1,1,1 ⟩	⟨ 7,7,8 ⟩	⟨ 8,9,9 ⟩	⟨ 6,6,7 ⟩	⟨ 5,6,6 ⟩	⟨ 4,5,6 ⟩
Social awareness	⟨ 1/7,1/7,1/6 ⟩	⟨ 1,1,1 ⟩	⟨ 6,7,8 ⟩	⟨ 5,6,6 ⟩	⟨ 4,4,5 ⟩	⟨ 3,4,5 ⟩
Access to reporting mechanisms	⟨ 1/8,1/9,1/9 ⟩	⟨ 1/6,1/7,1/8 ⟩	⟨ 1,1,1 ⟩	⟨ 7,8,9 ⟩	⟨ 6,7,7 ⟩	⟨ 5,6,6 ⟩
Policy monitoring	⟨ 1/6,1/7,1/7 ⟩	⟨ 1/5,1/6,1/6 ⟩	⟨ 1/7,1/8,1/9 ⟩	⟨ 1,1,1 ⟩	⟨ 5,6,7 ⟩	⟨ 4,5,5 ⟩
Institutional training	⟨ 1/5,1/6,1/6 ⟩	⟨ 1/4,1/4,1/5 ⟩	⟨ 1/6,1/7,1/7 ⟩	⟨ 1/5,1/6,1/7 ⟩	⟨ 1,1,1 ⟩	⟨ 6,7,7 ⟩
Inter-institutional coordination	⟨ 1/4,1/5,1/6 ⟩	⟨ 1/3,1/4,1/5 ⟩	⟨ 1/5,1/6,1/6 ⟩	⟨ 1/4,1/5,1/5 ⟩	⟨ 1/6,1/7,1/7 ⟩	⟨ 1,1,1 ⟩

Table 3: Pairwise Comparison Matrix

NAHP+NSC Analysis Results

The calculation of the weight vector was performed using the proposed neutrosophic formula. The final results are presented in Figure **2 ,** where the relative weights of the factors are illustrated.

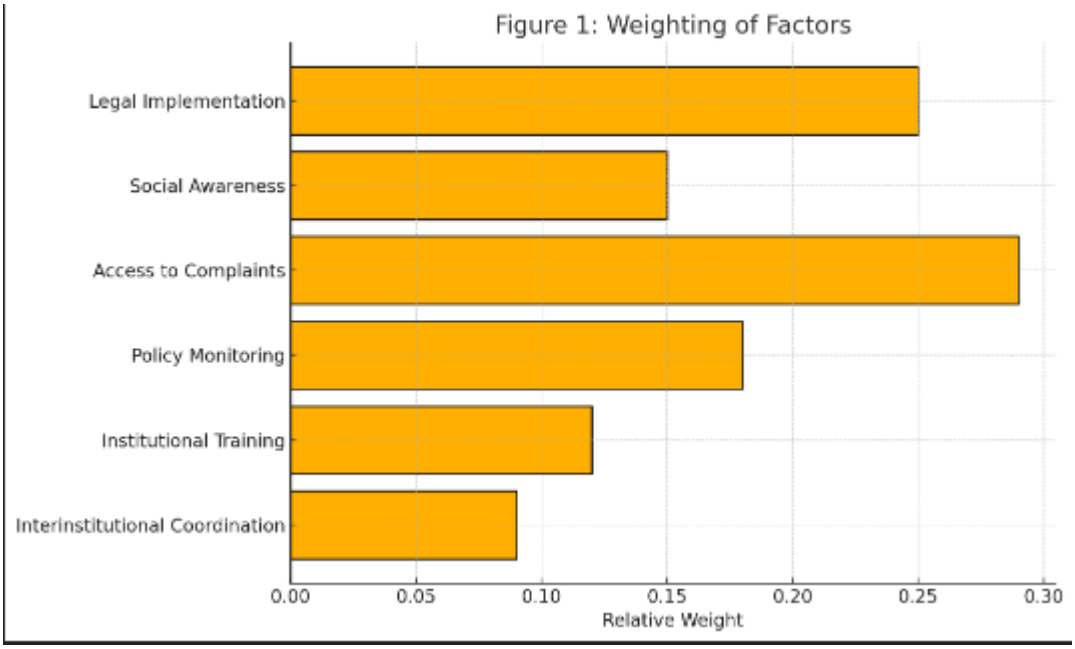

Figure 2: Factor Weightings

The factors with the highest relative weight were access to reporting mechanisms (0.29) and effective legal implementation (0.25), while inter-institutional coordination received the lowest weight (0.09). These results reflect that priority actions should focus on strengthening victims' capacity to access effective reporting systems and ensuring that existing laws are rigorously enforced.

The results of the Delphi method indicated a clear consensus on the importance of access to reporting mechanisms and legal implementation. However, the NAHP+NSC method revealed that, although social awareness and institutional training are relevant, their impact is minor compared to other factors. This suggests that policies should prioritize the improvement of reporting platforms and the training of justice system operators.
On the other hand, the low weighting assigned to inter-institutional coordination reflects a perception that current initiatives lack adequate integration between the responsible entities. This could indicate the need to establish more effective joint working mechanisms to avoid duplication of efforts and ensure a coherent response to street harassment.
In conclusion, the combined Delphi and NAHP+NSC assessment provided a comprehensive framework for prioritizing actions to protect women from street harassment. These methodologies, by considering indeterminacy and complex interactions between factors, offer a solid basis for designing more effective and contextually adapted public policies.

5. CONCLUSION.

The results of this study underline that women's legal protection against street harassment depends on a complex interaction between key factors such as access to reporting mechanisms, effective implementation of laws and social awareness. Although each element has its own weight, the analysis suggests that their integration is crucial to building more effective and reality-adapted public policies. This not only reinforces the idea that street harassment is a systemic problem, but also highlights that solutions must be equally multidimensional. In practical terms, the implications of these findings are significant. Strengthening reporting channels, training responsible institutions and ensuring compliance with regulations are not isolated actions, but parts of a larger mechanism. These have the potential to transform public spaces into safer places, promoting an environment where women can exercise their rights without fear or restrictions. Among the most relevant contributions of the study, the incorporation of methodologies such as Delphi and NAHP+NSC to the analysis of complex social problems stands out. These approaches allowed us to unravel relationships that might be missed by more traditional methods while offering a robust framework for prioritizing interventions. Furthermore, the use of neutrosophic scales added dimension to the analysis, effectively handling the uncertainty inherent in the data. However, it is important to acknowledge limitations. The subjectivity in the experts' responses and the focus on a specific context raise questions about the generalizability of the results. Furthermore, factors such as cultural barriers or economic constraints were not considered in depth, suggesting that much remains to be explored. These limitations do not invalidate the findings but invite careful interpretation. Looking ahead, it would be interesting to extend the analysis to different cultural and geographical contexts to better understand how the dynamics of street harassment vary according to circumstances. Furthermore, the integration of complementary approaches, such as fuzzy analysis or artificial intelligence systems, could further enrich the study. Finally, exploring how the identified factors interact over time could offer deeper insights into the sustainability of the implemented policies.

In conclusion, although this work does not aim to offer definitive solutions, it lays the groundwork for addressing the problem of street harassment from a more comprehensive perspective. The results not only broaden our understanding of the issue, but also offer a roadmap for future efforts seeking to ensure safety and respect in public spaces.

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EXAMINATION OF THE OBSTACLES IN ACHIEVING EFFECTIVE INTERNAL CONTROL WITHIN THE CONTEXT OF STATE GOVERNANCE: PERSPECTIVES THROUGH NEUTROSOPHIC SOFT SETS.

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ABSTRACT:
Under constitutional precepts and provisions, state governance stands as the main driver of policies aimed at addressing social needs. However, there is a lack of effective supervision of companies involved in illicit activities, which represents a threat to citizens. The purpose of this research is to examine the aspects related to state governance and its impact on the implementation of internal control, using soft neutrosophic sets, with special attention to the criminal liability of legal entities in Ecuador. The methodology used follows a qualitative approach based on a bibliographic review that includes the compilation of academic articles and the consultation of the Constitution of the Republic of Ecuador. The results reveal that in the context of governance in Ecuador, business management, both public and private, continues to be affected by acts of corruption due to the lack of clarity on the rights of citizens regarding the criminal responsibility of companies that commit crimes against society. In this sense, it is suggested that the strengthening of internal state control may be essential to guarantee the protection of citizen rights and satisfy social demands.
KEYWORDS: Soft Neutrosophic Sets, Internal Control, Governance, Constitutional Regulations

MSC: 03E72, 91B32, 90B50, 93B85, 62P25

RESUMEN
En virtud de preceptos y disposiciones constitucionales, la gobernanza estatal se erige como el principal impulsor de políticas dirigidas a atender necesidades sociales. Sin embargo, existe una falta de supervisión efectiva sobre las empresas involucradas en actividades ilícitas, lo que representa una amenaza para los ciudadanos. El propósito de esta investigación es examinar los aspectos relacionados con la gobernanza estatal y su impacto en la implementación del control interno, utilizando conjuntos neutrosóficos suaves, prestando especial atención a la responsabilidad penal de las personas jurídicas en Ecuador. La metodología empleada sigue un enfoque cualitativo basado en una revisión bibliográfica que incluye la recopilación de artículos académicos y la consulta de la Constitución de la República del Ecuador. Los resultados revelan que, en el contexto de la gobernanza en Ecuador, la gestión empresarial, tanto pública como privada, sigue viéndose afectada por actos de corrupción debido a la falta de claridad en los derechos de los ciudadanos respecto a la responsabilidad penal de las empresas que cometen delitos contra la sociedad. En este sentido, se sugiere que el fortalecimiento del control interno estatal puede ser esencial para garantizar la protección de los derechos ciudadanos y satisfacer las demandas sociales.
PALABRAS CLAVE: Conjuntos Neutrosóficos Suaves, Control Interno, Gobernanza, Regulaciones Constitucionales.

1. INTRODUCTION

In the intricate framework of state governance, achieving effective internal control stands as a pivotal challenge. Internal control mechanisms, designed to ensure transparency, accountability, and operational efficiency, are integral to the success of governance systems. Yet, the complexities and uncertainties inherent in state-level administration often render these mechanisms ineffective. This study delves into the examination of obstacles impeding effective internal control within state governance, adopting a novel perspective through neutrosophic soft sets. The neutrosophic approach, which excels in managing indeterminacy and ambiguity, provides a unique lens to address the multifaceted nature of these obstacles [1]. Historically, the evolution of internal control systems has been shaped by global efforts to combat corruption, enhance public sector efficiency, and ensure adherence to legal and ethical standards. The foundation of modern internal control frameworks can be traced back to the Committee of Sponsoring Organizations of the Treadway Commission (COSO), which established a structured approach for evaluating control effectiveness [2]. However, despite decades of refinement, state governance continues to grapple with issues such as resource misallocation, lack of transparency, and systemic inefficiencies. Recent technological advancements, including data analytics and artificial intelligence, have introduced new tools for control monitoring, yet their implementation often falls short due to institutional resistance and a lack of contextual adaptability [3,14].

The central problem addressed in this study revolves around the persistent obstacles that undermine the effectiveness of internal control systems in state governance. These obstacles range from structural limitations, such as bureaucratic inefficiencies, to subjective factors like conflicting stakeholder interests and inadequate

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accountability frameworks. The critical question emerges: how can state governance systems overcome these barriers to achieve effective internal control, particularly in contexts characterized by high levels of uncertainty and dynamic complexity? Addressing this question requires a multidimensional approach that integrates technical, organizational, and perceptual perspectives. The neutrosophic soft set framework offers a promising solution by enabling the analysis of these challenges through a model that accounts for indeterminacy, vagueness, and subjective variability [4]. Unlike traditional methods, this approach allows for the integration of conflicting or incomplete data, providing a more comprehensive understanding of the barriers to effective internal control. By leveraging the flexibility of neutrosophic logic, this study aims to bridge the gap between theoretical models and practical applications, fostering a deeper comprehension of the underlying dynamics within governance systems [7,15,17].
The objectives of this study are twofold. First, it seeks to identify and prioritize the primary obstacles that hinder effective internal control in state governance. Second, it aims to propose a methodological framework, grounded in neutrosophic soft sets, that facilitates the development of adaptive strategies for overcoming these challenges. The outcomes of this research are expected to contribute to the enhancement of governance systems by providing actionable insights and innovative tools for decision-making in uncertain environments [8,16,18]. The subsequent sections of this article outline the theoretical foundation of the study, including an in-depth exploration of neutrosophic soft set theory and its applicability to governance contexts. The methodological approach is then detailed, followed by a presentation of the findings and their implications. By situating the research within the broader discourse on governance and control, this study aims to advance the field and inspire further investigations into the application of neutrosophic models in complex organizational systems.
This research underscores the urgency of addressing the systemic challenges faced by state governance in achieving effective internal control. By examining these obstacles through the lens of neutrosophic soft sets, the study not only offers a novel analytical framework but also seeks to foster a paradigm shift in how internal control systems are designed, evaluated, and implemented. Ultimately, the findings aim to empower policymakers and administrators to navigate the complexities of governance with greater clarity and confidence.

2. PRELIMINARIES

2.1. Neutrosophic soft sets:

Consider a set *U*, representing a universe of scenarios, and *H* as a non-empty subset of *U*, with *P(H)* as the power set of *H*. Let *A* be an attribute, and *A* be a set of values for this attribute.
A function $F: A \rightarrow P(H)$ is termed an indeterminate or smooth function if any of the following conditions are met:
- Set *A* exhibits some degree of uncertainty.
- *P(H)* exhibits some degree of uncertainty.
- There exists at least one attribute value *v* in *A* such that $F(v) = indetermintae$ *(unclear, uncertain, or not unique).*
- Any combination of two or all three of the above situations occurs.

The neutrosophic soft set is defined as a soft set in which maybe (indeterminate, etc.)., is approximately equivalent to $F(yes)$, $F((not)$, $F(true)$, or $F(false)$, associated with a triad of values (α, β, γ), where (α,β,γ) belongs to the interval($[0,1]^3$ representing the degrees of truth, indeterminacy, and falsity, respectively **[10,16]**.
Based on the preceding analysis, we can characterize the following neutrosophic trinomial:
- Classical Function: This function is fully defined (internally defined) for all elements in its domain, or

$$(T, I, F) = (1, 0, 0).$$

- Neutrofunction (or neutrosophic function): It is a function that is partially defined (with a degree of truth *T*), partially indeterminate (with a degree of indeterminacy *I*), and partially externally defined (with a degree of falsity *F*) in its domain, where *(T,I,F)* belongs to the set *{(1,0,0), (0,0,1)}*.

In the mathematical context described in Definition 1, we are discussing a scenario where *U* represents a universe of potential scenarios, while *H* is a specific subset within that universe. This subset *H* is non-empty and has an associated power set *P(H)*. Additionally, we consider an attribute with its respective set of values, denoted as *A*. In this context, the pair *(F,H))*, where $F: A \rightarrow P(H)$, is referred to as a classical soft set over *H* .
Definition 1: If the function $F: A \rightarrow P(H)$, where for each $x \in A$, *f(x)* in *P(H)* and *f(x)* is true and unique, it is called a Determined Function (classical).

3. METHODOLOGY

This chapter outlines the methodologies employed to collect, analyze, and validate the information necessary to address the research problem from a rigorously scientific and mathematical perspective. The selection and engagement of experts, the implementation of structured interviews, and systematic observation form the foundational pillars of a robust analytical framework. Each method has been meticulously designed to ensure the objectivity and validity of the results, integrating mathematical reasoning with critical analysis. Through these approaches, the chapter aims to unravel the complexities of the phenomenon under study and generate conclusions that not only answer the posed questions but also contribute to advancing knowledge within the field of mathematical sciences.

Figure 1. Methodological Framework

Interviews: A series of meticulously planned interviews will be conducted with carefully selected experts, who will play a pivotal role in the exploration of the subject matter. These interviews, designed with precision and rigor, aim to uncover the complexities of the problem under investigation. The ultimate goal is to derive well-founded conclusions that serve as a guiding framework for advancing knowledge in this field.

Observation: Observation will serve as a systematic and discerning tool, allowing for the detailed exploration of the environment in which the phenomenon under study unfolds. Acting as an objective observer, this method seeks to identify patterns, behaviors, and nuances within the context, unveiling critical insights that contribute to a deeper mathematical understanding of the dynamics at play.

Selection of Experts: The selection process for experts will be carried out with meticulous care, employing a rigorous methodology to identify individuals with substantial expertise. A competency validation survey will be utilized, where candidates self-assess their proficiency using a structured scale that transcends numerical evaluation. A mathematical model will then be applied to quantify each expert's rating factor, ensuring an objective balance between subjective expertise and quantitative rigor. This process will ensure that the selected panel of experts represents the highest standards of knowledge and competence [9].

The "Expert Competence Coefficient" is calculated based on the opinion expressed by the expert on his level of knowledge about the research problem, as well as the sources that allow him to support the established criterion. The coefficient is obtained by applying the following formula:

$$K = \frac{(Kc + Ka)}{2} \quad (1)$$

K_c is the «Knowledge coefficient» or information that the expert has about the topic or problem raised. It is calculated from the assessment made by the expert himself on a scale of 0 to 10, multiplied by 0.1.

K_a is the so-called «Argumentation coefficient» or foundation of the experts' criteria. This coefficient is obtained from the assignment of a series of scores to the different sources of argumentation that the expert has been able to put forward.

With the final values obtained, the experts are classified into three large groups:

- If K is greater than 0.8, greater than or less than or equal to 1, then there is a high influence from all sources.
- If K is greater than or equal to 0.7, greater than or less than or equal to 0.8, then there is a medium

influence from all sources.

- If *K* is greater than or equal to 0.5, greater than or less than or equal to 0.7, then there is a low influence from all sources.

It is also important to mention that experts with values lower than 0.8 are not considered in the study and are therefore rejected.

2.3 Neutrosophic Soft Set-Based Evaluation Model for Legal Statements

The model based on Neutrosophic Soft Sets begins with a collection of statements or propositions denoted by $A = \{a, a_2, \dots, a_k\}$, which are to be assessed by specialists from the selected expert group $E = \{e_1, e_2, \dots, e_l\}$. Each statement's veracity and relevance in the legal context are evaluated using a binary parameter set *C={Yes, No}*, where "Yes" signifies the expert's affirmation of the statement's positivity, while "No" indicates the opposite stance.

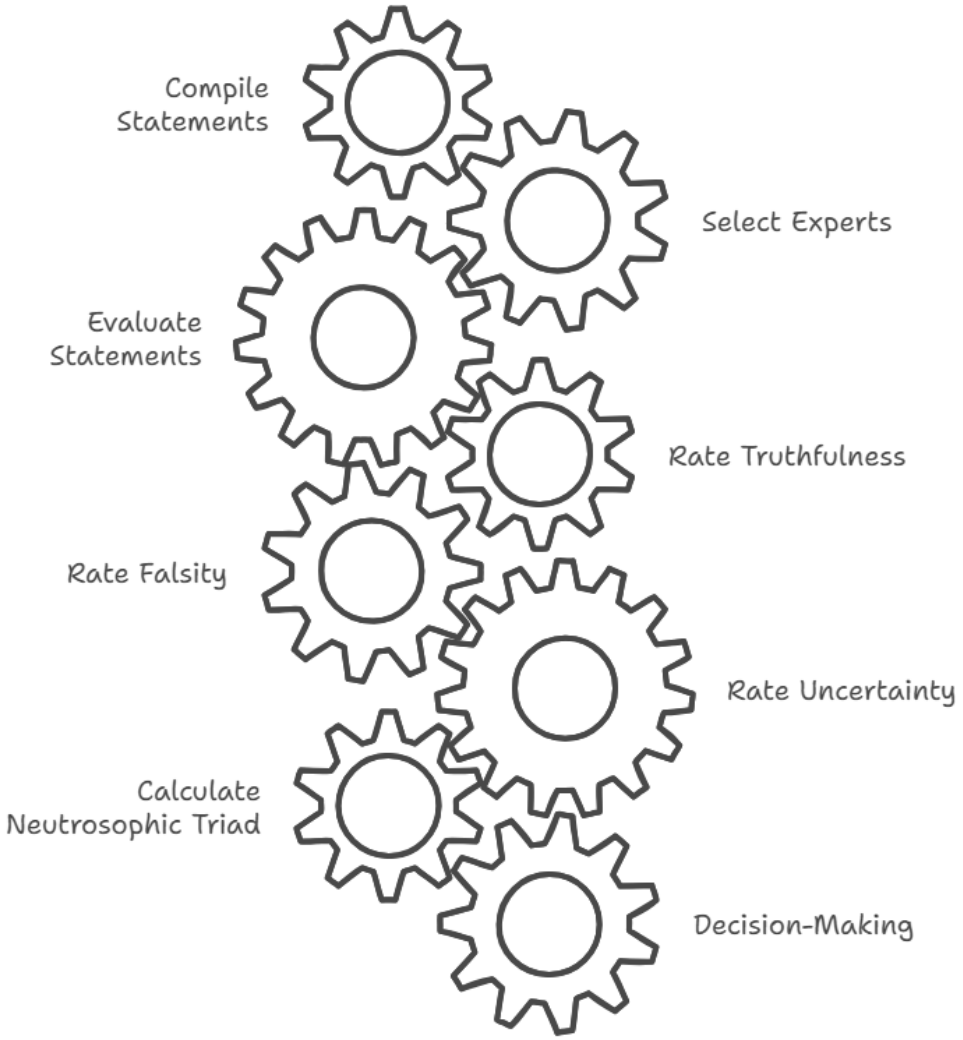

Figure 2. Neutrosophic Soft Set Framework for Decision-Making

The outlined procedure unfolds as follows:

1. Compile a set of statements to evaluate their veracity and relevance in the legal context, denoted by *A*, $A = \{a, a_2, \dots, a_k\}$.
2. Convene a group of experts or specialists to provide their assessments regarding the veracity or relevance of the described statements. This group is denoted as $E = \{e_1, e_2, \dots, e_l\}$
3. Each expert e_j is tasked with delivering their judgment on the statement a_i concerning its veracity and relevance.

4. Experts are requested to rate the truthfulness and relevance of the statement on a scale from 0 to 100, denoted as α_{ij}

5. Experts are also asked to evaluate the falsity and irrelevance of the statement on the same scale, represented as γ_{ij}.

6. Furthermore, experts are requested to assess the uncertainty and irrelevance of the situation on the same scale, denoted as β_{ij}.

7. Consequently, a triad $R_{ij}=\langle\alpha_{ij}/100, \beta_{ij}/100,\gamma_{ij}/100\rangle$ is obtained. This triad represents the truth values between 0 and 1, evaluating the degrees of truthfulness, indeterminacy, and falsity, respectively, of the relevance of the *i*-th statement according to the *j*-th expert.

The Soft Set is then formed by $F: A\rightarrow P(H)$, where $P(H)=\{Yes,No\}$. Two sets of results, $F(Yes)$ and $F(No)$ are considered for tests or evidence. The final results are derived from two different sets, $G(Yes)$ and $G(No)$, [11].

The evaluation process ensures an objective ranking of statements based on their relevance and truthfulness, providing a robust foundation for informed decision-making.

4. RESULTS

To discern the primary obstacles concerning adherence to the legal framework underpinning governance policies in Ecuador and its ramifications on internal control, a series of interviews were conducted involving 25 governmental officials. To ensure the integrity of the research, a panel of 5 subject matter experts was assembled, each boasting *K* scores ranging from 8 to 10, indicative of their extensive expertise and experience in the field.

A structured interview guide was devised, encompassing a spectrum of assertions about internal control, for appraisal by the experts on a 0 to 100 scale concerning veracity, indeterminacy, and falsehood. These assertions delved into matters such as the imperative of securing internal control within entities and corporations, the adequacy of extant legal frameworks, the obligations incumbent upon officials and executives, and the allotment of resources to auditing systems.

The experts denoted as e_1,e_2,e_3,e_4, and e_5, tendered their assessments regarding these assertions, affording a more expansive and nuanced perspective on the perceptions of these issues by seasoned practitioners. This iterative process was conducted on two separate occasions to scrutinize the authenticity and significance of the assertions at distinct junctures.

Table 1 presents the derived values, offering a solid basis for understanding the challenges and areas requiring improvement in internal control within the framework of state governance in Ecuador. By integrating insights from government officials and experts, a holistic perspective of the situation is achieved, aiding in the identification of potential corrective measures or enhancements to current policies and practices.

Expert/Assertion	c_1	c_2	c_3	c_4
b_1	⟨64,15,21⟩	⟨89,10,10⟩	⟨35,10,60⟩	⟨56,10,13⟩
b_2	⟨76,10,20⟩	⟨58,20,30⟩	⟨38,0,52⟩	⟨72,8,20⟩
b_3	⟨85,0,20⟩	⟨79,0,20⟩	⟨36,0,45⟩	⟨82,12,15⟩
b_4	⟨68,4,18⟩	⟨72,15,18⟩	⟨45,0,58⟩	⟨54,15,22⟩
b_5	⟨81,8,16⟩	⟨90,12,26⟩	⟨42,0,36⟩	⟨57,9,18⟩

Table 1: Displays the outcome of the assessment regarding the accuracy of the statement as determined by the experts chosen for the study.

The previous results are divided by 100 to bring them to a scale [0, 1] which is more common in neutrosophic theories.

Expert/Assertion	c_1	c_2	c_3	c_4
b_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⟩
b_2	⟨0.76,0.1,0.2⟩	⟨0.58,0.2,0.3⟩	⟨0.38,0,0.52⟩	⟨0.72,0.08,0.2⟩
b_3	⟨0.85,0,0.2⟩	⟨0.79,0,0.2⟩	⟨0.36,0,0.45⟩	⟨0.82,0.12,0.15
b_4	⟨0.68,0.04,0.18⟩	⟨0.72,0.2,0.18⟩	⟨0.45,0,0.58⟩	⟨0.54,0.15,0.22
b_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: Outcome of experts' assessment regarding the truthfulness of the statement, presented using neutrosophic numbers**.**

Upon examining the results derived from the assessment, it is evident that statements a_1, a_2, and a_4 have been affirmed as true by the consulted experts, whereas statement a_3 has not received such validation. Consequently, it is imperative to analyze the significance of the three statements recognized as true by the experts. This decision is supported by the comparison of the average relevance values, where $V_1=0.8$ is greater than F_1 and $V_2=0.7$ is greater than F_2, and $V_4=0.7$ is greater than F_4. Thus, it is deduced that statements a_1, a_2, and a_4 hold considerable importance based on their truth values and relevance assessments, indicating their pertinence in the legal context

under scrutiny.

1. The need to guarantee internal control to entities and companies: This statement has the support of experts, which indicates a clear and urgent demand to establish effective internal control mechanisms in organizations. This aspect is crucial to ensure transparency, efficiency and responsibility in the management of resources and processes, both in the public and private spheres. The relevance of this statement lies in its strategic importance in strengthening internal control as a fundamental part of the governance and proper functioning of entities.
2. The insufficiency of the legal framework to guarantee internal control, following international standards and the national Constitution: The confirmation of this statement highlights the need to review and improve the legal framework related to internal control in the country. The lack of alignment with international standards and constitutional principles indicates a deficiency that could compromise the effectiveness of internal control. Therefore, the relevance of this statement lies in the urgency of carrying out legal reforms to strengthen the regulatory framework and guarantee internal control following international standards.
3. The limited allocation of resources to audit systems to strengthen internal control: This statement highlights the need to allocate adequate resources to audit systems as a measure to strengthen internal control. Although experts have validated this statement, its relevance lies in pointing out the importance of guaranteeing sufficient resources to carry out effective audits that allow detection and address possible deficiencies in internal control systems. This is essential to mitigate risks and promote integrity and efficiency in organizational management.

In summary, the three statements validated as true by the experts are relevant due to their impact on the effectiveness and integrity of internal control systems in the context of state governance in Ecuador. Its detailed analysis provides a solid basis to identify areas of improvement and take necessary corrective measures to strengthen internal control and promote efficient and transparent management in the country's organizations.

Expert	a_1	a_2	a_4
e_1	⟨86,11,12⟩	⟨51,13,15⟩	⟨67,24,16⟩
e_2	⟨71,10,20⟩	⟨63,11,17⟩	⟨78,10,19⟩
e_3	⟨86,6,18⟩	⟨68,15,10⟩	⟨73,3,15⟩
e_4	⟨84,10,16⟩	⟨51,12,16⟩	⟨73,21,21⟩

Table 3: Result of the evaluation of the relevance of the statements according to the experts**.**

The previous results are divided by 100 to bring them to a scale [0, 1] which is more common in neutrosophic theories.

Expert/Assertion	a_1	a_2	a_4
e_1	⟨0.86,0.11,0.12⟩	⟨0.51,0.13,0.15⟩	⟨0.67,0.24,0,
e_2	⟨0.71,0.10,0.20⟩	⟨0.63,0.11,0.17⟩	⟨0.78,0.10,0.
e_3	⟨0.86,0.06,0.18⟩	⟨0.68,0.15,0.10⟩	⟨0.73,0.03,0.
e_4	⟨0.84,0.10,0.16⟩	⟨0.51,0.12,0.16⟩	⟨0.73,0.23,0.
e_5	⟨0.73,0.09,0.20⟩	⟨0.52,0.21,0.23⟩	⟨0.66,0.15,0.

Table 4: Result of experts' assessments

After careful examination and analysis, it is apparent that statements a_1, a_2, and a_3 have been deemed relevant by the experts, supported by their respective truth values. Specifically, statement a_1 holds a truth value of 0.72, indicating its significant relevance in the context under consideration. Similarly, statement a_2 is also regarded as relevant, with a truth value of 0.55, slightly less compared to a_1. Furthermore, statement a_3, despite its lower truth value of 0.16, still carries relevance according to the experts' evaluations. It is imperative to consider these findings seriously, as they provide valuable insights into the importance and pertinence of each statement within the legal framework being examined. Therefore, these conclusions serve as a foundation for prioritizing actions and addressing key issues to ensure effective governance and compliance with legal standards. The determination has been reached following a comparative assessment of the mean relevance scores attributed to each statement. Specifically, it is noted that the mean relevance scores for the statements are as follows: $V_1=0.80$, $V_2=0.69$, and $V_3=0.76$, while the mean irrelevance values are $F_1=0.45$, $F_2=0.49$, and $F_3=0.41$.

From the findings, it can be inferred that all statements are significant, given that the mean relevance scores surpass the mean irrelevance values for each. Moreover, a hierarchy of statement relevance is delineated as follows: a_1 emerges as the most pertinent statement, succeeded by a_3, trailed by a_2.

Henceforth, the hierarchy of statement relevance is delineated as follows:

1. a_1: Ensuring internal control within entities and companies is imperative.
2. a_3: Inadequate allocation of resources to audit systems to fortify internal control.
3. a_2: Shortcomings in the legal framework supporting internal control, aligned with international declarations and domestic legislation.

This sequence is predicated on the extent of significance attributed to each statement by the consulted experts, furnishing a lucid roadmap to pinpoint the paramount areas and priorities concerning adherence to the legal framework and fortification of internal control within the governmental domain of Ecuador.

4. CONCLUSIONS

The findings of this study highlight the critical relevance of internal control mechanisms in the field of governance, as underlined by expert evaluations of statements A1, A2, and A3. Declaration A1, with a truth value of 0.72, emerged as the most significant, reflecting the urgent need to prioritize internal control within entities and companies. Declaration A3, although slightly lower with 0.16, indicates the insufficient allocation of resources to audit systems, a challenge that weakens the effectiveness of internal control. For its part, Declaration A2, with a truth value of 0.55, highlights the deficiencies in the legal framework that hinder its alignment with international standards and national legislation. Together, these results provide a structured basis to understand and address the main challenges in governance. From a practical perspective, the study emphasizes actionable ideas that can directly impact the design and implementation of solid internal control systems. When delineating a clear hierarchy of priorities, those responsible for decision-making have a road map to address critical areas such as the allocation of resources and the strengthening of the legal framework. These findings offer a valuable guide to improve compliance, transparency, and government efficiency in contexts such as the public sector of Ecuador. An outstanding contribution of this study is the application of neutral methods to evaluate the relevance of governance challenges under conditions of uncertainty and complexity. This innovative approach integrates mathematical rigor with practical utility, advancing theoretical understanding while offering pragmatic tools for prioritization. The hierarchy established through expert evaluations is a testimony of the usefulness of neutrosophical analysis to address multifaceted problems within the legal and administrative landscape.

However, it is important to recognize certain limitations inherent to the study. The dependence on expert judgments introduces a degree of subjectivity that, although mitigated by methodological rigor, can affect the generalization of the results. In addition, the specific nature of the context of the findings - based on the framework of governance of Ecuador - can limit its applicability to other environments without additional adaptations. Future research should focus on expanding these findings by incorporating alternative methodologies, such as Fuzzy analysis or automatic learning algorithms, to validate and improve the ideas presented. In addition, extending the study to a broader range of contexts and populations could improve the generalization of the results. It is necessary to explore more thoroughly the interaction between the legal frameworks, the allocation of resources and the internal control systems to build a more comprehensive understanding of the governance challenges. In summary, this study not only sheds light on urgent issues related to internal control mechanisms but also provides a methodological scheme to address them. By connecting mathematical theory with government practice, research offers a significant contribution to continuous efforts to strengthen institutional frameworks and guarantee compliance with legal standards.

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INDETERMINATE LIKERT SCALES FOR THE PERCEPTION OF RIGHTS VIOLATION IN PREGNANT ADOLESCENTS IN TULCÁN

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ABSTRACT
The current study explored the perception of rights violations among pregnant adolescents in the city of Tulcán, using a mixed-methodological approach that integrates quantitative and qualitative analysis through the use of indeterminate Likert scales and probabilities via Plithogenic Logic. Through cluster analysis, different groups within the sample were identified, based on their perceptions of knowledge about legal regulations and rights, experiences of vulnerability, and the care received in educational, health, and public institutions. The results revealed a high perception of rights violation, especially concerning medical care and educational support, though with significant variability influenced by various factors. The need for focused and differentiated public policies that address both the symptoms and the underlying causes of vulnerability is underscored, aiming toward the creation of a safer and more empowering environment for pregnant adolescents in Tulcán.

KEYWORDS: vulnerability; pregnant adolescents; perception; indeterminate Likert scale, Plithogenic Statistics

MSC: 62P25, 91D10, 68T37, 93A30, 03B70

RESUMEN
El presente estudio exploró la percepción de violaciones de derechos entre adolescentes embarazadas en la ciudad de Tulcán, utilizando un enfoque metodológico mixto que integra análisis cuantitativo y cualitativo a través del uso de escalas Likert indeterminadas y probabilidades mediante Lógica Plitogénica. A través de un análisis de conglomerados, se identificaron diferentes grupos dentro de la muestra, basados en sus percepciones sobre el conocimiento de las regulaciones legales y derechos, experiencias de vulnerabilidad y la atención recibida en instituciones educativas, de salud y públicas. Los resultados revelaron una alta percepción de violación de derechos, especialmente en lo que respecta a la atención médica y el apoyo educativo, aunque con una variabilidad significativa influenciada por diversos factores. Se subraya la necesidad de políticas públicas focalizadas y diferenciadas que aborden tanto los síntomas como las causas subyacentes de la vulnerabilidad, con el objetivo de crear un entorno más seguro y empoderador para las adolescentes embarazadas en Tulcán.

PALABRAS CLAVE: vulnerabilidad, adolescentes embarazadas, percepción, escala Likert indeterminada, Estadísticas Plitogénicas.

1. INTRODUCTION

Adolescence represents a critical phase of transition and growth, marked by profound changes that shape an individual's journey toward adulthood. Deriving its etymology from the Latin term adolecere, which signifies growth, advancement, and overcoming dependency, adolescence embodies a period of evolution and dynamic transformation. It is during this phase that the foundations for holistic development, spanning physical, emotional, cognitive, and social dimensions, are established. However, adolescent pregnancy can disrupt this natural trajectory, leading to adverse consequences such as diminished autonomy, interruption of educational pursuits, social disengagement, and delayed personal growth [1]. As a public health concern, adolescent pregnancy has far-reaching implications, precipitating conflicts within families, schools, and communities, while also significantly impacting the national economy and altering adolescents' life trajectories. The intersection of sociocultural, historical, religious, political, and economic factors has often hindered the development of comprehensive sexual education within familial, communal, and educational contexts [9]. Poor communication between adolescents, parents, educators, and society further exacerbates this issue, impeding the cultural shift required to address gaps in sexual education. Effective education must encompass not only biological aspects but also the socio-emotional, psychological, and cognitive dimensions, fostering informed decision-making and awareness of the rights and responsibilities associated with sexuality [7].

In Latin America and the Caribbean, approximately 140 million young people form a significant demographic, among whom unplanned adolescent pregnancies contribute to heightened vulnerability. The region reports the world's second-highest adolescent pregnancy rate, with nearly 18% of births attributed to mothers under 20 years

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of age. In Ecuador, over 41,000 girls and adolescents aged 10 to 19 become mothers annually [11]. Data from Ecuador's National Institute of Statistics and Censuses reveals that 15.7% of births are from adolescent mothers, with 0.7% involving girls under 14 years old. This positions Ecuador as the country with the second-highest incidence of adolescent pregnancies in the region. The situation remains critical, as evidenced by the Ministry of Health's data: by May 2022, 2,184 girls aged 10 to 14 had attended their first prenatal check-up, compared to 4,196 cases reported for the entire year of 2021. Additionally, in the first five months of 2022, 32,146 adolescents aged 15 to 19 sought prenatal care, compared to 61,090 throughout 2021. Seven provinces show the highest prevalence of adolescent pregnancy: three in the Amazon region (Morona Santiago, Pastaza, and Zamora Chinchipe) and four in the coastal region (Los Ríos, Manabí, Esmeraldas, and Guayas) [6].

In addressing adolescent reproductive health, a multidisciplinary and intersectional approach is essential. Such a framework must transcend unilateral interventions, encompassing individual, familial, community, and societal levels to safeguard reproductive health while upholding fundamental human rights [5]. However, the inherent indeterminacies in evaluating and managing reproductive health and rights in adolescents, particularly in Tulcán, introduce additional complexities. These uncertainties stem from variations in individual circumstances and broader socioeconomic, cultural, and political dynamics that influence adolescent health and well-being [2]. To navigate this complexity, the integration of plithogenic logic into the analysis of perceptions among pregnant adolescents in Tulcán offers a novel and promising approach. This framework enables a more nuanced understanding of the challenges faced by this vulnerable group [4]. Complementing this methodology, the use of indeterminate Likert scales facilitates the collection of granular data on adolescents' attitudes and perceptions. By allowing respondents to express varying degrees of agreement or disagreement with statements about their rights and well-being, this method highlights the effectiveness of current policies and identifies areas needing improvement [10].

In Tulcán, where sociocultural, economic, and legal factors intersect to create a challenging environment for pregnant adolescents, the application of these tools is particularly relevant. Analyzing perceptions through Likert scales not only reveals the extent of rights violations but also provides empirical evidence for refining policies and designing targeted interventions. Furthermore, this participatory approach empowers adolescents, acknowledging their agency and valuing their input in the development of inclusive and respectful solutions. This study, therefore, aims to evaluate the perception of rights violations experienced by pregnant adolescents in Tulcán. By employing an analytical framework grounded in plithogenic logic and enriched with indeterminate Likert scales, this research seeks to deepen the understanding of the health and rights of this population. The findings aspire to contribute to the formulation of effective interventions that ensure the protection and promotion of adolescent well-being in this context.

2. REFINED NEUTROSOPHIC SET AND PLITHOGENY

Introduced by Smarandache in 2005, Neutrosophic delves into the study of a concept, phenomenon, or entity "A" in terms of its opposition "Anti-A" and its non-existence "Non-A," as well as the state of being neither "A" nor "Anti-A," termed as "Neut-A". [8]

Consider X to represent a metric space, with each element within X indicated by x. Within this framework, a Single-Valued Neutrosophic Set (SVNS) A in space X is delineated by three membership functions: the truth function $T_{A(x)}$, the indeterminacy function $I_{A(x)}$, and the falsity function $F_{A(x)}$. For any given point x in X, the values of $T_{A(x)}$, $I_{A(x)}$, and $F_{A(x)}$ lie within the interval $[0, 1]$, satisfying the condition

$$0 \leq T_{A(x)} + I_{A(x)} + F_{A(x)} \leq 3.$$

Hence, the SVNS A is represented as $A = \{ x, T_{A(x)}, I_{A(x)}, F_{A(x)} | x \in X \}$, [9]. Building upon smarandache's refined neutrosophic logic, the following is obtained: [10]

Definition 1: The notion of truth T is subdivided into various subclasses $T_1, T_2, \dots, T_p$; similarly, indeterminacy I is categorized into $I_1, I_2, \dots, I_r$, and falsity F into $F_1, F_2, \dots, F_s$. Here, p, r, s where p, r, and s, are positive integers with the sum $p + r + s = n$.

The concept of Triple Refined Indeterminate Neutrosophic Sets (TRINS) further segments the idea of indeterminacy into three distinct membership categories, thus enhancing specificity and relevance for applications such as personality assessment using the Likert scale. In contrast, a Double-Valued Neutrosophic Set (DVNS) divides indeterminacy into two parts.

Definition 2: A TRINS A in X, as previously outlined, is identified by five membership functions, namely positive $P_{A(x)}$, indeterminate $I_{A(x)}$, negative $N_{A(x)}$, positively indeterminate $IP_{A(x)}$, and negatively indeterminate $IN_{A(x)}$, each accompanied by a respective weight $w_m \in [0, 5]$.

For every $x \in X$, we say: $P_A(x), IP_A(x), I_A(x), IN_A(x), N_A(x) \in [0, 1]$ with their weighted forms:

$$w_m P(P_A(x)), w_m IP(IP_A(x)), w_m I(I_A(x)), w_m IN(IN_A(x)), w_m N(N_A(x)) \in [0, 5],$$

adhering to the restriction

$$0 \leq P_A(x) + IP_A(x) + I_A(x) + IN_A(x) + N_A(x) \leq 5.$$

Thus, the TRINS *A* is denoted as

$$A = \{\ x, P_A(x), IP_A(x), I_A(x), IN_A(x), N_A(x) | x \in X\}$$

Concentrating on a pair of TRINS, identified as *A* and *B* within the confines of the metric space *X*, a third TRINS, *C*, is obtained through the intersection of *A* and *B*, which is mathematically denoted as $C = A \cap B$. The determination of *C*'s membership regarding truth, inclination towards truth, absolute indeterminacy, inclination towards falsity, and outright falsity, is accomplished through specific functional equations derived from the membership levels of *A* and *B:*

$$T_{C(x)} = \min\left(T_{A(x)}, T_{B(x)}\right)$$
$$IT_{C(x)} = \min\left(IT_{A(x)}, IT_{B(x)}\right)$$
$$I_{C(x)} = \min\left(I_{A(x)}, I_{B(x)}\right)$$
$$IF_{C(x)} = min\left(IF_{A(x)}, IF_{B(x)}\right)$$
$$F_{C(x)} = \max\left(F_{A(x)}, F_{B(x)}\right)$$

In the sphere of advanced Neutrosophic, there is a critical concept regarding the computation of an overarching weight, which aggregates the effects of all membership functions in the TRINS structure. This concept is crucial for the evaluation of the relevance and impact of each membership function on the neutrosophic set's aggregate value. The overall weighting for a TRINS A, represented as w_A, is mathematically articulated as:

$$w_A = \left(\sum_{i=1}^{n} w^T T_{A(x_i)} + w^I IT_{A(x_i)} + w\, I_{A(x_i)} + w^F IF_{A(x_i)} + w^N F_{A(x_i)}\right) \quad (1)$$

In this equation, $w^T, w^I, w, w^F, y\, w^N$ are the weights associated with the truth, inclination towards truth, indeterminacy, inclination towards falsity, and falsity membership functions, respectively. These weights play a critical role in assessing the significance of each membership function in the neutrosophic set and their overall contribution to the neutrosophic analysis's expansive theoretical framework.

F. Smarandache's Plithogeny concept delves into the origins, development, evolution, and refinement of novel entities through the dynamic integration of existing, potentially disparate elements, which may be antagonistic, neutral, or synergistic. This idea advocates for the fusion and integration of conceptual frameworks and insights across a wide range of disciplines, promoting an interdisciplinary confluence of knowledge from diverse fields such as the soft sciences, hard sciences, arts, and theoretical aspects of literature. [11]

Within this paradigm, a Plithogenic Set is defined as a significant set P, located within a specified domain $U(P \subseteq U)$ distinguished by one or more unique attributes $A_1, A_2, \ldots, A_m, m \geq 1$. Each attribute in this set has the potential to assume values across *S*, a vast spectrum of possible states. This spectrum is characterized by its variability, encompassing finite or infinite, discrete or continuous, and open or closed ranges. [12]

This framework emphasizes the flexibility and dynamic nature of plithogenic sets, reflecting the breadth and complexity of the knowledge and phenomena they aim to represent. By integrating a diverse array of attributes and their possible values into a cohesive set, the plithogenic methodology enables a deeper, more holistic investigation of entities. It encourages an interdisciplinary exchange and inquiry that breaks down traditional barriers between various academic disciplines.

In the context of each element $x \in P$, its characteristics span the complete array of possible attribute values within the set $V = \{v_1, v_2, \cdots, v_n\}$. The degree of membership $d(x, v)$ for an element *x* in set *P* is determined in relation to a particular criterion, and can be described as fuzzy, intuitionistic fuzzy, neutrosophic, among others.[13]

This signifies that for every element *x* in the set *P*, there exists a function $d: P \times V \rightarrow \wp([0,1]^z)$, where $\wp([0,1]^z)$ denotes the power set of $[0,1]^z$. The variable, *z* signifies the level of belonging, with $z = 1$ denoting a fuzzy membership level, $z = 2$ indicating an intuitionistic fuzzy membership level, and, and $z = 3$ representing a neutrosophic membership level.

In this advanced exposition of plithogenic sets, a nuanced mechanism is introduced for evaluating the degree of contradiction between different attribute values within such sets. If we denote *V* as the value set with its cardinality being greater than or equal to 1, we define a specialized function $c: V \times V \rightarrow [0,1]^2$. This function, known as the attribute value contradiction degree function, is designed to quantify the level of contradiction between any pair of attribute values v_a, v_b. The functionality of this measure is governed by a set of fundamental principles: [14,17]

$c(v_a, v_a) = 0$, which asserts that there is no contradiction in an attribute value when compared with itself, encapsulating the principle of non-contradiction.

$c(v_a, v_b) = c(v_b, v_a)$, which underscores the symmetry in the degree of contradiction between any two distinct attribute values, suggesting that the contradiction is mutual and unaffected by the order of comparison.

The notation *c* is specifically chosen to highlight that this function operates within the realm of fuzzy logic, implying a continuum of contradiction degrees rather than binary or discrete states. Additionally, variations of this function, such as $c_{IF}: V \times V \rightarrow [0,1]^2$, are conceptualized to accommodate the framework of neutrosophic logic, thereby acknowledging and quantifying varying levels of certainty or contradiction inherent in the attribute values.

Within the framework of a Plithogenic Set, described as (*P*, *a*, *V*, *d*, *c*), the element of the primary set *P*, an attribute set *A*, a set of values *V*, a membership function *m*, and a contradiction degree function *d*, conceptually

corresponding to *c*. The function of contradiction is very important for the assessment and quantification of contradiction levels among attributes, especially when considering a primary attribute as critically more significant than others. This framework thus equips a sophisticated mechanism for dissecting and comprehending the intricate relationships of attributes within a Plithogenic Set, providing deep insights into the contradiction and congruence dynamics among set elements. [15,18]

On another note, (*U*, *a*, *V*, *d*, *c*) is identified as Plithogenic Probability, where *E* signifies the event space. Plithogenic Probability is articulated as the probability of an event happening, influenced by all associated random variables, which might follow classical, *T*, *I*, *F*-neutrosophic, *I*-neutrosophic, *T*, *F*-intuitionistic fuzzy, *T*, *N*, *F*-picture fuzzy, *T*, *N*, *F*-spherical fuzzy, or other fuzzy extensions distribution functions. Hence, Plithogenic Probability broadens the traditional scope of multivariate probability. [16]

Additionally, Plithogenic Statistics expands upon traditional multivariate statistics by embracing the principles of Plithogenic Probability. This approach is distinguished by its capability to dissect and scrutinize probabilities into intricate components of truth, ambiguity, and falsity. Specifically, it segments probabilities into detailed fractions such as $1, 2, \dots, T_1, T_2, \dots . T_p$, for truths; $1, 2, \dots, I_1, I_2, \dots . I_q$ for indeterminacies; and $1, 2, \dots, F_1, F_2, \dots . F_r$, for falsities. This detailed segmentation ensures that within truths, indeterminacies, or falsities, at least one category contains more than a singular element, showing the complex nature of probabilities within a plithogenic context.

This nuanced subdivision enables Plithogenic Statistics to more accurately reflect the complexity of phenomena in the real world compared to classical approaches. By recognizing and quantifying varying degrees of truth, the potential for indeterminacy, and the possibilities of falsity in any scenario, Plithogenic Statistics offers a layered, multidimensional perspective on statistical analysis. This methodological enhancement allows for a deeper and more nuanced interpretation of statistical data, accounting for the inherent uncertainties and complexities present, thereby offering a more sophisticated and detailed understanding of statistical findings. [6,19]

3. METHODOLOGY

This study is framed within a mixed research design, which incorporates both quantitative and qualitative methodologies to assess the perception of rights violations among pregnant adolescents in the city of Tulcán. This approach allows for a comprehensive analysis of the participants' subjective and objective perceptions, facilitating the identification of patterns and the interpretation of indeterminacies in the collected responses.

The study population consists of 95 pregnant adolescent females at the time of the study. The initial selection of the sample covered the entirety of the target population. However, due to the incidence of exogenous factors that hindered the application and proper validation of the collected questionnaires, only a set of 76 pregnant adolescents residing in the city of Tulcán was considered, an effective sample for the analysis of the study. The participants present various stages of gestation, allowing for a differentiated analysis of perceptions throughout this vital period.

The applied questionnaire is structured based on indeterminate Likert scales, designed to measure the adolescents' perceptions regarding the violation of their rights derived from their gestational state. The questions cover a wide spectrum of potential violation situations, from access to health services to the treatment received in the educational and family environment.

The responses were analyzed using a mixed approach that combines traditional statistical analysis with plithogenic logic, specifically through the use of Neutrosophic Probabilities (NP). For each respondent, a TRINS matrix was constructed, categorizing each Likert scale response from negative membership (1) to positive membership (5). This allowed the degree of acceptance of the statements by the respondents to be determined, expressing the responses in the form of TRINS, denoted as G_x.

Each evaluation was represented by a vector in $[0,1]^5$, where each component of the vector reflects a category of evaluation from "Very High" to "Very Low". The formula $\gamma = 2v_1 + v_2 + 0.5v_3 - v_4 - 2v_5$ was used to analyze these data, calculating their relative frequency in percentages. Subsequently, frequency values were transformed into neutrosophic plithogenic probabilities to express the overall behavior of the dimensions studied. This was done using the equation $PN = p_1 + p_2, pI, np_2 + np_1$, representing the probabilities of each variable and their dimensions with values of the type *(T, I, F)*, where *T* indicates the "highly certain" probability that the variable or dimension analyzed is adequately fulfilled, *I* represents the "indeterminate" probability, and *F* the "highly certain" probability that the variable or dimension analyzed does not occur as expected.

This study is classified as exploratory-descriptive, as it seeks to explore and describe perceptions of rights violations in a specific context, using an innovative design that integrates quantitative and qualitative elements, and that allows the interpretation of complexities through plithogenic logic and the theory of neutrosophic probabilities.

4. RESULTS

The data collected through the surveys have undergone rigorous preliminary processing, laying the foundation for subsequent detailed analysis. Initially, a cluster analysis, a multivariate analysis technique, has been implemented

to discern intrinsic patterns in the data set. This statistical method allows for the classification of observations into homogeneous groups based on the similarities of their characteristics, which is crucial for understanding the underlying trends and structure of the data. Figure 1 displays the results obtained from this analytical procedure for the first section of the survey, providing a visual representation of the clustering and behavior of the respondents' answers.

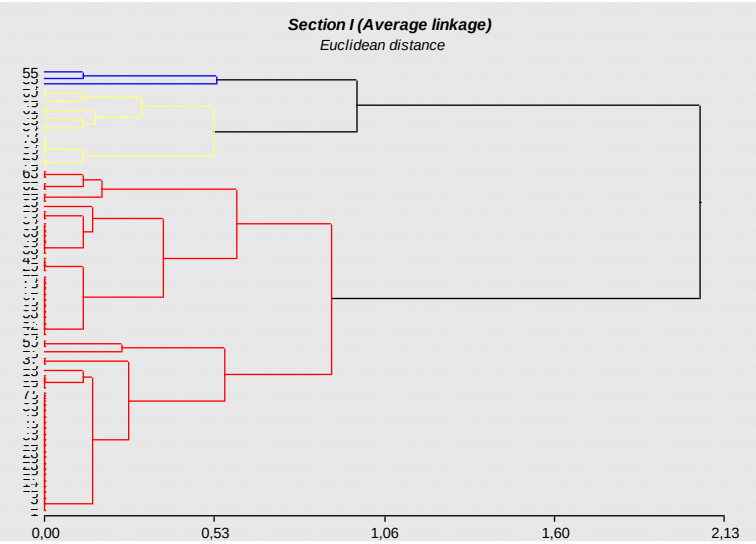

Figure 1. Cluster Analysis for the data obtained and included in the first section of the questionnaire: Knowledge of Legal Regulations and Rights of pregnant adolescents in Tulcán.

In this case, a relatively small group of respondents encompasses pregnant women with a medium level of knowledge, averaging an index of 1.08, which denotes a leaning towards a slightly positive perception or at least not fully defined in terms of their understanding of rights. In contrast, there is a much smaller group that encapsulates participants with the most limited knowledge, with an average index of -0.23, suggesting a significant lack of understanding or a possible disconnection regarding relevant regulations and rights. Finally, in a much larger group, those with the most robust knowledge are represented, with an average index of 1.83, suggesting a high degree of agreement or conformity with knowledge about their rights.

From the results, pertinent conclusions emerge: a pronounced division in the understanding of rights and legal regulations is observed. A non-negligible segment of the sample exhibits a positive understanding; however, there is a minority with a level of knowledge perceived as negative or uncertain.

The analysis carried out for the other two sections of the questionnaire reveals similar results. On the one hand, regarding Section II of the survey, which examines the perception of rights violations in pregnant adolescents, a very large first group with a high centroid is observed. This reveals a generally high index among its members, indicating a consensus or conformity regarding the perception of violation of their rights. This group seems to reflect a generalized agreement or an acceptance of the presence of violation in their daily experiences. Additionally, a smaller group with a much lower centroid is observed, grouping a segment of the sample whose general index denotes disagreement or a marked dissatisfaction. This suggests that the experiences or perceptions of this group contrast with the notion of violation, possibly indicating less adverse experiences or a different perspective on the reality of their treatment received.

The smallest cluster encompasses participants with a moderate perception of rights violation, which indicates a zone of uncertainty or more equidistant stances between agreement and disagreement with the statements proposed in the survey. This pattern highlights that a substantial proportion of the surveyed population in Tulcán shares a vision of significant violation of their rights.

The cluster analysis carried out in Section III, aimed at evaluating the attention in educational, health, and public institutions, also unraveled three main groups with approximate centers of 1.75, -1.2, and 0.73. The largest group, with a center close to -1.2, shows indices indicating negative perceptions or dissatisfaction with the level of attention received, which could be interpreted as a disapproval of the services provided by the mentioned institutions. The smallest cluster, with a center of 1.75, reflects a pronounced perception of satisfaction, indicating an experience of efficient attention that could translate into high conformity with the services received. Finally, the existence of a third group encapsulates those with ambiguous perceptions, possibly indicating variability in the quality of attention or a heterogeneous experience in these institutions. This group illustrates the need for a nuanced analysis to understand varied experiences and properly direct efforts for improvement in public policies and institutional management. [20,21]

On the other hand, when analyzing in general the perceptions of the respondents regarding the evaluated elements, Figure 2 shows interesting results. The examined data reveal a tendency towards a constructive perception in relation to the knowledge of legal regulations and rights in Section I of the survey, implying a satisfactory level of awareness and understanding among participants. However, this positive perception experiences a decline when addressing the experience of rights violation in Section II and decreases even further when evaluating the attention received in institutional entities in Section III, which could reflect a less favorable evaluation of the experiences and services received.

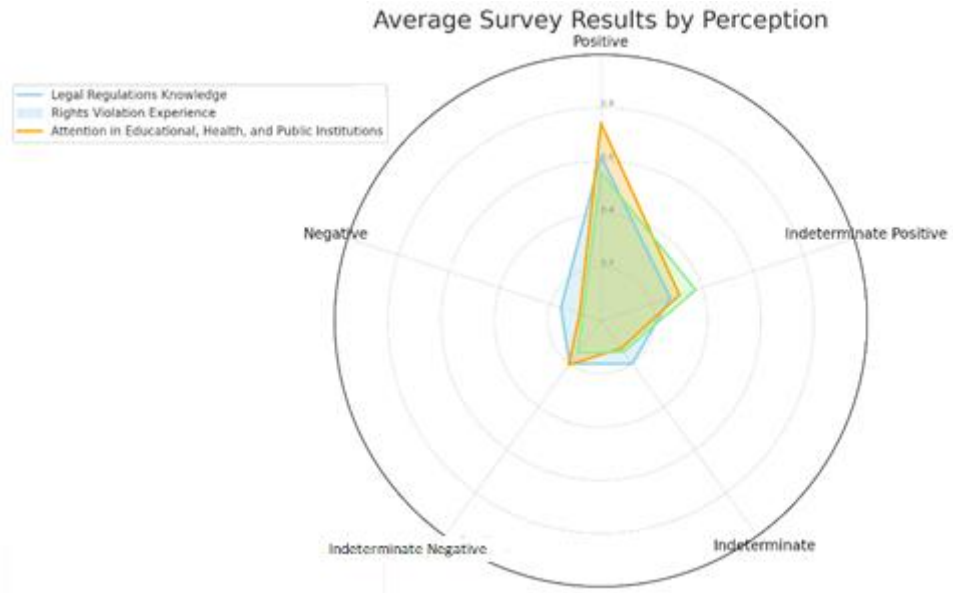

Figure 2: General average results of perceptions based on TRINS according to the surveys applied

The perception of indeterminacy with positive inclinations occurs to a lesser extent compared to the positive perception in all sections, although it maintains a similar decreasing sequence, being more pronounced in Section I. This pattern suggests that, although there is uncertainty with a tendency to agree, this is outweighed by more defined convictions. As for the perception of indeterminacy, it shows a low presence in Section I and slightly rises in Section II, subsequently decreasing in Section III. This dynamic could be interpreted as a comparatively greater clarity in understanding rights versus experiences of violation and interactions with institutions.

On the other hand, negative indeterminate perceptions and negative perceptions, although minor about the positive and positive indeterminate ones, are significant, especially in Section II where there is a greater propensity towards negative valuations. The existence of these perceptions highlights the presence of a segment of the population that experiences and perceives adversities in all the evaluated areas.

The synthesis of these results illustrates a predominance of favorable attitudes and knowledge in the areas of interest. However, it is identified that negative experiences and the perception of rights violations constitute areas of latent concern, which substantially impact the general perception and demand focused attention. These findings offer valuable insight that emphasizes the need to strengthen protection and support mechanisms for pregnant adolescents, especially regarding the optimization of institutional services and the expansion of education on rights and legal regulations.

Furthermore, the analysis of plithogenic probabilities was carried out following the proposed logic. From this, it was possible to create a table of refined and plithogenic probabilities that allows a more focused analysis of the obtained data.

Sections	RP	PP
Knowledge about Legal Regulations and Rights	(6.6; 63.2; 28.9; 1.3; 0)	(69.8; 28.9; 1.3)
Experience of Rights Violation	(22.4; 63.2; 11.8; 2.6; 0)	(85.6; 11.8; 2.6)

Violation in School, Health, and Public Institutions	(9.21; 60.53; 27.63; 2.63; 0)	(69.74; 27.63; 2.63)

Table 1: Table of refined and plithogenic probabilities

The presented analysis allows us to infer with a significant degree of certainty, specifically with a probability of 69.8%, that there is substantial knowledge about legal regulations and rights among the study subjects. This observation points to a relatively high level of familiarity with legal frameworks and relevant rights, although it is important to note the presence of a margin of uncertainty and a minimal percentage (1.3%) that suggests the possibility of inadequate knowledge in this domain among the examined sample.

Additionally, a marked probability is highlighted that respondents experience perceptions of rights violations related to their pregnancy status. This finding is particularly relevant, as instances of indeterminacy or ambiguity in the responses are significantly lower compared to other sections of the questionnaire. This indicates a tendency of the participants to adopt more defined positions, and ambiguous perceptions of their experiences are secondary. In this context, the probability of not recording a high perception of violation in the analyzed sample is limited to 2.6%.

Lastly, a high probability of perceiving rights violations within institutional settings, such as educational institutions, health, and public institutions, is identified. This observation suggests that negative perceptions are not limited to a specific area but extend to various facets of the interaction of pregnant adolescents with institutional structures. This phenomenon underscores the pressing need to address the dynamics contributing to these perceptions of violation, and to implement effective strategies that improve the interaction of pregnant adolescents with such institutions and, therefore, their overall experience concerning exercising their rights and accessing adequate services.

The findings highlight the need to develop and apply public policies that are both focused and differentiated, to mitigate the perceived vulnerability of pregnant adolescents in Tulcán. The results demonstrate a widespread perception of rights violations in this group. In response to this need, it is imperative that designed public policies comprehensively address the identified challenges, transcending temporary solutions to eradicate the very roots of vulnerability. This involves not only ensuring access to quality health and education services but also promoting an inclusive and respectful environment that empowers pregnant adolescents, recognizing and protecting their rights.

Given the evidence obtained from the study on the perception of vulnerability among pregnant adolescents, a set of strategies designed to address both manifestations and underlying causes of such vulnerability is proposed. These policies must respond to specific and differentiated needs, being able to adapt to the diversity of conditions and experiences within this population group. The proposed strategies are as follows:

1. **Creation of specialized educational programs:** Implement educational programs that address not only reproductive health and the legal rights of pregnant adolescents but also promote inclusion and respect within the educational system. These programs should be sensitive to the cultural and socioeconomic context of the young women, ensuring their accessibility and relevance.
2. **Strengthening access to comprehensive health services:** Expand and improve access to specialized health services for pregnant adolescents, including prenatal care, psychological support, and nutritional guidance. These services must be provided respectfully and without stigmatization, ensuring confidentiality and informed consent.
3. **Development of social protection policies:** Establish social protection mechanisms that address the socioeconomic causes of vulnerability, such as financial support programs, educational scholarships, and vocational training for pregnant adolescents and young mothers. These programs should aim to promote economic autonomy and facilitate a return to education or integration into the labor market.
4. **Encouragement of community participation and empowerment:** Actively involve pregnant adolescents in the design and implementation of policies and programs that directly affect them. The creation of safe spaces for dialogue, experience sharing, and collective empowerment is essential to ensure that public policies are truly inclusive and effective.
5. **Implementation of awareness campaigns:** Conduct awareness campaigns aimed at the general population, as well as health professionals, educators, and policymakers, to combat stigma and prejudices associated with teenage pregnancy. These campaigns should promote a culture of respect, equality, and support for the rights of pregnant adolescents.

The adoption of these actions requires a multi-sectorial commitment and collaboration among the government, non-governmental organizations, the private sector, and civil society. Only through an integrated and evidence-based approach will it be possible to effectively mitigate the vulnerability of pregnant adolescents in Tulcán and promote their well-being and that of their future children.

5. CONCLUSION

The results obtained in this study allow us to conclude with a high degree of certainty, specifically with a probability of 69.8%, that pregnant adolescents participating have considerable knowledge about legal regulations and their rights. Although this level of familiarity is remarkable, there is a margin of uncertainty and a small percentage (1.3%) that demonstrates a lack of knowledge in this area among certain participants. In addition, a marked perception of violations of adolescents related to their state of pregnancy was identified, which underlines the relevance of this problem. The answers reflected low levels of ambiguity, which suggests that most participants adopted defined positions on their situation. This finding is crucial since it shows the prevalence of negative perceptions about respect for their rights, especially within institutional environments such as educational, health and public. In practical terms, the findings of this study are of considerable importance. Vulnerability and rights violations perceptions in this population group highlight the need to implement focused public policies and adapted to the specific conditions of pregnant adolescents in Tulcán. These policies must transcend temporary solutions, addressing the structural causes of vulnerability. Among the priorities identified are to guarantee access to quality health and education services, promote an inclusive and respectful environment, and empower adolescents, recognizing and protecting their fundamental rights. This study contributes to the research field by integrating an innovative approach based on plitogenic logic and indeterminate Likert scales. This methodological framework allowed to accurately capture the nuances in the perceptions of adolescents about their situation and the services received, contributing both to the theoretical analysis and the formulation of practical strategies. Likewise, the incorporation of the perceptions of adolescents themselves reinforces the importance of their active participation in the design of more inclusive and effective policies. However, the study presents certain limitations that must be considered. The local nature of the analysis, focused on Tulcán, restricts the generalization of the results to other contexts without additional adaptations. In addition, although a robust framework was used to reduce subjectivity in responses, dependence on individual perceptions can influence general conclusions. Finally, it would be necessary to expand the sample and carry out longitudinal studies to capture broader temporal and contextual dynamics. Looking ahead, it is recommended to deepen the evaluation of complementary strategies that address the needs of this population. Alternative methods, such as Fuzzy analysis or models based on artificial intelligence, could be integrated to validate and expand the findings. In addition, comparative studies in other geographical regions would allow contrasting and enriching the conclusions obtained. It is essential to investigate in greater detail the cultural and socioeconomic factors that influence the perception of rights and accessibility to essential services. In summary, this study highlights the urgency of designing comprehensive and evidence-based public policies that mitigate the vulnerability of pregnant adolescents. The implementation of strategies such as specialized educational programs, expanded access to health services, social protection mechanisms, community awareness and empowerment campaigns are essential to guarantee the respect and full exercise of the rights of this group. Only through a multisectoral commitment and a comprehensive approach, it will be possible to generate a significant change in the lives of these adolescents and in the well-being of their future children.

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NEUTROSOPHIC ANALYSIS OF SENTIMENTS IN ECUADORIAN LEGAL PROCESSES

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ABSTRACT.
This study addresses a central problem in the Ecuadorian legal field: the intersection between legal protection, admissibility of evidence, the origin of conflicts and the resources available within the justice system, all analyzed through an innovative approach based on applied neutroalgebra. In a context in which legal systems face challenges arising from social complexity and the uncertainties inherent to judicial cases, it is crucial to have tools that allow these situations to be analyzed comprehensively. Although the legal literature has widely explored issues related to rights and legal resources, few investigations have incorporated methods that explicitly consider the sentimentss, subjectivity and contradictions present in legal processes, leaving a significant theoretical and practical gap. This study uses neutrosophic analysis to evaluate sentimentss and perceptions in specific cases, integrating neutroalgebra as the main analytical tool. The results highlight how protection, admissibility and the origin of legal conflicts can be interpreted more accurately by incorporating dimensions of truth, falsehood and indeterminacy. These perspectives reveal patterns and biases that traditional methods fail to capture, offering a more holistic and dynamic view of the legal landscape in Ecuador. The implications are profound: in theoretical terms, an innovative framework is introduced that expands the boundaries of legal analysis; in practical terms, concrete strategies are proposed to improve transparency and effectiveness in judicial processes. This work not only redefines contemporary legal analysis but also sets a precedent for future interdisciplinary research that integrates neutrosophic logic with law.
KEYWORDS: Protection, admissibility, origin, appeal, neutrosophic analysis, neutroalgebra

MSC: 03B52, 68T37, 91D10, 93A30, 62P25.

RESUMEN.
El presente estudio aborda un problema central en el ámbito jurídico ecuatoriano: la intersección entre la protección legal, la admisibilidad de pruebas, el origen de conflictos y los recursos disponibles dentro del sistema de justicia, todo ello analizado a través de un enfoque innovador basado en la neutroálgebra aplicada. En un contexto en el que los sistemas jurídicos enfrentan retos derivados de la complejidad social y las incertidumbres inherentes a los casos judiciales, resulta crucial contar con herramientas que permitan analizar estas situaciones de manera integral. Aunque la literatura jurídica ha explorado ampliamente temas relacionados con derechos y recursos legales, pocas investigaciones han incorporado métodos que consideren de manera explícita los sentimientos, la subjetividad y las contradicciones presentes en los procesos legales, dejando un vacío teórico y práctico significativo. Este estudio utiliza el análisis neutrosófico para evaluar sentimientos y percepciones en casos específicos, integrando la neutroálgebra como herramienta analítica principal. Los resultados destacan cómo la protección, la admisibilidad y el origen de los conflictos legales pueden ser interpretados de manera más precisa al incorporar dimensiones de verdad, falsedad e indeterminación. Estas perspectivas revelan patrones y sesgos que los métodos tradicionales no logran capturar, ofreciendo una visión más holística y dinámica del panorama jurídico en Ecuador. Las implicaciones son profundas: en términos teóricos, se introduce un marco innovador que expande los límites del análisis legal; en términos prácticos, se proponen estrategias concretas para mejorar la transparencia y la eficacia en los procesos judiciales. Este trabajo no solo redefine el análisis jurídico contemporáneo, sino que también establece un precedente para futuras investigaciones interdisciplinarias que integren la lógica neutrosófica con el derecho.
PALABRAS CLAVE: Protección, admisibilidad, origen, recurso, análisis neutrosófico, neutroálgebra

1. INTRODUCTION.

The relationship between legal frameworks and their ability to protect rights, ensure the admissibility of evidence, establish the origin of conflicts and offer effective remedies constitutes a central axis in the study of comparative law [18]. In the Ecuadorian context, the complexities of these legal processes are intensified due to the diversity

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of interpretations and the coexistence of formal and informal normative systems. This article proposes an innovative approach that combines tools of neutrosophic analysis and applied neutroalgebra to explore the dynamics of sentimentss, uncertainties and contradictions inherent in these processes. Such analysis is crucial in a legal system that faces constant challenges to adapt to a rapidly evolving social and technological environment [17]. Historically, legal systems have been designed to guarantee justice and equity, although they have not always managed to meet these aspirations. In Ecuador, events related to the interpretation of the law, the admissibility of evidence and the legitimacy of judicial resources have generated intense debates in recent decades [14]. Recent changes in national legislation, particularly in criminal and civil matters, reflect an effort to modernize the system and adapt it to international standards. However, these reforms have not succeeded in fully resolving the tensions that arise from the application of regulations in contexts characterized by high subjectivity and indeterminacy [7]. The specific problem that this study addresses lies in the lack of an analytical framework that comprehensively captures and assesses the sentimentss, perceptions, and contradictions present in the interpretation and application of legal norms in Ecuador. How can the coherence and effectiveness of judicial processes be guaranteed in a context where human emotions and uncertainty play such an important role? This question guides the research, underlining the need for an interdisciplinary approach that allows addressing the limitations inherent to traditional methods [1]. In this article, it is argued that neutrosophic tools and applied neutroalgebra offer a powerful framework for analyzing complex legal problems. By integrating concepts of indeterminacy, partial truth, and relative falsity, these methodologies allow capturing dynamics that escape conventional analyses. In this way, the neutrosophic approach not only provides a richer and more nuanced perspective but also opens up new possibilities for the design of public policies and legal strategies that are more inclusive and effective [15].

This paper is also distinguished by its emphasis on sentimentss and perceptions as essential elements of legal analysis. This approach recognizes that legal systems do not operate in a vacuum, but constantly interact with the expectations, emotions, and perceptions of stakeholders. These interactions can influence both the interpretation of norms and the perception of justice, making their incorporation into any analytical model that seeks to be comprehensive indispensable [16]. The existing literature on admissibility, legal remedies, and normative analysis in Ecuador, although extensive, presents notable shortcomings. Previous studies have predominantly focused on technical and doctrinal aspects, leaving aside the subjective and contradictory dynamics that influence legal practice. This theoretical and methodological gap is particularly problematic in contexts of high uncertainty, where legal interpretations and decisions can have significant and far-reaching consequences [3]. Therefore, the objectives of this study are: first, to develop an analytical model based on applied neutralalgebra that allows a comprehensive assessment of the sentimentss and contradictions present in legal processes in Ecuador; and second, to offer concrete recommendations to improve the transparency, coherence and effectiveness of these processes. This article ultimately seeks not only to contribute to theoretical advancement in legal analysis, but also to provide practical tools to address the challenges inherent in contemporary legal systems. With this research, we aim to fill a critical gap in the legal literature, proposing an innovative and methodologically sound approach. The findings have the potential to transform the way legal norms are analysed and applied in contexts characterised by high subjectivity and uncertainty, providing new perspectives for both academics and legal practitioners.

2. PRELIMINARIES.

2.1. LEGAL PROTECTION .

Legal protection, understood as the safeguarding of fundamental rights and guarantees, constitutes the backbone of any legal system. In this context, the concept of admissibility of evidence and arguments acquires crucial relevance in determining the viability of a case within the regulatory framework [4]. Likewise, the identification of the origin of conflicts and the availability of effective resources for their resolution are essential pillars to ensure the functionality of the justice system. These four elements—protection, admissibility, origin and resources—not only constantly interact, but also face specific challenges in societies characterized by cultural diversity, inequality and normative uncertainty [5]. From a theoretical perspective, legal protection has deep roots in the philosophy of law and is intrinsically linked to concepts of justice, equity and legitimacy [18]. For its part, admissibility is closely linked to procedural rules, being the criterion that regulates which evidence or arguments are considered valid before a court [8]. This mechanism, far from being purely technical, reflects underlying values in the legal system, such as objectivity and impartiality. However, its application in real contexts is subject to interpretations that can vary considerably depending on the social and cultural environment [10]. Identifying the origin of conflicts is an equally relevant aspect, as it allows for the analysis of the underlying causes that generate legal or social tensions [14]. This exercise not only sheds light on the roots of the problems but also facilitates the search for sustainable solutions [9]. Finally, legal resources represent the practical tools that individuals or organizations can use to resolve disputes or protect their rights [20]. In this sense, their design and availability are key indicators of the accessibility and effectiveness of the judicial system [16].

In practice, these four elements face significant challenges. For example, legal protection is often limited by structural inequalities that hinder access to justice [18]. The admissibility of evidence, despite its normative criteria, can be influenced by subjective biases or technological constraints [15]. Similarly, identifying the origin

of conflicts can be complicated in multicultural contexts where different legal interpretations coexist. Moreover, the effectiveness of resources depends not only on their existence but also on the capacity of actors to use them appropriately [12].

First, it is imperative to recognize that legal protection, although widely recognized as a fundamental right, faces significant limitations in its practical implementation [7]. The gap between written laws and their application is a recurrent phenomenon in many countries, especially in those with fragile judicial systems. This mismatch can lead to situations of injustice, where legally protected rights are not accessible to all citizens [21]. On the other hand, the admissibility of evidence raises questions about the balance between technical rigor and procedural fairness [8]. While the rules of evidence are essential to ensure fair trials, their interpretation can be restrictive or exclusionary, especially in cases where the available evidence does not meet established standards. In this regard, a critical analysis of the admissibility criteria is necessary to ensure that they do not perpetuate pre-existing inequalities [3]. Regarding the origin of conflicts, it is observed that a superficial understanding of the underlying causes can lead to temporary solutions that do not address the problem in its entirety [15]. This approach is not only ineffective but may also exacerbate long-term tensions. Identifying and addressing the structural causes of conflict is therefore a priority task for any justice system that aspires to be truly functional [16]. Legal remedies must also be accessible and effective, not only in theory but also in practice [20]. This involves ensuring that individuals are aware of their rights and the tools available to protect them. Furthermore, remedy systems must be designed taking into account the socio-economic realities of users, ensuring that they are inclusive and do not discriminate against the most vulnerable [12]. A crucial aspect that deserves attention is the interaction between these four elements. Legal protection loses its meaning if there are no accessible resources to make it effective [9]. Similarly, the admissibility of evidence lacks relevance if it is not contextualized within a framework that allows the origin of conflicts to be identified appropriately [10]. This integrative approach is essential to understanding and improve the judicial system as a whole.

In practical terms, reforms are needed that address the shortcomings observed in each of these elements. These reforms must be guided by empirical research that analyses the impact of existing policies and proposes evidence-based solutions [1]. The adoption of innovative approaches, such as the use of advanced technologies or interdisciplinary methodologies, can play an important role in this process [22]. Finally, the interaction between the social and cultural context and the judicial system should not be underestimated [3]. Legal systems do not operate in a vacuum, but are deeply influenced by power dynamics, cultural norms and societal expectations. Therefore, any analysis of protection, admissibility, origin and resources must consider these dimensions to be truly effective and relevant [15].

2.2. Sentiment analysis

Sentiment analysis employs advanced natural language processing tools, combined with text mining and computational linguistics techniques, to identify and extract subjective information present in various sources [6]. In the context of text mining, this methodology is frequently used to classify large volumes of data according to their polarity, allowing trends and opinions to be discerned efficiently. Among the main categories in this discipline, approaches such as lexical affinity, statistical methods, and conceptual techniques stand out. However, evaluating sentiments, whether at an individual or collective level, represents an intrinsic challenge due to the complexity of emotional subjectivity. This is because affective states are often ephemeral and dynamic, and can change significantly in a matter of moments, which adds uncertainty to the analysis process [11].

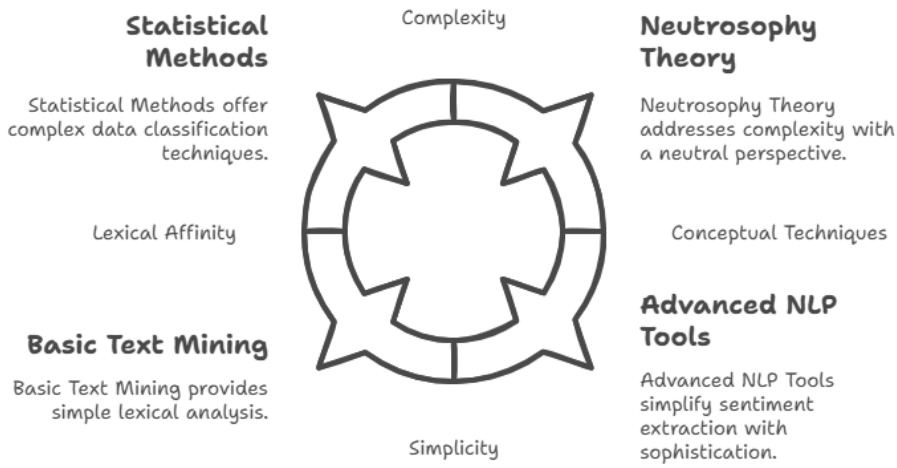

Figure 1. Sentiment Analisis Methodologies and Challenges

Regarding measurement scales, researchers emphasize the need to include neutral options. This is because a person

may be unsure of categorizing their emotional state as positive or negative, or they may be in a state of complete neutrality that does not align with any of the usual categories [2]. In this framework, the Neutrosophy theory becomes highly relevant, as it addresses not only positive and negative aspects, but also neutrality. This approach is particularly useful for analyzing the connotative load of words within a text, which adds a dimension of complexity to the evaluation process [17].

2.2 Neutrosophic Sentiment Analysis Using NeutroGroup in Prospector

The proposed sentiment analysis process integrates neutrosophic logic to capture positive, negative, and indeterminate sentiments within textual data. By leveraging NeutroGroup (NG) operations, the method systematically evaluates sentiment indicators such as integrity, transparency, and accountability. The approach accounts for linguistic intensity modifications, negation handling, and complex cases like ambiguous punctuation and emoticons. Through preprocessing techniques, including spell checking and natural language processing (NLP), relevant sentiment values are extracted and assigned a score on a -5 to 5 scale, or marked as indeterminate (I) when ambiguity arises. Finally, sentiment scores are aggregated across multiple individuals, allowing for a comprehensive and structured sentiment evaluation in organizational or analytical contexts.

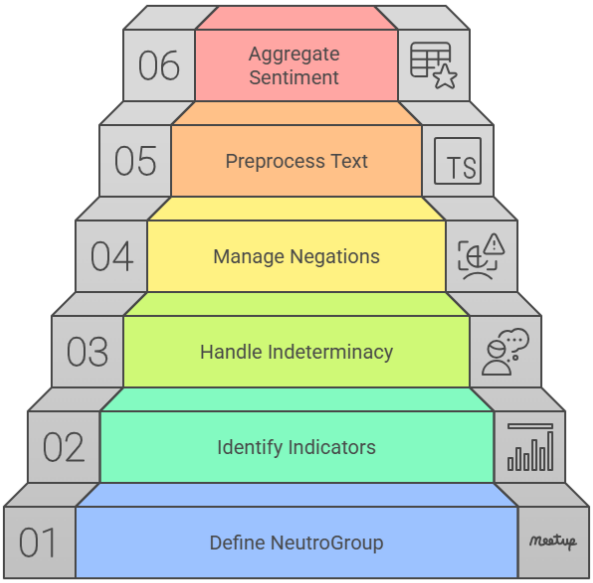

Figure 2. Flowchart of the Sentiment Analysis Process Based on Neutrosophic Logic

For a given natural number $n > 0$, NeutroGroup is defined from the combinator function of Prospector. Prospector is the well-known expert system used to model mining problems [15]. The set NeutroGroup consists of all integers between $-n$and $n$plus the symbolic element I to represent indeterminacy. This is $NG_5 = \{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, I\}$and $\oplus_5$is used. This is defined according to the following Cayley table:

$\oplus_5$	-5	-4	-3	-2	-1	0	Yo	1	2	3	4	5
-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	Yo
-4	-5	-5	-5	-5	-4	-4	-4	-4	-3	-2	0	5
-3	-5	-5	-4	-4	-4	-3	-3	-2	-1	0	2	5
-2	-5	-5	-4	-3	-3	-2	-2	-1	0	1	3	5
-1	-5	-4	-4	-3	-2	-1	-1	0	1	2	4	5
0	-5	-4	-3	-2	-1	0	Yo	1	2	3	4	5
Yo	-5	-4	-3	-2	-1	Yo	Yo	Yo	Yo	Yo	Yo	Yo
1	-5	-4	-2	-1	0	1	Yo	2	3	4	4	5
2	-5	-3	-1	0	1	2	Yo	3	3	4	5	5
3	-5	-2	0	1	2	3	Yo	4	4	4	5	5
4	-5	0	2	3	4	4	Yo	4	5	5	5	5
5	Yo	5	5	5	5	5	Yo	5	5	5	5	5

Table 1. Cayley table corresponding to $\oplus_5$. Source: [15].

$\oplus_5$It satisfies the properties of commutativity and associativity and has 0 as a null element. In addition , it satisfies each of the following properties :

- If x, y < 0then $x \oplus_5 y \leq min(x, y)$,
- If x, y > 0then $x \oplus_5 y \geq max(x, y)$,
- If x $< 0$and y > 0or if x $> 0$and y < 0, then we have $min(x, y) \leq x \oplus_5 y \leq max(x, y)$.
- $\forall x \in G, x \oplus_5 0 = x$.
- $(-5) \oplus_5 5 = 5 \oplus_5 (-5) = I$.

Sentiment analysis, through the neutrosophic method, focuses on assessing integrity, transparency, and accountability within organizations. Using this theory, opinions and perceptions are examined by considering the degrees of positivity, negativity, and indeterminacy. This approach not only captures clear sentiments, such as positive and negative ones, but also addresses those that are neutral or ambiguous, thus achieving a more accurate assessment and a better understanding of how these aspects are perceived in the organizational environment.

This method, particularly effective in the analysis of short and informal texts, as described in the technique mentioned above, requires the identification of a set of words that are classified as positive, negative or neutral, each with a strength value evaluated in a range from -5 to 5, or that are marked as indeterminate. Indeterminacy occurs when it is not possible to clearly decipher the individual's thoughts on the subject in question, which may occur due to a lack of clarity in the semantics of the text or because the text is unintelligible. Furthermore, in certain cases, it is possible that in the same text extreme evaluations of positivity (+5) and negativity (-5) are presented for the same variable, which generates a contradiction that is classified as indeterminate, marked with the letter I. This indeterminacy can have different origins, which becomes evident when the function used in the PROSPECT expert system, which evaluates the degree of evidence of an expert on a particular aspect, finds maximum evidence but in opposite directions for two different aspects.

This method, which borrows some elements from the SentiStrength sentiment strength detection algorithm [16], allows terms related to the analyzed variables to be classified as Positive, Negative or Neutral in a list using linguistic values. Each of these terms is associated with a value between -5 and 5, or even I, depending on the intensity of its positive or negative charge. For example, the term “I like” increases its positive value if expressed as “I like it a lot”, while “I don’t like it” becomes more negative when saying “I don’t like it a lot”. What applies is that for the word “much ” or “a lot” that modifies one of the positive or negative classifier words, is used $x \oplus_5 x$, and for “too much” $x \oplus_5 x \oplus_5 x$, where $x$is the value that is associated with the word. For example, $x > 0$it results in “very” with an even more positive value. On the other hand, when $x < 0$, the result is more negative.

Also, the modification of "quite" is converted to $\left[sig(x)\sqrt{|x|}\right]$.

- They take into account words that reverse the meaning of what is said. In this case, the sign is changed. For example, “I like” has a value of $x = 3$, when it comes to “I don't like” it is calculated as $x = -3$, both have the same strength, but with opposite meaning.
- In this algorithm, very complex cases, where there are exclamation or question marks, are ignored, since we want to evaluate what the members of the organization or clients write, if it makes sense, about each of the twelve aspects of ethics mentioned in the previous points.
- Another aspect that is taken into account in the proposed algorithm taken from the previous one is the evaluation of the emoticons.
- Spell checking also applies here.

The next step is the evaluation of a short informal text written by a person. To do this, natural language processing is performed, where words that express sentimentss or opinions about each of the twelve aspects mentioned above are searched for. Let us denote these aspects as $V = \{v_1, v_2, \cdots, v_{12}\}$:

Then, within the text processing, the words referring to each of these variables are identified. These words are identified with a value from -5 to 5 o I. Let us denote this as follows, for the i- th variable, the set $X_i$of word ratings that appear in the text:

$v_i \rightarrow X_i = \{x_{i1}, x_{i2}, \ldots, x_{im_i}\}$, where$x_{ij}$ It is the set of elements between -5 and 5 o I, used to qualify the words that refer to the i- th variable.

Note that even the individual evaluation of each word can be complicated. For example, when modifiers such as "very" appear, the value of the modified word changes. Also when there are spelling errors that make an evaluation illegible, it is necessary to use the value I. The final value associated with eachv_i is:

$$x_{total,i} = x_{i1} \oplus_5 x_{i2} \oplus_5 \ldots \oplus_5 x_{im_i} \quad (1)$$

Please note that we do not consider it convenient to obtain an aggregate ethical value for all the variables since the separate value is more useful to have an idea of the individual opinion or sentiments.

If we have a set of people whose opinion is being studied. Let us call this set of people by $P = \{p_1, p_2, \cdots, p_l\}$, so that the values are taken into account, $x_{total,i,j}$it is the total value of the i - th ethics variable in the organization, according to the j_{th} person.

It is calculated:

$$\bar{x}_{total,i} = \frac{\sum_{j=1}^{l} x_{total,i,j}}{l} \quad (2)$$

That is, the arithmetic mean of each of the variables is calculated.

3. RESULTS

This study aims to analyze, from a neutrosophic perspective, the opinions and sentimentss of 18 legal specialists on four key aspects of the Ecuadorian legal system: protection, admissibility, origin and recourse. This approach uses neutrosophic and neutroalgebra to assess the dimensions of positivity, negativity and indeterminacy in each variable, providing a more nuanced understanding of the ethical and functional perception of the system.

1. Definition of the Variables Evaluated The legal variables analyzed are:

- **Protection of fundamental rights (v_1)**
- **Procedural admissibility (v_2)**
- **Origin of applicable regulations (v_3)**
- **Appeal (v_4)**

2. Methodology For this analysis, information was collected from 18 legal specialists in various areas of law, who evaluated each variable using a range of values between -5 (very negative), 5 (very positive) and indeterminate (I). The results were calculated using the neutrosophic operation $\oplus_5$.

3. Expert Specialties The participants and their specialties are:

1. Constitutionalist
2. Criminal lawyer
3. Civilian
4. Labor Lawyer
5. Environmentalist
6. Administrativeist
7. Human Rights Specialist
8. Internationalist
9. Familiarist
10. Intellectual Property
11. Tax
12. Procedural lawyer
13. Mediation and Arbitration
14. Criminologist
15. Specialist in Economic Criminal Law
16. Specialist in Technology Law
17. Notarial and Registry
18. Researcher in Public Policy

3. **Data Collected and Assessments** Each expert provided an assessment for the variables, see Table 2.

Specialist	v_1	v_2	v_3	v_4
Constitutionalist	4	3	5	4
Criminal lawyer	3	4	3	5
Civilian	5	2	4	3
Labor Lawyer	2	3	5	2
Environmentalist	4	3	3	4
Administrativeist	5	4	4	3
Human Rights Specialist	5	3	5	5
Internationalist	4	3	4	4
Familiarist	3	2	5	3
Intellectual Property	2	3	3	2
Tax	3	4	4	3
Procedural lawyer	4	5	5	4
Mediation and Arbitration	3	4	4	3
Criminologist	4	3	3	4
Economic Penalty	2	4	4	3
Technological	4	3	3	2
Notarial and Registry	5	4	5	3
Public Policies	4	3	5	4

Table 2. Collected data.

Result **s** For each variable, the total value was calculated using the formula:

$$x_{total,i} = x_{i1} \oplus_5 x_{i2} \oplus_5 \dots \oplus_5 x_{im_i} \quad (1)$$

It is calculated:

$$\bar{x}_{total,i} = \frac{\sum_{j=1}^{l} x_{total,i,j}}{l} \quad (2)$$

For each variable evaluated, the total value is calculated using the neutrosophic aggregation operation. This operation is performed by adding the values of each evaluation where l is the total number of evaluators (18 in this case).

The results are presented in Table 3.

Variable	Mean ($\prod x_{in}$)	Commentary on the Trend
v_1 Protection	4.06	Highlighted positive perception
v_2 Admissibility	3.39	Balanced overall assessment
v_3 Origin	4.22	High confidence in regulations
v_4 Resource	3.56	Moderate positive evaluation

Table 3: Results **for** each variable.

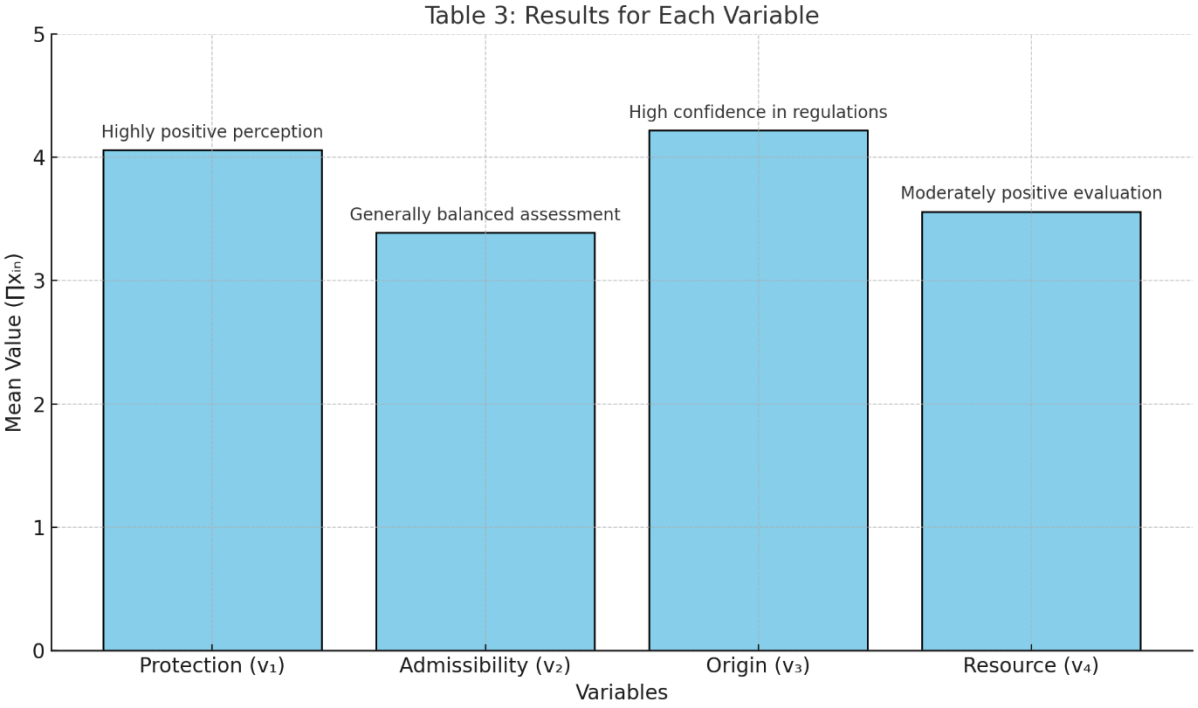

Figure 3. Results for Each Variable

The study revealed that the variables analyzed present distinct trends that align with the general objectives of the research.

Variable v_1, named "Protection," showed a mean score of 4.06, indicating a highly positive perception among participants. This suggests a strong recognition of the protection measures within the assessed framework. Variable v_3, "Origin," obtained the highest score with a mean of 4.22, reflecting a high confidence in the regulations associated with this variable (see Table 3).

In contrast, Variable v_2, "Admissibility," presented a more balanced evaluation with a mean score of 3.39. This result suggests that while the aspect of admissibility meets expectations to a certain extent, it remains an area with potential for improvement. Similarly, Variable v_4, "Resourcefulness," achieved a moderately positive evaluation with a mean of 3.56, highlighting areas of strength but also indicating opportunities for further development (see Table 3).

The bar chart in Figure 1 visually represents the mean scores of the variables, providing an intuitive comparison of their relative trends.

These findings emphasize areas of strength, such as protection and regulatory aspects, while pointing to domains that require further focus, notably admissibility and resource considerations. The inclusion of contrasting results,

such as lower scores on admissibility, enriches the overall interpretation and lays the groundwork for insights applicable in future research.

4. DISCUSSION.

The results obtained in this study outline an interesting picture of the perception of protection measures, confidence in regulations, and assessments of admissibility and appeals in the analysed framework. While the high scores in "Protection" (4.06) and "Origin" (4.22) reinforce the strength of the normative and security systems evaluated, the moderate values in "Admissibility" (3.39) and "Appeal" (3.56) raise questions that deserve attention in future developments.

These data suggest that trust in regulations is not only an essential pillar of the system, but also an indicator of stability and robustness perceived by participants. However, the balanced assessment of admissibility raises the need to explore potential bottlenecks that could limit the acceptance of current procedures. On the other hand, resources, although evaluated positively, seem to show an area with room to optimize their impact on the overall experience. When comparing these findings with previous research, there is consistency in the recognition of the importance of strong regulatory systems, as pointed out by similar studies in comparable settings. However, the lower emphasis on admissibility contrasts with works that highlight its critical role in the acceptance of systems by end users. Nevertheless, this study faces some inherent limitations. Among them, there is the subjectivity associated with participants' evaluations and the possible lack of representativeness in contexts other than the one analyzed. Also, the interpretation of the lower scores in "Admissibility" and "Resource" requires a deeper approach to identify specific factors that explain these evaluations. The implications for future research are numerous. It is recommended to explore approaches that directly address perceived weaknesses in admissibility and resources, as well as to develop interventions that strengthen these aspects. From a practical perspective, the results could guide adjustments in policies or implementation strategies to improve the overall acceptance of the assessed systems. One aspect worth mentioning is the absence of significant anomalous results, which reinforces the internal consistency of the data. Nevertheless, the relatively wide range in the "Admissibility" assessments could reflect contextual variations that will be the subject of analysis in subsequent work. In conclusion, this study provides a comprehensive perspective on the assessment of policy and resource systems in specific contexts. The findings not only confirm the robustness of certain aspects but also illuminate critical areas that need to be strengthened to ensure successful and widely accepted implementation.

5. CONCLUSIONS.

In summary, this study reaffirms the importance of well-structured regulatory systems and protection measures, evidencing their positive impact on the perception of participants. Despite the strengths observed in the variables of "Protection" and "Origin", weaknesses were also identified in "Admissibility" and "Recourse" that must be addressed to achieve continuous improvement. The practical applicability of these findings is relevant in the design and implementation of systems that seek to balance trust and functionality. These results can guide policymakers and designers toward informed decisions that maximize both user acceptance and system effectiveness. Among the main contributions of this research is the use of a systematic approach that allows the identification of key areas of strength and improvement. In addition, the findings provide a theoretical and practical basis for addressing similar challenges in analogous contexts. However, the study is not free of limitations. The subjectivity inherent in the evaluations and the specificity of the analyzed context can restrict the generalization of the results. Furthermore, variations in participants' responses suggest the need to include larger and more diverse samples in future research. Based on these findings, it is recommended to broaden the scope of research to other settings, as well as to incorporate complementary methodologies that delve deeper into less robust areas. Likewise, exploring the impact of specific interventions on "Eligibility" and "Recourse" could be key to strengthening these aspects. Finally, this work contributes to the knowledge of the field, highlighting both achievements and challenges, and lays the foundation for continued research that promotes more efficient, reliable, and accepted systems.

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LEGAL SECURITY AND PUBLIC HEALTH: THE ROLE OF THE PLITHOGENIC IADOV METHOD IN THE FORMULATION OF A PENAL REFORM PROPOSAL IN ECUADOR

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ABSTRACT
This research aimed to craft a legislative proposal to amend Ecuador's Comprehensive Organic Criminal Code, with the dual purpose of classifying crimes against public health and safeguarding the right to legal security. To accomplish this goal, the study undertook an extensive bibliographic review alongside a comparative legal analysis of statutes from other jurisdictions, seeking to identify deficiencies and potential improvements in the current criminal legislation. The bibliographic review offered a comprehensive understanding of Ecuador's existing legal framework and the multifaceted challenges it faces regarding public health offenses. Concurrently, the comparative examination facilitated the exploration of successful legislative models and approaches adopted by countries with similar legal systems. By synthesizing insights from both the literature and comparative law analysis, the research was able to formulate a draft bill designed to close existing legal gaps and establish explicit norms aimed at effectively addressing crimes against public health. The proposed legislative framework was subsequently validated using the Plithogenic IADOV method, which fostered an inclusive dialogue among experts in law, public health, civil society organizations, and governmental authorities. This methodological approach not only ensured the robustness of the proposal but also enriched it through diverse perspectives. The primary conclusions drawn from this study suggest that the proposed draft bill marks a significant advancement in the protection of public health and the assurance of legal security during health crises. The careful classification of crimes against public health, coupled with the establishment of proportionate sanctions, emerges as a crucial strategy for confronting potential future pandemics. Moreover, these measures underscore the importance of maintaining citizens' rights and legal integrity in the face of emerging public health challenges.

KEYWORDS: Draft bill; legal security; IADOV method; sanctions, citizens' rights.

MSC: 03B52, 91D10, 68T37, 93A30, 62P25

RESUMEN
Esta investigación tuvo como objetivo elaborar un proyecto de ley para enmendar el Código Orgánico Integral Penal de Ecuador, con el fin de tipificar los delitos contra la salud pública y garantizar el derecho a la seguridad jurídica. Para alcanzar esta meta, se llevó a cabo una exhaustiva revisión bibliográfica junto con un análisis comparativo de la legislación de otros países, con el propósito de detectar deficiencias y oportunidades de mejora en la normativa penal vigente. La revisión bibliográfica proporcionó una visión integral del marco legal existente en Ecuador y de los complejos desafíos que enfrenta en materia de delitos contra la salud pública. Simultáneamente, el análisis comparativo permitió explorar modelos legislativos exitosos y enfoques adoptados por naciones con sistemas jurídicos afines. La integración de los conocimientos extraídos tanto de la literatura como del estudio comparativo posibilitó la formulación de un proyecto de ley diseñado para subsanar vacíos legales y establecer normas claras orientadas a enfrentar eficazmente los delitos contra la salud pública. Posteriormente, la propuesta legislativa fue validada mediante el método Plitogénico IADOV, creando un espacio de diálogo inclusivo entre expertos en derecho, salud pública, organizaciones de la sociedad civil y autoridades gubernamentales. Este enfoque metodológico no solo aseguró la solidez del proyecto, sino que también lo enriqueció con perspectivas diversas. Las principales conclusiones de este estudio indican que el proyecto de ley propuesto representa un avance significativo en la protección de la salud pública y en la garantía de la seguridad jurídica durante crisis sanitarias. La minuciosa clasificación de los delitos contra la salud pública, junto con el establecimiento de sanciones proporcionales, se revela como una estrategia fundamental para enfrentar futuras pandemias. Además, estas medidas subrayan la importancia de preservar los derechos de los ciudadanos y la integridad jurídica frente a los desafíos emergentes en el ámbito de la salud.
PALABRAS CLAVE: Proyecto de ley; seguridad jurídica; método IADOV; sanciones; derechos de los ciudadanos.

1. INTRODUCTION

The study embarks on a critical examination of the electronic voting process through the innovative lens of the neutrosophic Delphi method, a subject that resonates deeply in contemporary discussions about democratic integrity. Given the increasing reliance on digital platforms for electoral procedures, understanding the uncertainties and subjective nuances behind voter perceptions has become paramount. The significance of this research lies not only in its technical contributions but also in its potential to inform policy decisions that shape electoral trust and security [1]. Through this exploration, the research addresses a gap in existing literature, blending advanced mathematical frameworks with the human elements of decision-making.

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Historically, the evolution of voting systems from manual to digital forms reflects a broader technological and social transformation that has swept across societies worldwide. In earlier times, the analog nature of elections presented its challenges, but as technology advanced, new problems emerged, such as cybersecurity threats, digital disenfranchisement, and the erosion of voter confidence. This historical progression underscores the necessity of adapting methodological approaches to suit new realities [2]. Previous decades have seen numerous attempts to reconcile technology with democratic ideals, yet only a handful of studies have attempted to systematically capture the nuances of voter sentiment amidst technological change. As electronic voting systems proliferate, they bring with them complexities that have often been glossed over by technical assessments alone. These systems do not operate in a vacuum; they interact with human behaviors, perceptions, and societal norms that can be unpredictable and fluid. The interplay between the rigid structures of technology and the fluid nature of human opinion creates a landscape ripe for in-depth analysis. This dynamic environment accentuates the urgency of developing robust tools capable of handling indeterminacy and ambiguity in public opinion [3]. Scholars have long argued that ignoring these human factors could lead to flawed policy implementations and erode trust in electoral systems [4]. The core conceptual framework of this study draws from a blend of social science and mathematical theory, seeking to bridge the gap between qualitative human insight and quantitative rigor. The neutrosophic Delphi method, at the heart of this research, offers a unique perspective by incorporating degrees of truth, indeterminacy, and falsity into the analysis. This approach is particularly well-suited to handle the uncertainties that traditional models struggle with, allowing for a more nuanced understanding of expert opinions and voter behavior [5]. By weaving together diverse strands of theory, the study situates itself at an interdisciplinary crossroads that promises richer insights into the electoral process. Despite technological advances, a significant gap remains in integrating human perception with technical evaluation in electronic voting systems. The central problem this research confronts is the lack of a holistic framework that seamlessly incorporates both the technical intricacies of digital voting and the complexity of human attitudes toward these systems. How can we ensure that security measures and transparency protocols in electronic voting not only function flawlessly but also resonate with the varied and often uncertain perceptions of the public? This question underpins the investigation, drawing attention to an area that has been underexplored in previous research [6].

By posing this question, the study highlights the magnitude and multifaceted nature of the challenge. Evaluating the effectiveness of electronic voting cannot be reduced to binary outcomes or simple metrics; it demands an approach that can navigate shades of opinion and varying degrees of certainty. The problem spans technical, psychological, and sociopolitical domains, making it complex and significant. The integration of neutrosophic methods into this realm seeks to capture this multifarious reality, moving beyond traditional models that oversimplify human judgment. The objectives of the study emerge clearly from this complex landscape. Primarily, the research aims to assess the applicability and efficacy of the neutrosophic Delphi method in evaluating electronic voting systems. By doing so, it seeks to encapsulate the inherent uncertainties present in voter perceptions and expert opinions. Additionally, the study strives to provide actionable recommendations that could enhance the security and transparency of electronic voting, informed by a deep understanding of public sentiment and technical feasibility [7, 8]. These objectives align seamlessly with the central research question, carving a path forward for both academic inquiry and practical policy-making. The methodological innovation promised by the neutrosophic Delphi method not only addresses the intricacies of the problem but also sets the stage for future investigations into related areas of electoral integrity. Through this work, the study endeavors to contribute meaningfully to the fields of political science, computer science, and public policy, opening new avenues for research and development in the assurance of democratic processes.

2. METHOD

The Plithogenic [9] IADOV Method is an advanced evaluation technique that integrates plithogenic logic and neutrosophic analysis to assess satisfaction levels while accounting for contradictions and uncertainties in expert opinions. By employing a structured linguistic evaluation system and aggregation operators, this method provides a comprehensive framework for measuring and interpreting complex perceptions in legal and policy analysis. A brief explanation of the approach is the following

-Definition of Plithogenic Set

Establishes the fundamental concept of a plithogenic set, extending classical, fuzzy, intuitionistic fuzzy, and neutrosophic sets. It defines the key components: set (P), attributes (a), value range (V), membership degree (d), and contradiction degree (c).

-Linguistic Evaluation System

Implements a linguistic scale adapted to plithogenic modeling and assigns satisfaction categories and translates them into neutrosophic values for expert evaluations.

-Survey Design and Expert Evaluation

Develops a structured questionnaire with closed and open-ended questions to measure expert opinions on legal reforms. Iut ses a neutrosophic scale to assess truth, falsity, and indeterminacy.

-Computation of the Neutrosophic Plithogenic Global Satisfaction Index (NPGSI)

Aggregates expert evaluations using plithogenic operations such as union (OR), intersection (AND), and aggregation functions based on t-norm and t-conorm.

-Contradiction Evaluation and Aggregation

In this part the contradiction degree between attribute values is calculated. It is applied to modify aggregation functions. Indeed, a contradiction function (c) is used to determine consistency in responses.

-Neutrosophic Plithogenic Intersection and Union

Defines intersection and union functions to handle membership, non-membership, and indeterminacy. It ensures comprehensive representation of expert evaluations.

-Resolution and Decision Matrix Construction

Computes the median of plithogenic numbers to generate a decision matrix. So, it establishes a unique decision model incorporating truth, indeterminacy, and falsehood components.

The steps are depicted in Figure 1.

Figure 1. Flowchart of the Plithogenic IADOV Method for Satisfaction Evaluation
Source: Own Elaboration.

Plithogenic logic allows for the inclusion of indeterminacy and contradiction in the evaluation of sets and systems. To understand the extension of the method to a plithogenic environment [10,15], it is necessary to define what a plithogenic set is:

Plithogenic set [11,16]: An extension of classical, fuzzy, intuitionistic fuzzy, and neutrosophic sets. A plithogenic set is defined as (P, a, V, d, c), *w*here:

a) "P" is a set, "a" is an attribute (multidimensional in general), "V" is the range of values of the attribute, "d" is the degree of membership of the attribute value of each element x to the set P for some given criteria $(x \in P)$, and "d" means "d_F" or " d_{IF} " or "d_N", when it is a degree of fuzzy membership, an intuitionistic fuzzy membership, or a degree of neutrosophic membership, respectively, of an element x to the plithogenic set P;

b) "c" means "c_F" or "c_{IF}" or "c_N", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value contradiction degree function [12,17], respectively.

c) Functions are defined according to the applications that experts need to solve. $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$, the following notation is used: $x(d(x,V))$, where $d(x,V) = \{d(x,v), \text{for all } v \in V\}, \forall x \in P$. The attribute value contradiction degree function is calculated between each attribute value with respect to the particular dominant attribute value (denoted by), and also for other attribute value v_D.

Thus, the Plithogenic IADOV method allows for addressing the complexity of respondents' perceptions. This requires a linguistic evaluation system adapted to the plithogenic model to accurately capture the opinions of experts (see Table 1). This system and its equivalents on a plithogenic scale are defined as the score function *T* of a neutrosophic number according to the formula proposed by Basset, as per equation (1) [13,19].

$$F(T) = \frac{T + F - I}{2} \quad (1)$$

Linguistic term of the plithogenic IADOV	**SVNN**	$\mathcal{S}([\mathrm{T,I,F}])$	**IADOV Neutrosophic Equivalent**
Extremely satisfied (ES)	(1,0,0)	0.50	Clearly satisfied
Very Very satisfied (VVS)	(0.95,0.15,0.14)	0.47	-
Very satisfied (VS)	(0.85,0.25,0.24)	0.42	-
Satisfied (S)	(0.75,0.35,0.34)	0.37	More satisfied than dissatisfied
Moderately satisfied (MDS)	(0.65,0.45,0.44)	0.32	-
Indefinite (I)	(0.55,0.55,0.54)	0.27	Not defined (I)
Moderately Dissatisfied (MDD)	(0.45,0.65,0.64)	0.22	-
Dissatisfied (D)	(0.35,0.75,0.74)	0.17	More dissatisfied than satisfied
Very Dissatisfied (VD)	(0.25,0.85,0.84)	0.12	
Very Very Dissatisfied (VVD)	(0,0.95,1)	0.03	Clearly dissatisfied
Contradictory (C)	(1,0,1)	1.00	Contradictory

Table 1: Evaluation System for Experts.

Source: Own Elaboration

The term *I* in Neutrosophic is interpreted as a unit of indeterminacy. Another inherent component of the method is the IADOV Logical Table, which assigns numerical values to three closed questions applied to the experts. If necessary, open questions can be included in the surveys. Among the questions used in this study are:

I. Do you believe that the sanctions proposed in the penal reform for public health are proportional to the severity of the crimes?
II. What aspects of the penal reform for public health do you consider most beneficial to ensure legal security and protect public health?
III. Do you think the penal reform includes adequate preventive measures to avoid crimes against public health?
IV. Do you agree that the penal reform should promote alternative approaches to penal sanction, such as education and mediation, for certain crimes against public health?
V. From your perspective, what improvements could be incorporated into the reform proposal to strengthen its effectiveness in preventing and sanctioning crimes against public health?

To calculate the Neutrosophic Plithogenic Global Satisfaction Index (NPGSI) of the respondents, the H_N^P aggregation operator was used, taking into account the evaluations of each element *X* to the plithogenic set *P;* $x \in Pd_F\, d_{IF}\, d_N$. This was done to obtain the NPGSI from the sum of the elements analyzed within the evaluated plithogenic subset (S_i^P) (see Equation 2).

$$H_N^P\left(S_{1,}^P S_2^P, \ldots, S_n^P\right) = \sum_{i=1}^{n} \left[w_j\, , S_i^P\right] \quad (2)$$

Among the Plithogenic Operators to be used in the study are: union (OR), intersection (AND), and other aggregation operators that combine attribute values based on t_{norm} and t_{conorm}. Linear and non-linear aggregation operations can be created [14,18].

Calculation of contradiction and aggregation: The contradiction function *c* evaluates the contradiction between attribute values. This influences how the t_{norm} and t_{conorm} are applied to create aggregation operators.

If the t_{norm} is applied to the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then it is applied to the attribute value v_2 in the following manner:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2), \quad (3)$$

Neutrosophic Plithogenic Intersection and Union: They are defined in such a way that for membership, one criterion is applied, and for non-membership, the opposite is applied, while for indeterminacy, the average is taken.

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right) \quad (4)$$

Resolution and Decision Matrix: Formulas are used to calculate the median of plithogenic numbers, allowing the construction of a unique decision matrix for all experts.

$$median_{i=1}^{m}\{PN_i\} = (median_{i=1}^{m}\{T(PN_i)\}, median_{i=1}^{m}\{I(PN_i)\}, median_{i=1}^{m}\{F(PN_i)\}), \quad (5)$$

where the analyzed elements constitute plithogenic numbers. Here the components of truth, indeterminate components, and components of falsehood are visualized. In other words, it means that the median of a set of plithogenic numbers is defined as the plithogenic number of the medians of its components $PN_i, T(PN_i), I(PN_i)$ and $F(PN_i)$.

2.1. Proposal for a Draft Bill to Amend the Comprehensive Organic Criminal Code to Typify Crimes against Public Health in Order to Guarantee the Right to Legal Security.

General Objective:

The objective of this bill proposal is to carry out a comprehensive reform of the Comprehensive Organic Criminal Code (COIP) in order to include a specific section that typifies and effectively sanctions crimes against public health. The purpose is to guarantee the right to legal security for all citizens, protect their lives, integrity, and health, and provide a clear and adequate legal framework to address health crises such as pandemics.

Statement of Reasons:

Public health is a legal good of utmost importance, as the spread of infectious diseases can have serious consequences for the general population. The global COVID-19 pandemic has highlighted the need for clear and effective penal regulations to sanction those who put public health at risk.

Currently, the COIP does not have a specific section that comprehensively addresses crimes against public health, which has led to the application of sanctions through states of exception or health emergencies. This lack of specific regulation generates legal uncertainty and hinders the proper protection of citizens' health.

It is essential to establish a solid and clear legal framework that allows for the proportional and effective sanctioning of those who fail to comply with health measures or spread infectious diseases. To this end, it is advisable to take as a reference the legislation of other countries, such as the Colombian Penal Code, which has a specific section on crimes against public health.

Law Proposal:

Article 1: A section will be added to Chapter Three - Crimes against the Rights of Good Living, which will address Crimes against Public Health.

Article 2: Violation of health measures. It is established that any person who deliberately violates the health measures adopted by the competent authority to prevent the introduction or spread of infectious diseases will be sanctioned with imprisonment of three to five years. This penalty may be increased in the case of recidivism or when the violation of measures seriously endangers the health of the population.

Article 3: Spread of infectious diseases. Any person who, intentionally, spreads infectious diseases, either by concealing their condition as a carrier, failing to comply with mandatory quarantines, or endangering the health of others, will be sanctioned with imprisonment of five to eight years. The penalty may be increased if the spread causes serious damage to public health or causes the death of people.

Article 4: Spread of diseases with aggravating factors. Aggravating factors will be established for those cases where the spread of infectious diseases is carried out by health professionals, public officials, individuals with prior knowledge of their carrier status, or organized groups with the intention of causing harm to the population. The penalties in these cases may be increased by one-third of the maximum penalty provided for each crime.

Article 5: Complementary measures. In addition to imprisonment, complementary measures such as fines, disqualification from practicing certain professions or activities, and community service may be applied. These measures will seek to ensure a comprehensive and proportional sanction to the gravity of crimes against public health.

Article 6: Inter-institutional coordination. The creation of an inter-institutional committee for the prevention and control of infectious diseases will be established. This committee will be comprised of representatives from the health, justice, and education sectors, and other related organizations, and will aim to design joint strategies to prevent, control, and sanction crimes against public health.

General Provision:

The reformed section relating to Crimes against Public Health will be incorporated into the Comprehensive Organic Criminal Code.

Final Provision:

This Draft Reform Bill will come into effect from its promulgation and publication in the Official Register.
Given and signed in the Plenum of the National Assembly of Ecuador on the __ day of _____, 202__.

2.2. Validation of the Proposal through the Plithogenic IADOV Method.

Once the draft bill amendment to the COIP is presented, the next step is to present and determine the level of acceptance by the various stakeholders involved, such as legal professionals, public health experts, representatives of civil organizations, and government authorities. To determine if the draft bill is acceptable and recognized for its contribution to society, the Plithogenic IADOV method is applied. For the development of the method, it is necessary to define the plithogenic set, the elements that influence the acceptance of the draft bill, and their degrees of membership (Plithogenic GSI) (see Table 2).

Plithogenic set	Evaluation of penal reform focused on public health in Ecuador, $\forall P_{S_n} = \{S_{V_1}, S_{V_2}, \dots, S_{V_n}\}$
Plithogenic subset	Review and acceptance phase of the preliminary project (S_1).
Attributes	Acceptance elements, $\forall S_{V_{1n}} = \{S_{V_{11}}, S_{V_{12}}, S_{V_{13}}\}$
Variable	Level of acceptance for implementing the draft bill to amend the COIP.
Factor (F)	Classification of crimes against public health in Ecuador.
Measuring scale	Plithogenic linguistic term (See Table 1).

Table 2: Characteristics of the Plithogenic Set.

Source: Own Elaboration.

For this study, only this subset within the plithogenic set is analyzed since it is in a fundamental stage in the implementation of the regulations. To this end, work was conducted with different stakeholder groups involved in the penal reform, such as legislators, criminal law experts, public health professionals, and representatives of civil society.

By using the Plithogenic IADOV method, the perceptions and expectations of the subset (S_1) regarding the proposed reform are evaluated. This analysis focuses on identifying areas of consensus, divergence, and contradiction among the groups. Among the points to be evaluated are:

- Aspects of the penal reform with a high degree of acceptance or support among the analyzed subset.
- Areas where there is uncertainty or a lack of clear consensus among the groups.
- Elements of the penal reform that face significant opposition or rejection.

The sampling procedure of 60 participants determines the distribution for the population, allowing for the direct and explicit selection of subjects considered most accessible and likely to offer the most information. Subsequently, five questions, three closed and two open, are applied to capture the diversity of opinions on penal reform. The closed questions focus on specific aspects of the proposal, while the open questions seek to obtain qualitative insights. Among the acceptance elements defined by the experts and evaluated by the Plithogenic IADOV are:

- Proportional sanctions (A1).
- Prevention measures (A2).
- Alternative approaches (A3).

The results obtained through the Plithogenic IADOV reflect the following outcomes identified in Figure 2. It illustrates the GSI calculated for each of the questions, providing a clear visualization of the areas of satisfaction and opportunities for improvement in the reform proposal. This visual analysis facilitates the identification of priorities and decision-making for the optimization of penal reform in Ecuador.

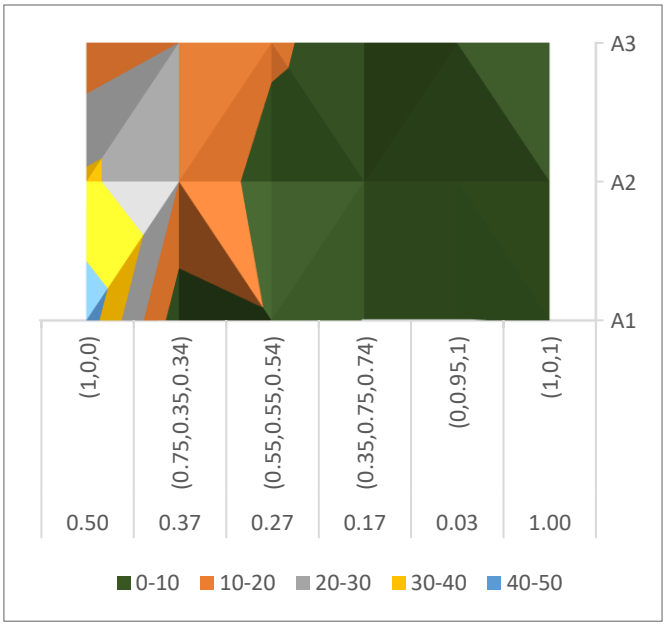

Figure 2: Segment of the plithogenic set of acceptance of the draft bill to amend the COIP.
Source: Own Elaboration.

The results obtained regarding the draft bill to amend the Comprehensive Organic Criminal Code reflect for: *Proportional sanctions* (A1) that the majority of respondents are between *Clearly satisfied and More satisfied than dissatisfied*, with a tendency towards clearly satisfied (see Table 3). This conclusion is reached because 40 to 50 people fall within the classification (1, 0, 0). Whereas, for other intermediate levels, the trend is towards the acceptance of the draft concerning element A1, and therefore a reduction in contradictions is visualized.

Linguistic term	SVNN	Scoring	Frequency	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	0.50	46	23	0.38
More satisfied than dissatisfied	(0.75,0.35,0.34)	0.37	4	1.48	0.02
Undefined	(0.55,0.55,0.54)	0.27	9	2.43	0.04
More dissatisfied than satisfied	(0.35,0.75,0.74)	0.17	0	0	0.00
Clearly dissatisfied	(0,0.95,1)	0.03	0	0	0.00
Contradictory	(1,0,1)	1.00	1	1	0.02
Group Satisfaction Index					**0.47**

Table 3: Calculation of the GSI for element (A1).
Source: Own Elaboration.

Regarding element A1, an $H_N^P = 0.47$ was obtained, resulting in a plithogenic classification of Very *Very Satisfied (VVS)* for the respondents with a value of (0.95, 0.15, 0.14), supporting the interpretation of graph 1.
For *preventive measures* (A2): the majority of respondents are in various plithogenic areas from beyond undefined to satisfied. The trend is towards the levels of *Clearly Satisfied* and *More Satisfied than Dissatisfied* (see Table 4). This trend suggests there are significant concerns about the effectiveness or sufficiency of the preventive measures included in the reform. It indicates that respondents are less satisfied with the reform's ability to prevent crimes against public health, pointing out a key area for improvement. While for lower criteria, participation is low within a range of 0 to 10 people.

Linguistic term	SVNN	Scoring	Frequency	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	0.5	32	16	0.27
More satisfied than dissatisfied	(0.75,0.35,0.34)	0.37	twenty	7.4	0.12
Undefined	(0.55,0.55,0.54)	0.27	5	1.35	0.02
More dissatisfied than satisfied	(0.35,0.75,0.74)	0.17	1	0.17	0.00
Clearly dissatisfied	(0,0.95,1)	0.025	1	0.025	0.00
Contradictory	(1,0,1)	1	1	1	0.02
Group Satisfaction Index					**0.43**

Table 4: Calculation of the GSI for element (A2).

Source: Own Elaboration.

To support the identified plithogenic trend, the GSI for this element was evaluated, where an $H_N^P = 0.43$. was obtained. The obtained classification represents an evaluation close to the plithogenic criterion of *Very Satisfied (VS)* with a value of (0.85, 0.25, 0.24). Therefore, it reinforces the acceptance of this plithogenic trend and defines a criterion within the evaluated levels.

As for *alternative approaches* (A3): The respondents consider it would be beneficial to incorporate monitoring and review mechanisms into the draft bill, consider human rights aspects, and promote a comprehensive approach that combines sanctions with preventive strategies. This generalized criterion by the respondents focuses on a suggestion or proposal for inclusion. Thus, the respondents accept and support the draft bill (action X) and, at the same time, indicate a suggestion or condition (action Y). Therefore, in the plithogenic area, 10 to 33 people are defined as being in the areas of *Clearly Satisfied* and *More Satisfied than Dissatisfied*, which supports action X. Whereas 0 to 20 people support action Y. In addition, a small minority of people with indeterminate and contradictory criteria in this element is observed.

Linguistic term	SVNN	Scoring	Frequency	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	0.5	13	6.5	0.11
More satisfied than dissatisfied	(0.75,0.35,0.34)	0.37	twenty	7.4	0.12
Undefined	(0.55,0.55,0.54)	0.27	12	3.24	0.05
More dissatisfied than satisfied	(0.35,0.75,0.74)	0.17	4	0.68	0.01
Clearly dissatisfied	(0,0.95,1)	0.025	10	0.25	0.00
Contradictory	(1,0,1)	1	1	1	0.02
Group Satisfaction Index					**0.32**

Table 5: Calculation of the GSI for element (A3).

Source: Own Elaboration.

To support the indeterminate plithogenic trend, the GSI is evaluated and defined to what point it is oriented. Therefore, the modeling for this element obtained an $H_N^P = 0.32$.. The GSI of this element orients the trend towards a plithogenic criterion of *Moderately Satisfied (MDS)* with a value (0.65, 0.45, 0.44). In order to achieve a higher level of plithogenic satisfaction, it is necessary to incorporate monitoring and review mechanisms.

The obtaining of plithogenic GSIs allows for defining the neutrosophic membership degree d_N of the attribute value of each element x to the set P for the established elements (A1, A2, and A3). However, with the coexistence of indeterminate and opposing criteria to the levels of satisfaction, it is proposed to perform an intersection between the predominant criteria like the element (A3). For this, it is proposed to analyze and define the criteria between legislators and professionals to determine the level of contradiction between the criteria and obtain an evaluation of the element from the following plithogenic intersection:

- Plithogenic intersection between legislators ($A3_1$) and public health professionals ($A3_2$) (see Tables 6 and 7).
- Define the scope of the consensus area: Obtain conformity with international standards and the implementation of preventive measures. In addition, to achieve mutual recognition of the importance of aligning legislation with Ecuador's international commitments and including preventive strategies within the legal framework.

$A3_1$	$A3_2$
S (0.75, 0.35, 0.34)	MDS (0.65, 0.45, 0.44).

Table 6: Evaluations between the elements $A3_1$ and $A3_2$.

Source: Own Elaboration.

Neutrosophic Plithogenic Intersection	S_N	Contradiction: $v(A3_1; A3_2)$	Assessment
$(a_1, a_2, a_3) \wedge_p (b_1, b_2, b_3)$ = (0.66,0.40,0.44)	0.35	0.05	It is located in a sublevel between *Satisfied* and *Moderately Satisfied*.

Table 7: Plithogenic Neutrosophic Intersection between the elements $A3_1$ and $A3_2$.

Source: Own Elaboration.

Therefore, given that the contradiction is low and an area of consensus among the criteria of the different stakeholders was defined, an evaluation of *satisfaction with a certain degree of dissatisfaction* is achieved. This

low degree of dissatisfaction focuses on improving some aspects of the draft bill, such as strengthening the effectiveness of the draft by considering preventive measures and consultations by health and law experts. It is also suggested to incorporate monitoring and review mechanisms that combine sanctions with preventive strategies.

To conclude the analysis, the GSI of elements A1, A2, and A3 was determined, with a plithogenic value that is close to a sublevel near *Very Satisfied (MS) to Satisfied (S)*. Thus, a satisfactory index value in the plithogenic segment was observed, reflecting acceptance and recognition of its utility. This translates into the legislators and criminal law experts issuing criteria where they demonstrated their satisfaction with the contribution of the draft bill to amend the COIP. Additionally, to achieve the implementation of the draft bill to amend the comprehensive organic criminal code based on plithogenic intersections of the elements, the following strategies are proposed:

- Multidisciplinary dialogues: Organize dialogue tables that bring together representatives of each interest group to discuss and jointly refine the key aspects of the reform, based on the identified areas of consensus.
- Legislative analysis and adjustments: Use the plithogenic intersections as a guide to making specific adjustments to the draft, ensuring it effectively responds to the concerns and suggestions of the different stakeholder groups.
- Promotion of inter-sectorial collaboration: Encourage ongoing collaboration between the legal and public health sectors, as well as with civil society, for the effective implementation and monitoring of the reform once approved.

3. CONCLUSIONS.

The primary findings of this research indicate that the proposed criminal reform for public health in Ecuador has garnered a high degree of approval among various stakeholders, with satisfaction levels ranging from "Very Satisfied" to "Satisfied." This consensus not only highlights a favorable reception but also points to the necessity of integrating monitoring and reviews mechanisms, as well as a holistic approach that pairs punitive measures with preventive strategies. Employing the Plithogenic IADOV method allowed for a nuanced breakdown and analysis of the reform from diverse critical perspectives, effectively managing uncertainties and contradictions through intersection operators to identify agreed-upon actions and overcome potential challenges. The practical significance of these results lies in their capacity to guide the implementation of a robust and equitable legislative framework aimed at safeguarding public health and ensuring legal security. By synthesizing areas of convergence among interest groups and promoting a balance between sanctioning offenses and preventive measures, this study offers clear directives for lawmakers and policymakers. Consequently, the findings present opportunities to enhance legal responses to public health crimes, particularly during crises, while ensuring that the resulting regulations are both effective and socially acceptable. Notably, the study contributes an innovative methodological approach by incorporating the Plithogenic IADOV technique into legislative reform analysis. This flexible and dynamic method not only serves as a valuable tool for deconstructing complex legal issues but also advances the field by demonstrating how to integrate varied perspectives and handle indeterminate factors in policy formulation. Such an approach paves the way for replicable models in similar legislative contexts and broadens the scope of applying advanced techniques in evaluating and crafting public policies.

Nonetheless, certain limitations are apparent. For instance, the draft law requires refinements in terminological precision and clearer definitions of key concepts, indicating that some aspects remain open for improvement. Furthermore, while stakeholder approval is promising, it does not guarantee a seamless implementation; the true effectiveness of the proposal will depend on how well the diverse inputs are managed and incorporated during execution. Looking ahead, it is advisable to explore complementary methods alongside Plithogenic IADOV, such as fuzzy analysis or artificial intelligence techniques, which might enrich the evaluation of complex legislative reforms further. Moreover, deepening consultations with experts in health and law, and establishing ongoing monitoring and evaluation mechanisms, will be crucial to ensure the law's adaptability and relevance. Expanding research to encompass different contexts and populations can help validate and generalize these findings, ultimately ensuring that legal reforms evolve effectively to meet society’s emerging needs.

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MODELING OF THE PLITHOGENIC IADOV METHOD TO STRENGTHEN LEGAL AND EDUCATIONAL FRAMEWORKS AGAINST CHEMICAL AGGRESSIONS

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ABSTRACT
In Ecuador, aggressions using chemical substances are recognized as acts of violence capable of inflicting both physical and emotional harm on individuals, with potentially severe medical and psychological repercussions for those who suffer them. These actions, classified as crimes within the country's legal framework, can lead to charges against the aggressors ranging from personal injury to accusations of attempted homicide. Thus reflecting the commitment of Ecuadorian legislation to safeguard victims and ensure an adequate judicial response to such incidents. Therefore, the study aims to propose actions that provide security to citizens who are victims of chemical substance aggression. To this end, a survey was conducted and processed among people affected by chemical substance aggressions and some of their relatives using the Plithogenic IADOV method. Among the main results, dissatisfaction with the handling of these cases during the pandemic is evident. Thus, proposals for actions aimed at increasing citizen security against chemical aggressions are encouraged. The plithogenic intersection between subsets proposes improving prevention and legal management by suggesting measures that seek not only to enhance citizen security but also to optimize legal prevention and response to this type of violence and its effects.
KEYWORDS: Aggressions; chemical substances; victim; legal framework; Plitogenic IADOV.

MSC: 03b52, 62p25, 91d10, 91b06, 93a30

RESUMEN
En Ecuador, las agresiones con sustancias químicas son reconocidas como actos de violencia capaces de infligir tanto daño físico como emocional a las personas, con repercusiones médicas y psicológicas potencialmente graves para quienes las sufren. Estas acciones, clasificadas como delitos dentro del marco legal del país, pueden llevar a cargos contra los agresores que van desde lesiones personales hasta acusaciones de intento de homicidio, lo que refleja el compromiso de la legislación ecuatoriana con la protección de las víctimas y la garantía de una respuesta judicial adecuada. El presente estudio tiene como objetivo proponer acciones que brinden seguridad a los ciudadanos víctimas de agresiones con sustancias químicas. Se realizó una encuesta entre personas afectadas por estas agresiones y algunos de sus familiares, cuyos datos fueron procesados mediante el método Plitogénico IADOV. Los principales resultados muestran insatisfacción con el manejo de estos casos durante la pandemia. Por lo tanto, se promueven propuestas de acciones encaminadas a aumentar la seguridad ciudadana frente a las agresiones químicas. La intersección plitogénica entre subconjuntos propone mejorar la prevención y la gestión legal, sugiriendo medidas que buscan no solo mejorar la seguridad ciudadana, sino también optimizar la prevención y la respuesta legal ante este tipo de violencia y sus efectos.
PALABRAS CLAVE: agresiones, sustancias químicas, víctima, marco legal, Plitogénico IADOV.

Msc :

1. INTRODUCTION

Acid attacks and other chemical substances as manifestations of extreme violence. These acts are characterized by the intention to inflict severe harm through disfigurement, mutilation, torture, or even the death of the victims. Thus, they reflect premeditation and malice inherent in the attacker's behavior. For this, the resulting injuries are classified based on the causative agent, the type and permanence of the sequelae, as well as the duration of the generated disability, whether it is temporary or permanent.

Globally, and specifically in Ecuador, these crimes, although not numerically dominant, have gained notoriety as methods of revenge and are closely linked to acts of gender violence, including femicides [1] [2] [3]. The Constitution of the Republic of Ecuador establishes the state's commitment to protecting life, promoting an environment free of violence, and fostering good living. However, the existence of uncertainty regarding the legal and procedural mechanisms for addressing these crimes is pointed out, emphasizing the need to strengthen prevention and response policies.

According to data from the Institute of Legal Medicine, in Ecuador, between 8 and 12 victims of aggressions with corrosive substances are registered annually, although a significant dark figure is acknowledged due to fear of retaliation and the stigma associated with reporting these crimes. The situation was aggravated during the COVID-

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19 pandemic, a period in which domestic tension increased and, consequently, so did this type of aggression. Thus, shortcomings in legal compliance and awareness of the rights of victims are evident.

Classification of burns and their effect on people.

The classification of the agents causing these injuries is divided into physical (such as cold, heat, electricity, and radiation), chemical (acids, alkalis, medications, fuel, among others), and biological. The resulting burns can have both temporary and permanent effects on health, including scarring, skin discoloration, and damage to internal organs through chemical absorption into the bloodstream [13,15].

Acid attacks are often directed against women as a form of punishment for rejecting sexual proposals or out of jealousy, often involving romantic partners or rejected individuals [16]. The acids most frequently used in these attacks are sulfuric, nitric, and hydrochloric, with the latter being easily accessible in many contexts. The severity of the injuries can affect critical areas of the body, such as the head and trunk, with potentially permanent consequences [9,14].

These attacks not only seek to inflict physical harm but also have a significant psychological and social component, attempting to punish or control the victims through fear and intimidation. The prevalence of this type of violence underscores the need for more effective legal and preventive actions to protect potential victims and punish the perpetrators.

Legal framework.

The legal review underscores the importance of the right to personal integrity as a fundamental pillar of legislation. In such a way, it emphasizes the protection of life and the preservation of the physical, psychological, and moral integrity of the human being. Physical integrity is related to maintaining good health, while psychological integrity encompasses the motor, psychological, and intellectual capacities necessary for personal development. Moral integrity, on the other hand, is associated with the right of each individual to live according to their convictions.

The Constitution of Ecuador firmly establishes the principle of legal security, based on respect for the Constitution and the existence of prior, clear, and public legal norms, applied by competent authorities. In addition, it identifies several vulnerable groups specifically protected by the Magna Carta, to whom the state must guarantee rights and grant benefits.

The right to due process is governed by principles such as legality, procedural challenge, intimacy, contradiction, motivation, impartiality, privacy, confidentiality, and objectivity. Regarding the crime of injuries, Ecuadorian criminal legislation establishes specific sanctions based on the severity of the damage caused to the victim, with penalties ranging from thirty days to seven years of deprivation of liberty, depending on the severity and consequences of the injuries.

However, despite the classification of "Permanent damage to health" in the Comprehensive Organic Criminal Code, there is a notable absence of specific provisions for crimes involving the use of acids and other chemical substances. This omission contrasts with the constitutional principles related to "good living" and underscores the need for these forms of aggression to be adequately considered and classified in the legislation. Article 151 of the mentioned code defines torture in a way that includes inflicting severe pain or suffering, whether physical or psychological, with sanctions of up to thirteen years of deprivation of liberty under certain circumstances. This legislative review highlights the urgency of adapting criminal legislation to offer more comprehensive and effective protection against all forms of aggression that compromise personal integrity.

In this context, researchers propose to develop strategies aimed at providing greater security to citizens affected by chemical substance attacks [6,10] [12]. This approach involves a critical review of current policies and the implementation of concrete measures to improve legal protection and support for victims. This ensures a comprehensive and effective response to this type of violence.

2. NEUTROSOPHIC AND PLITHOGENIC LOGIC.

In neutrosophic sets, indeterminacy is explicitly quantified through a new parameter I. True membership (t), indeterminate membership (I), and false membership (F) are independent of each other, and the sum between them satisfies the inequalities $0 \leq T + I + F \leq 3$ [9]. The term Neutrosophic means knowledge of neutral thought, and this neutrality represents the main distinction between fuzzy logic and intuitionistic fuzzy logic.

If U is 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 satisfy the condition

$$0 \leq -\inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3+$$

for all $x \in X$. $u_A(x), r_A(x), v_A(x)$ are the membership functions of the truth, indeterminacy, and falsehood of x in A, respectively, and their images are standard or non-standard subsets of $]0-, 1+[$.

Addressing the perspective of indeterminacy and contradiction, as is the case with Gödel's incompleteness theorem, it posits that any proposition in a mathematical axiom system will present a degree of truth (T), falsehood (F), and indeterminacy (I). Neutrosophic, therefore, establishes a unique solution for the existence of paradoxes in philosophy 4,11].

Plithogeny is the genesis or origin, creation, formation, development, and evolution of new entities from dynamics and fusions of multiple previous entities that are contradictory and/or neutral and/or non-contradictory [5,8]. Plithogeny advocates for connections and the unification of theories and ideas in varied fields of science. As "entities," "knowledge" in various fields is taken, such as social sciences, technical sciences, theories of arts and letters, etc.

Plithogeny is the dynamics of various types of opposites, and/or their neutrals, and/or non-opposites and their organic fusion. Plithogeny is a generalization of dialectics (dynamics of one type of opposites: <A> and <antiA>), Neutrosophic (dynamics of one type of opposites and their neutrals: <A> and <antiA> and <neutA>), as Plithogeny studies the dynamics of many types of opposites and their neutrals and non-opposites (<A> and <antiA> and <neutA>, <B> and <antiB> and <neutB>, etc.), and many non-opposites (<C>, <D>, etc.) all together. As an application and particular case derived from Plithogeny, the plithogenic set is an extension of the classical set, fuzzy set, intuitionistic fuzzy set, and neutrosophic set, and has multiple scientific applications.

So, it is called a plithogenic set.(P, a, V, d, c)

1. Where "P" is a set, "a" is an attribute (multidimensional in general), "V" is the range of values of the attribute, "d" is the degree of membership of the attribute value of each element x to the set P for some given criteria ($x \in P$), and "d" means "d_F" or "d_{IF}" or "d_N", when it is a degree of fuzzy membership, an intuitionistic fuzzy membership, or a degree of neutrosophic membership, respectively, of an element x to the plithogenic set P;
2. "c" means "c_F" or "c_{IF}" or "c_N", when it is a fuzzy attribute value contradiction degree function, intuitionistic fuzzy attribute value contradiction degree function, or neutrosophic attribute value contradiction degree function, respectively.

Functions are defined according to the applications that experts need to solve. $d(\cdot,\cdot)$ and $c(\cdot,\cdot)$ then, the following notation is used: $x(d(x,V))$, where $d(x,V) = \{d(x,v)$, for all $v \in V\}, \forall x \in P$. The attribute value contradiction degree function is calculated between each attribute value for the dominant attribute value (denoted by) in particular, and also for other attribute values v_D.

The attribute value contradiction degree function c evaluated between the values of two attributes is used in the definition of plithogenic aggregation operators (intersection (AND), union (OR), implication ($\Longrightarrow$), equivalence ($\Longleftrightarrow$), inclusion (partial order), and other plithogenic aggregation operators that combine two or more attribute value degrees based on a t_{norm} and a t_{conorm}. Most plithogenic aggregation operators are linear combinations of fuzzy t_{norm} (indicated by) with a fuzzy t_{conorm} (indicated by), but non-linear combinations can also be constructed $\wedge_D$ and $\vee_D$.

If the t_{norm} is applied to the dominant attribute value denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then it is applied to the attribute value v_2 as follows:

$$[1 - c(v_D, v_2)] \cdot t_{norm}(v_D, v_2) + c(v_D, v_2) \cdot t_{conorm}(v_D, v_2), \quad (1)$$

Or according to the following expression:

$$[1 - c(v_D, v_2)] \cdot (v_D \wedge_F v_2) + c(v_D, v_2) \cdot (v_D \vee_F v_2), \quad (2)$$

Similarly, if the t_{conorm} is applied to the value of the dominant attribute denoted by v_D, and the contradiction between v_D and v_2 is $c(v_D, v_2)$, then it is applied to the attribute value v_2 as shown below:

$$[1 - c(v_D, v_2)] \cdot t_{conorm}(v_D, v_2) + c(v_D, v_2) \cdot t_{norm}(v_D, v_2), \quad (3)$$

Or, according to the following expression:

$$[1 - c(v_D, v_2)] \cdot (v_D \vee_F v_2) + c(v_D, v_2) \cdot (v_D \wedge_F v_2), \quad (4)$$

The plithogenic neutrosophic intersection is defined as:

$$(a_1, a_2, a_3) \wedge_P (b_1, b_2, b_3) = \left(a_1 \wedge_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \vee_F b_3\right), \quad (5)$$

The plithogenic neutrosophic union is defined as:

$$(a_1, a_2, a_3) \vee_P (b_1, b_2, b_3) = \left(a_1 \vee_F b_1, \frac{1}{2}[(a_2 \wedge_F b_2) + (a_2 \vee_F b_2)], a_3 \wedge_F b_3\right), \quad (6)$$

In other words, regarding what applies to membership, the opposite applies to non-membership, while for indeterminacy, the average between them is applied. Next, an algorithm for resolving this research is presented, where Plithogeny is merged with the Neutrosophic algorithm. From this point forward, the previously mentioned expressions should be applied to execute the operations of the classic algorithm with plithogenic numbers.

To create a single decision matrix, the median of the plithogenic numbers for each combination, for all specialists, is calculated. The median is calculated using the following formula:

$$\text{median}_{i=1}^{m}\{PN_i\} = (\text{median}_{i=1}^{m}\{T(PN_i)\}, \text{median}_{i=1}^{m}\{I(PN_i)\}, \text{median}_{i=1}^{m}\{F(PN_i)\}), \quad (7)$$

Where PN_i, are plithogenic numbers, $T(PN_i)$ are their truth components, $I(PN_i)$ are their indeterminate components, and $F(PN_i)$ are their falsehood components. In other words, it means that the median of a set of plithogenic numbers is defined as the plithogenic number of the medians of its components.

To compare the relationships between the quadrants, the following formula is used to blur a neutrosophic number. To compare the relationships between the quadrants, the following formula is used to blur a neutrosophic number[5]:

$$\mathcal{S}([\mathrm{T},\mathrm{I},\mathrm{F}]) = \frac{2+\mathrm{T}-\mathrm{I}-\mathrm{F}}{3} \quad (8)$$

- Determine for each line of the pairwise comparison matrix, a weighted sum based on the sum of the product of each cell times the priority of each corresponding alternative or criterion (see Table 1).

Linguistic Expression	Scale	Plithogenic number (T, I, F)	S
Poor Importance (PI)	0	(0.12, 0.92, 0.97)	0.08
Less Important (LI)	1	(0.27, 0.87, 0.82)	0.19
Low Importance (LWI)	2	(0.42, 0.67, 0.72)	0.34
Moderately Important (MDI)	3	(0.57, 0.52, 0.62)	0.48
Important (I)	4	(0.72, 0.37, 0.52)	0.61
More Important (MI)	5	(0.82, 0.27, 0.12)	0.81
Very Important (VI)	6	(0.97, 0.07, 0.03)	0.96

Table 1: Linguistic expression to determine the level of importance of the factor on the variable. Source: own elaboration.

- For each line, divide its weighted sum by the priority of its corresponding alternative or criterion.
- Determine the average λmax of the result of the previous stage.
- Calculate the consistency index (CI) for each alternative or criterion.

$$CI = \frac{\lambda_{max} - m}{m-1} \quad (9)$$

Where *m* is the number of alternatives

- Determine the Random Index (RI) from Table 2
- Determine the consistency quotient index (the ratio between the consistency index and the random index.
-

3. METHOD

The Neutrosophic IADOV technique integrates traditional IADOV methodology with neutrosophic logic to assess satisfaction levels, accounting for uncertainty and contradictions in expert opinions. The steps to apply this technique are as follows

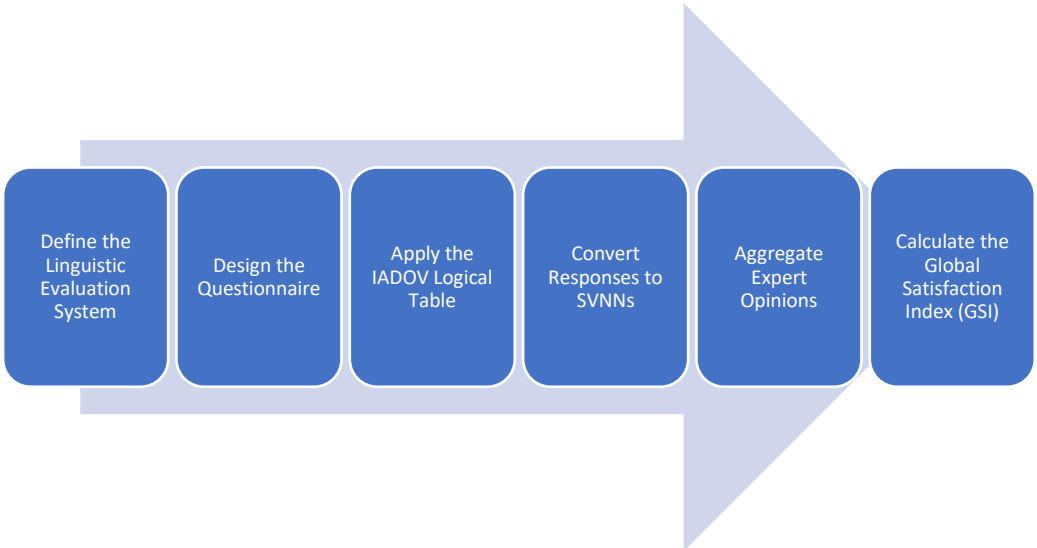

Figure 1: IADOV Methodological Framework

To apply the neutrosophic IADOV technique, experts must rely on a linguistic evaluation system that reflects the expert's opinion. This system and its neutrosophic and numerical equivalents are shown in Table 2.

Linguistic term	SVNN	Scale
Clearly satisfied	(1,0,0)	3

More satisfied than dissatisfied	(1,0.35,0,35)	23
Undefined	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 2: Evaluation system for experts. Linguistic terms are associated with their neutrosophic evaluation and score value. Source: own elaboration.

The term I in Neutrosophic 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 applied to the experts (see Table 3). If necessary, open-ended questions can be included in the surveys.

Approaches	**Possible answers**								
1st QUESTION	Do you think that the level of response to aggressions with chemical substances satisfies the victims and their families?								
2nd QUESTION	Yes			I don't know			No		
Do you think that a Response System for attacks with chemical substances should be developed?	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
3rd QUESTION	How do you perceive the results obtained in the judicial processes regarding aggressions with chemical substances?								
Clear satisfaction	1	2	6	2	2	6	6	6	6
More satisfied than dissatisfied	2	3	3	2	3	3	6	3	6
Undefined	3	3	3	3	3	3	3	3	3
More dissatisfied than satisfied	6	3	6	3	4	4	3	4	4
Clear dissatisfaction	6	6	6	6	4	4	6	4	5
Contradictory	2	3	6	3	3	3	6	3	4

Table 3: Logical Framework of the IADOV Method. Source: own elaboration.

To survey the satisfaction level of experts, the neutrosophic IADOV technique was used. This technique is based on the use of Single-Valued Neutrosophic Sets (SVNS) associated with linguistic variables or their ability to enhance interpretation in recommendation models and the use of indeterminacy.
The definition of SVNS is as follows, let X be a universe of discourse. An SVNS A over X is an object of the form[9].

$$A = \{[x, u_a(x), r_a(x), v_a(x)] : \in X\}\, dA = \{[x, u_a(x), r_a(x), v_a(x)] : \in X\} d \quad (10)$$

Where $u_a(x)$: $X \rightarrow [0,1], r_a(x)$: $X \rightarrow [0,1]$ y $v_a(x)$: $X \rightarrow [0,1]$,
With $0 \leq u_a(X), r_a(X), v_a(X) \leq 3, \forall x \in X$
For convenience, a Single Value Neutrosophic Number (SVNS) will be expressed as$A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfies $0 \leq a + b + c \leq 3$.
Aggregation operators are used to find a single SVNS set that describes several sets at the same time. One of these operators is the neutrosophic weighted average (WA), which is defined as follows
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 (WA) operator is calculated as[9]:

$$WA\,(A_1, A_2, \dots, A_n) = \sum_{i=1}^{n} [w_j\,, A_i] \quad (11)$$

Where $WA\,(w_1, w_2, \dots, w_n) = \sum_{i=1}^{n} [w_j\,, A_i]$ is the $A_j\ (j = 1,2, \dots, n)$ vector such that $w_n \in [0,1]$ and $\sum w_j = 1$.
To calculate the Global Satisfaction Index (GSI) of the respondents, the WA aggregation operator was used, taking into account the score values and that all respondents have the same weight, so $w_i = \frac{1}{n}$.

4. RESULTS

The research analyzed five cases of chemical substance aggressions that occurred during the pandemic. For the modeling of the information, the Plithogenic IADOV method was applied to evaluate the satisfaction of the victims and their families regarding the legal treatment received (see Figure 1).

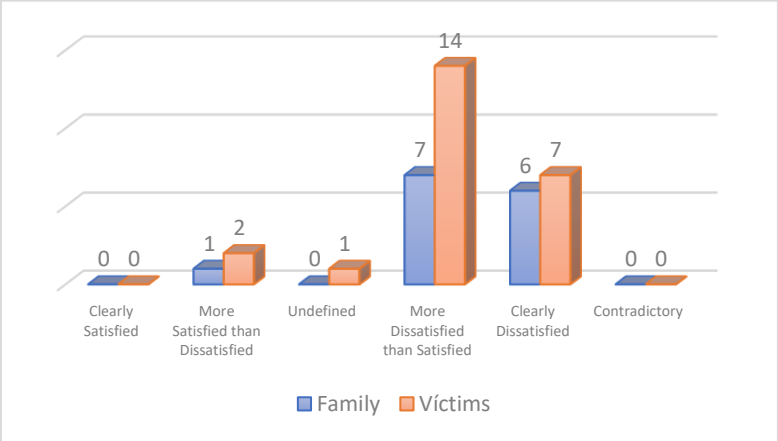

Figure 1: Satisfaction levels of the expert group for each factor. Source: Own elaboration.

The study involved individuals, including victims and relatives, who revealed pronounced dissatisfaction with judicial processes. Many attribute this dissatisfaction to perceived neglect during the pandemic, which exacerbated their discomfort and underscored the need for additional psychological support. The calculations of the Global Satisfaction Index (GSI) according to the observation frequency and the individual satisfaction indexes of this subset and their corresponding scores are shown in Tables 4 and 5, for each analyzed subset.

Linguistic term	**SVNN**	**Punctuation (S)**	**Frequency (F)**	**FS**	**(FS)/n**
Clearly satisfied	(1,0,0)	3	0	0	0.00
More satisfied than dissatisfied	(1,0.35,0.35)	23	1	2.5	0.18
Undefined	I	1.5	0	0	0.00
More dissatisfied than satisfied	(0.35, 0.35.1)	1	7	7	0.50
Clearly dissatisfied	(0,0,1)	0.5	6	3	0.21
Contradictory	(1,0,1)	2	0	0	0.00
Group Satisfaction Index					**0.89**

Table 4: Calculation of the GSI of the legal and judicial framework subset according to the perspective of assault victims. Source: Own elaboration.

Linguistic term	**SVNN**	**Punctuation (S)**	**Frequency (F)**	**FS**	**(FS)/n**
Clearly satisfied	(1,0,0)	3	0	0	0.00
More satisfied than dissatisfied	(1,0.35,0.35)	2.5	2	5	0.21
Undefined	Yo	1.5	1	1.5	0.06
More dissatisfied than satisfied	(0.35, 0.35.1)	1	14	14	0.58
Clearly dissatisfied	(0,0,1)	0.5	7	3.5	0.15
Contradictory	(1,0,1)	2	0	0	0.00
Group Satisfaction Index					**1.00**

Table 5: Calculation of the ISG of the legal and judicial framework subset according to the perspective of the victim's relatives. Source: Own elaboration.

From the analysis of the legal and judicial subset, it can be observed that patients are *mostly dissatisfied rather than satisfied* and *clearly dissatisfied*. The survey revealed that neither the victims nor their families felt satisfied with the handling of the cases. This indicates a significant gap between justice expectations and the experienced reality. This finding highlights the urgency of improving legal actions and awareness to protect and safeguard the victims of these aggressions.

When analyzing this neutrosophic subset concerning the plithogenic variable of the *level of response to chemical aggression*, it can be argued that the contradiction levels are at zero. Meanwhile, the resulting indeterminacy

reflects the discomfort due to the importance of the process of protecting the victims of the aggressions. Therefore, the obtained results should be taken into the plithogenic logic and analyzed both within and outside the subset. To do this, an extension to the IADOV method should be carried out when analyzing the results and their intersection within the plithogenic set.

To perform a plithogenic analysis of the IADOV results, we must first consider that aggressions with chemical substances represent a severe form of violence. Such violence inflicts lasting physical and psychological harm on the victims and has profound implications for their family and social environment. Therefore, to determine the scope of this factor and how it affects society, we need to understand the characteristics of the plithogenic set (see Table 6).

Plithogenic set:	Response system to aggressions with chemical substances, $\forall F_{V_n} = \{F_{V_1}, F_{V_2}, F_{V_3}\}$
Subset Attributes:	• Prevention of attacks, $\forall F_{V_{1n}} = \{F_{V_{11}}, F_{V_{12}}, F_{V_{13}}, F_{V_{14}}\}$ • Treatment of victims, $\forall F_{V_{2n}} = \{F_{V_{21}}, F_{V_{22}}, F_{V_{23}}\}$ • Legal and judicial framework, $\forall F_{V_{3n}} = \{F_{V_{31}}, F_{V_{32}}\}$
Variable:	Level of response to aggressions with chemical substances.
Factor (F):	Attacks with chemical substances.
Measuring scale	Linguistic term (See Table 1).

Table 6: Characteristics of the plithogenic set. Source: own elaboration.

As can be seen, the plithogenic set is composed of three subsets: V_1, V_2, and V_3. Therefore, a plithogenic set consisting of 7 attributes is defined, each with its respective attributes and possible values in linguistic expression to determine the level of importance of the factor on the variable (see Table 5). Additionally, it can be observed that for this analysis, the attributes of aggression prevention and victim treatment were expanded, as well as the sub-dimensions they interact with (see Table 7).

No.	Dimension	COD	Sub-dimension or factor	$d_n(x; V_n)$	Attribute value
V1	Aggression prevention	v11	Education and Awareness	(0.82, 0.27, 0.12)	MI
		v12	Control and regulation of substances	(0.72, 0.37, 0.52)	I
		v13	Community programs	(0.97, 0.07, 0.03)	VI
		v14	Awareness campaigns	(0.82, 0.27, 0.12)	MI
V2	Treatment of victims	v21	Immediate medical attention	(0.57, 0.52, 0.62)	MDI
		v22	Psychological support	(0.42, 0.67, 0.72)	LWI
		v23	Long-term rehabilitation	(0.72, 0.37, 0.52)	I
V3	Legal and judicial framework	v31	Protection of victims	(0.27, 0.87, 0.82)	MI
		v32	Prosecution of offenders	(0.82, 0.27, 0.12)	MI

Table 7: Structure, d_N, and attribute value within the plithogenic set. Source: own elaboration.

A plithogenic multi-attribute set of dimension 3 and cardinality 4x3x2 = 24 is represented, with dominant values in attributes v_{13}, v_{23}, and v_{32}. Therefore, the degrees of contradiction between the values for each attribute within each dimension are defined:

- Dimension V_1: $c_N(v_{13}, v_{11}) = 0.10$; $c_N(v_{13}, v_{12}) = 0$; $c_N(v_{13}, v_{14}) = 0.06$
- Dimension V_2: $c_N(v_{23}, v_{21}) = 0.05$; $c_N(v_{23}, v_{22}) = 0.10$
- Dimension V_3: $c_N(v_{32}, v_{31}) = 0$

When v_{23}, v_{13}, and v_{32} are activated, it triggers the union and interaction with the other attributes, indicating that the level of response to chemical aggression is caused by:

- The deficit of community programs aimed at preventing aggression (dominant value in the plithogenic subset V_1).
- There is no focused long-term rehabilitation follow-up in the treatment of victims of aggression (dominant value in the plithogenic subset V_2).
- The delay in processing aggressors within the legal and judicial framework (dominant value in the plithogenic subset V_3).

From these three neutrosophic subsets analyzed, it is observed that the most dominant within the plithogenic set is the element aimed at preventing aggression through community programs. This subset constitutes the gateway to aggression with chemical substances, while the other subsets are focused after the aggression has occurred. To determine a level of solution, it is necessary to know which subsets to act on through the relationship and the level of importance (Table 8), as follows:

- Community programs and long-term rehabilitation (see Table 9).
- Community programs and aggressors' processing (see Table 10).

V_{13}	V_{23}	V_{32}
VI(0.97, 0.07, 0.03)	**I**(0.72, 0.37, 0.52)	**MI**(0.82, 0.27, 0.12)

Table 8. Evaluations between the elements of the sub-dimensions (v_{13}), (v_{23}), and (v_{32}). Source: Own elaboration.

Neutrosophic Plithogenic Union	S_N	**Assessment**
(a1, a2, a3) $\vee_p$ (b1, b2, b3) = (a1$\wedge_d$b1,$\frac{1}{2}$[(a2$\wedge_d$b2)+(a2$\vee_d$b2)], a3$\wedge_d$b3)	0.7913	It is located in a sublevel between I and MI
(a1, a2, a3) $\vee_p$ (b1, b2, b3) = (0.82,0.22,0.23)		

Table 9: Plithogenic neutrosophic union between sub-dimensions V_{13} and V_{23}. Source: own elaboration.

Neutrosophic Plithogenic Intersection	S_N	**Assessment**
(a1, a2, a3) $\wedge_p$ (b1, b2, b3) = (a1$\wedge_d$b1,$\frac{1}{2}$[(a2$\wedge_d$b2)+(a2$\vee_d$b2)], a3$\vee_d$b3)	0.8753	It is located in a sublevel between MI and VI
(a1, a2, a3) $\wedge_p$ (b1, b2, b3) = (0.88,0.17,0.08)		

Table 10: Plithogenic neutrosophic intersection between sub-dimensions V_{13} and v. Source: own elaboration.

There is a stronger relationship between the subsets of *aggression prevention and legal and judicial framework [in their attributes (v_{13}) and (v_{23})]* than *between aggression prevention* and *victim treatment*, considering the most predominant factors. A relationship closer to *more important than very important* is obtained according to the neutrosophic plithogenic union and intersection operator. Therefore, solutions should focus on addressing factors (v_{13}) and (v_{32}) that affect the development of education. Consequently, the intersection of both subsets generates a plithogenic area called chemical education and legislation with a $d_n(x;\ V_n)$ of (0.88, 0.17, 0.08). Therefore, actions are proposed to address these needs, focused on both the legal and prevention and education fields (see Table 11). These include ensuring adequate punishment for aggressors and offering legal training and advice to the population.

No.	Action/alternative	Description and scope	Implementation	Time
1	Multimedia educational campaigns.	Dissemination of dangers and legal consequences of chemical aggressions through various means.	Content creation and alliances with media.	1-6 months
2	School awareness programs.	Integration of programs on legal and social responsibility against chemical aggressions in the school curriculum.	Collaboration with educational institutions for curricular development.	6-12 months
3	Specialized training for law enforcement.	Training in handling chemical incidents and evidence collection.	Organize workshops and courses with experts in chemistry and legislation.	3-6 months
4	Strengthening the legal framework.	Strengthening laws related to chemical assaults to ensure adequate punishments.	Legal analysis and proposals for modification or new laws.	6-12 months
5	Creation of a helpline.	Legal and psychological assistance for victims of chemical attacks.	Establishment of helpline services and an online portal.	3-6 months
6	Collaboration with the chemical industry	Implementation of controls on hazardous substances to reduce their availability.	Agreements and regulatory policies with chemical companies.	6-12 months

7	Observatory of chemical aggressions.	Monitoring and analysis of cases for the creation of effective public policies.	Development of data infrastructure and collaboration with research entities.	12-24 months

Table 11: Strategies to strengthen the prevention and legal management of chemical aggressions. Source: own elaboration.

6. CONCLUSION

Acid attacks represent a severe form of violence that inflicts lasting physical and psychological harm on victims and has profound implications for their families and social environment. This type of aggression, which is increasing both in Ecuador and globally, demands a more decisive legislative and social response. The integration of the IADOV Plithogenic method offers a detailed and nuanced way to assess the satisfaction or adequacy of different attributes in a complex system. By applying this method to the analysis of responses to chemical aggression, it is possible to more precisely identify where to focus improvement efforts based on the plithogenic evaluation of each component of the system. It is crucial to implement stricter sanctions for perpetrators of chemical aggression, underlining the premise that the intention behind these acts is to cause significant harm. Based on expert recommendations, the importance of adopting specific measures to prevent these crimes in Ecuador is emphasized, advocating for the well-being of victims and public safety.

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NEUTROSOPHIC ANALYSIS OF PROCEDURAL OBJECTIVITY AND LEGAL SECURITY IN ABBREVIATED PROCEDURES.

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ABSTRACT
This study focused on exploring perceptions of objectivity and legal security among different groups of legal professionals in the context of abbreviated procedures. Using a methodological approach that combines phylogenetic statistics with indeterminate Likert scales, the study aimed to capture the complexity and multidimensionality of these perceptions. Specific questionnaires were designed and distributed, incorporating items on impartiality, predictability, transparency of the procedure, and personal experiences related to the principle of objectivity. The data analysis revealed a general trend towards positive perceptions of transparency and objectivity in judicial proceedings. However, significant variabilities in the perception of impartiality and predictability were observed, highlighting potential areas for improvement. Through the application of neutrosophic phylogenetic probabilities, a valuable framework was provided for interpreting these complexities, emphasizing the importance of indeterminacy in analyzing professional behaviors and attitudes in legal and judicial contexts.
KEYWORDS: neutrosophic analysis; objectivity; abbreviated procedures; legal security; phylogenetic statistics.

MSC: 62P25, 03B52, 91D10, 93A30, 68T37

RESUMEN
Este estudio se centró en explorar las percepciones de objetividad y seguridad jurídica entre diferentes grupos de profesionales del derecho en el contexto de los procedimientos abreviados. Utilizando un enfoque metodológico que combina estadísticas filogenéticas con escalas de Likert indeterminadas, el estudio tuvo como objetivo capturar la complejidad y multidimensionalidad de estas percepciones. Se diseñaron y distribuyeron cuestionarios específicos, incorporando ítems sobre imparcialidad, predictibilidad, transparencia del procedimiento y experiencias personales relacionadas con el principio de objetividad. El análisis de datos reveló una tendencia general hacia percepciones positivas de transparencia y objetividad en los procesos judiciales. Sin embargo, se observaron variabilidades significativas en la percepción de imparcialidad y predictibilidad, destacando áreas potenciales de mejora. A través de la aplicación de probabilidades filogenéticas neutrosóficas, se proporcionó un marco valioso para interpretar estas complejidades, enfatizando la importancia de la indeterminación en el análisis de comportamientos y actitudes profesionales en contextos legales y judiciales.
PALABRAS CLAVE: análisis neutrosófico; objetividad; procedimientos abreviados; seguridad jurídica; estadísticas plitogénicas.

1. INTRODUCTION

Ensuring the full exercise of rights implies adhering to legal regulations, making the topic significant. By delving into this, a better understanding of the challenges that arise when applying the abbreviated procedure can be gained, especially when the prosecutor does not consider the analysis of evidence for and against, as dictated by article 5, numeral 21, of the Comprehensive Organic Criminal Code. This results in a violation of the constitutional principle of legal security. It is important to consider that, although the abbreviated procedure speeds up the pursuit of justice, the preservation of constitutional principles must not be neglected at any time, for the correct administration of justice, since the State's primary responsibility is to guarantee the protection of guarantees, constitutional rights, and compliance with the law. The constitutional action of protection is part of the Ecuadorian Constitutional Procedural Law, established as a constitutional action that allows protection of the rights recognized in the Constitution and international human rights instruments through a simple, agile, quick, and effective procedure. This action foresees compliance with the principle that safeguards personal freedom and establishes criminal guarantees that allow the protection of individuals' fundamental rights [3]. The historical roots of the abbreviated procedure can be traced back to Roman Law, where it appears as an alternative within the spectrum of special criminal processes. This procedure emerged from agreements between the parties involved in litigation originating from criminal acts. In the Roman legal corpus, the Law of the Twelve Tables codified norms covering a wide range of subjects, establishing a sanctioning regime that facilitated the interaction of different rights. In this

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system, the law of Talion, applicable to severe crimes like theft, and composition, aimed at minor offenses such as insults or minor injuries, were highlighted [4].

From a historical perspective, Anglo-Saxon law constitutes a key precedent that shaped and provided viability to this procedural modality, offering a more robust legal structure. This framework allowed the prosecutor to assume a predominant role in optimizing judicial management, marking the beginning of the implementation of the abbreviated procedure. This historical foundation facilitated the emergence of legal figures such as plea bargaining and the guilty plea during the 19th century, aligned to simplify the judicial process, reduce associated costs, and provide the accused with an early resolution of the litigation [5]. The incorporation of the abbreviated procedure into Ecuador's legislation does not stem from its legal tradition but rather adopts practices from Anglo-Saxon law, specifically the American concept of "plea bargaining," known in Spanish as "súplica negociada." This procedure is activated when an individual, advised by their defender, acknowledges the consequences of accepting the charges against them in exchange for a reduced sentence, demonstrating a commitment to the principles of efficiency and procedural speed [1,14]. According to the Comprehensive Organic Criminal Code, it is established that the prosecutor's function must be exercised under a prism of objectivity, ensuring the correct application of legal norms and the safeguarding of individual rights. This responsibility encompasses the exhaustive investigation of the facts and circumstances that may affect, both aggravating and mitigating, the criminal responsibility of the processed subject, as well as those aspects that could exonerate, mitigate, or extinguish such responsibility. The clarity with which the Comprehensive Organic Criminal Code articulates the principle of objectivity justifies the need to focus the explanation in this manner, underlining its critical importance within the framework of judicial investigation for its full understanding. Legal objectivity, defined by its impartiality and the absence of preconceptions in the decision-making process, along with legal security, characterized by the predictability and transparency of legislation, constitute fundamental pillars to foster trust in the judicial system and ensure a fair administration of justice. However, it is important to recognize that the interpretation and application of these principles are not manifested uniformly among different members of the legal field, presenting considerable variations among judges, prosecutors, and defenders. Such diversity of perceptions highlights the intrinsic complexity in understanding and managing these concepts, which can be affected by individual, contextual, and procedural elements.

The abbreviated procedure, designed to simplify and expedite case resolution, presents an ideal scenario to explore the dynamics of objectivity and legal security from the perception of different judicial actors. The condensed nature of this procedure raises questions about how objectivity and legal security are maintained and how they are perceived by those immersed in the justice system. In this context, phylogenetic statistics, which emerges as an extension of classic multivariate statistics, offers a theoretical and methodological framework to address the indeterminacy and variability of perceptions [6]. By integrating uncertainty and multiplicity of perspectives into statistical analysis, phylogenetic statistics allows for a deeper exploration of complex phenomena, such as the perception of objectivity and legal security. This study proposes applying phylogenetic statistics and indeterminate Likert scales [7,15] to evaluate how judges, prosecutors, and defenders perceive objectivity and legal security in the context of the abbreviated procedure. Through this innovative approach, the aim is not only to identify patterns and discrepancies in these perceptions but also to deepen the understanding of how the specific characteristics of the abbreviated procedure influence the trust and legitimacy of the justice system. By exploring the intersection between objectivity, legal security, and the abbreviated procedure from a phylogenetic perspective, this study contributes to existing legal literature, offering valuable insights for academics, lawmakers, and legal professionals. Furthermore, incorporating indeterminacy as a central element of the analysis opens the door to a more nuanced understanding of fundamental legal principles and their impact on everyday legal practice.

2. PRELIMINARIES

Neutrosophic and refined neutrosophic set.

Neutrosophic explores the concept of a phenomenon or entity, denoted as "A," concerning its opposite "Anti-A," its negation "Non-A," and the state of being neither "A" nor "Anti-A," referred to as "Neut-A." In this framework, if we consider X as a metric space where its elements are represented as x, then within X, a single-valued neutrosophic set (SVNS) named A can be defined through three distinct membership functions: the truth membership function $T_{A(x)}$, the indeterminacy membership function $I_{A(x)}$, and the falsity membership function $F_{A(x)}$[7]. For any given element x within the space X, the values derived from $T_{A(x)}, I_{A(x)}$, and $F_{A(x)}$ are restricted to the interval [0,1]. These values must satisfy the equation $0 \leq T_{A(x)} + I_{A(x)} + F_{A(x)} \leq 3$), positioning SVNS A as represented by $A = \{ x, T_{A(x)}, I_{A(x)}, F_{A(x)} | x \in X \}$.[8]

Building on this, Smarandache's refined neutrosophic logic segments the concept of truth into several subclasses $T_1, T_2, \dots, T_p$; similarly, indeterminacy is divided into $I_1, I_2, \dots, I_r$, and falsity into $F_1, F_2, \dots, F_s$, where p, r, and s are positive integers that collectively sum up to n [9]. This detailed categorization allows for the establishment of triple refined indeterminate neutrosophic sets (TRINS), which further dissect the notion of indeterminacy into three clear

memberships, thus enhancing precision and relevance for applications such as personality assessments or the nuanced interpretations of Likert scale data. Unlike TRINS, a double-valued neutrosophic set (DVNS) simply splits the concept of indeterminacy into two distinct parts.

A TRINS A in X is detailed by five membership functions: positive $P_{A(x)}$, indeterminately positive $IP_{A(x)}$, indeterminate $I_{A(x)}$, indeterminately negative $IN_{A(x)}$, and negative $N_{A(x)}$, each associated with a specific weight w_m within the range of [0,5]. For every element x in X, it is established that: [10,20]

$$P_A(x), IP_A(x), I_A(x), IN_A(x), N_A(x) \in [0,1]$$

And accordingly, their weighted forms:

$$w_m P(P_A(x)), w_m IP(IP_A(x)), w_m I(I_A(x)), w_m IN(IN_A(x)), w_m N(N_A(x)) \in [0,5]$$

subject to the condition that:

$$0 \leq P_A(x) + IP_A(x) + I_A(x) + IN_A(x) + N_A(x) \leq 5$$

Hence, TRINS A is represented as:

$$A = \{ x, P_A(x), IP_A(x), I_A(x), IN_A(x), N_A(x) | x \in X \}$$

When considering two TRINS, namely A and B, defined within the metric space X, their intersection results in a third TRINS, C, denoted as $C = A \cap B$. The definition of membership for C in terms of truth, truth-leaning indeterminacy, pure indeterminacy, falsity-leaning indeterminacy, and falsity is determined by functional relationships grounded in the respective membership values of A and B.

$$T_{C(x)} = \min(T_{A(x)}, T_{B(x)})$$
$$IT_{C(x)} = \min(IT_{A(x)}, IT_{B(x)})$$
$$I_{C(x)} = \min(I_{A(x)}, I_{B(x)})$$
$$IF_{C(x)} = min(IF_{A(x)}, IF_{B(x)})$$
$$F_{C(x)} = \max(F_{A(x)}, F_{B(x)})$$

In the realm of refined Neutrosophic, a pivotal fourth definition is introduced concerning the computation of a generalized weight, which encapsulates the influence of all membership functions within the framework of Triple Refined Indeterminate Neutrosophic Sets (TRINS). This definition is instrumental for assessing the significance and contribution of each membership function to the overall value of a neutrosophic set. The generalized weighting for a TRINS A, denoted as w_A, is mathematically defined as:

$$w_A = (\sum_{i=1}^{n} w^T T_{A(x_i)} + w^I IT_{A(x_i)} + w\, I_{A(x_i)} + w^F IF_{A(x_i)} + w^N F_{A(x_i)}) \quad (1)$$

Here, $w^T, w^I, w, w^F, y\, w^N$ signify the weights associated with the truth, truth-leaning indeterminacy, pure indeterminacy, falsity-leaning indeterminacy, and falsity membership functions, respectively. These weights are essential for evaluating the importance of the various membership functions within the neutrosophic set and determining their contribution to the broader theoretical construct of neutrosophic analysis.

This approach emphasizes the nuanced understanding that in a neutrosophic context, not all membership functions are of equal importance or influence. By assigning distinct weights to different types of membership functions (truth, various forms of indeterminacy, and falsity), this methodology acknowledges the complexity and multi-dimensionality of phenomena that neutrosophic sets aim to model. Consequently, the generalized weight w_A serves as a critical tool for synthesizing the diverse influences of these membership functions, providing a more comprehensive and differentiated insight into the nature and significance of the set in question.

Basic Notions on Plithogeny

F. Smarandache's concept of Plithogeny elaborates on the genesis, establishment, progression, and advancement of new entities through the vibrant and organic amalgamation of pre-existing entities, which could be opposing, Neutrosophic, or compatible. This notion champions the synthesis and consolidation of theoretical frameworks and insights spanning diverse disciplines, effectively calling for a cross-disciplinary melding of knowledge from areas as varied as the soft sciences, hard sciences, arts, and the theoretical dimensions of literature. [11]

Within this framework, a Plithogenic Set is identified as a non-trivial set P, situated within a given domain $U (P \subseteq U)$ characterized by one or more distinguishing attributes $A_1, A_2, \dots, A_m, m \geq 1$. Each attribute within this set is capable of taking on values from a broad spectrum *S* of possible states. This spectrum can manifest in various forms – be it finite or infinite in nature, discrete or continuous in representation, and open or closed in its range. [12]

This delineation underscores the versatility and dynamism inherent in plithogenic sets, mirroring the diversity and complexity of knowledge and phenomena they are intended to model. By accommodating a wide array of attributes and their corresponding values within a unified set, the plithogenic approach facilitates a more nuanced and comprehensive exploration of entities, fostering interdisciplinary dialogue and exploration that transcends conventional boundaries between disparate fields of study.

For each element $x \in P$, it is characterized by the entire range of potential values for the attributes contained within the set $V = \{v_1, v_2, \cdots, v_n\}$. An attribute's value has a degree of belonging $d(x, v)$ for an element x in set P

based on a specific criterion. This degree of belonging can manifest as fuzzy, intuitionistic fuzzy, or neutrosophic, among other types.[13]

This signifies that for every element x in the set P, there exists a function $d: PxV \rightarrow \wp([0,1]^z)$, as shown in equation (2), where $d(x,v) \subseteq [0,1]^z$ and $\wp([0,1]^z)$ represents the power set of $[0,1]^z$. Here, z indicates the degree of appurtenance, with $z = 1$ corresponding to the fuzzy degree, $z = 2$ to the intuitionistic fuzzy degree, and $z = 3$ to the neutrosophic degree of appurtenance.

$$\forall x \in P, d: PxV \rightarrow \wp([0,1]^z) \quad (2)$$

In this advanced exposition of plithogenic sets, a nuanced mechanism is introduced for evaluating the degree of contradiction between different attribute values within such sets. If we denote V as the value set with its cardinality being greater than or equal to 1, we define a specialized function $c: V \times V \rightarrow [0,1]^2$. This function, termed the attribute value contradiction degree function, is designed to quantify the level of contradiction between any pair of attribute values v_a, v_b. The operation of this function is guided by several key axioms: [14]

$c(v_a, v_a) = 0$, which asserts that there is no contradiction in an attribute value when compared with itself, encapsulating the principle of non-contradiction.

$c(v_a, v_b) = c(v_b, v_a)$, which underscores the symmetry in the degree of contradiction between any two distinct attribute values, suggesting that the contradiction is mutual and unaffected by the order of comparison.

The notation c is specifically chosen to highlight that this function operates within the realm of fuzzy logic, implying a continuum of contradiction degrees rather than binary or discrete states. Additionally, variations of this function, such as $c_{IF}: V \times V \rightarrow [0,1]^2$, are conceptualized to accommodate the framework of neutrosophic logic, thereby acknowledging and quantifying varying levels of certainty or contradiction inherent in the attribute values.

In the context of a Plithogenic Set, delineated as (P, a, V, d, c), this structure encompasses the principal set *P*, the attribute set *A*, the value set *V*, a membership function *m*, and the contradiction degree function *d*, which is conceptually aligned with *c*. This contradiction function plays a critical role in analyzing and quantifying the extent of contradiction present across the attributes, particularly in relation to a primary attribute, if such an attribute is identified as being of paramount importance relative to others. This analytical framework thus provides a robust tool for dissecting and understanding the complex interplay of attributes within a Plithogenic Set, offering insightful perspectives into the dynamics of contradiction and harmony among the elements of the set.[15]

In contrast, (U, a, V, d, c) is designated as Plithogenic Probability, wherein E represents the event space. Plithogenic Probability is defined as the likelihood of an event's occurrence across all random variables that influence it, each random variable may adhere to classical, T, I, F-neutrosophic, I-neutrosophic, T, F-intuitionistic fuzzy, T, N, F-picture fuzzy, T, N, F-spherical fuzzy, or other fuzzy extensions distribution functions. Thus, Plithogenic Probability extends the classical concept of multivariate probability.[16]

Moreover, Plithogenic Statistics extends the concept of traditional multivariate statistics by incorporating the principles of Plithogenic Probability, which in turn, is characterized by its ability to dissect and analyze probabilities into nuanced components of truth, indeterminacy, and falsehood. Specifically, it breaks down probabilities into detailed segments represented as $T_1, T_2, \ldots, T_p$ for truths; $I_1, I_2, \ldots, I_q$ for indeterminacies; and $F_1, F_2, \ldots, F_r$ for falsehoods. This granular approach ensures that at least one set among the truths, indeterminacies, or falsehoods is comprised of more than one element, indicating the multifaceted nature of probabilities within the plithogenic framework.

This sophisticated subdivision allows Plithogenic Statistics to capture the complexity of real-world phenomena more accurately than classical methods. By acknowledging and quantifying the degrees of truth, the potential for indeterminacy, and the possibility of falsehood in any given situation, Plithogenic Statistics provides a richer, more dimensional view of statistical analysis. This methodological advancement enables researchers and analysts to account for the inherent uncertainties and ambiguities in data, offering a more refined and nuanced understanding of statistical outcomes. [17]

3. METHOD

The study (Figure 1) conducted employs a quantitative approach to investigate the perception of objectivity and legal security among judges, prosecutors, and defenders in the context of the abbreviated procedure. The methodology focuses on the application of phylogenetic statistics and indeterminate Likert scales to capture the complexity and multidimensionality of the participants' perceptions.

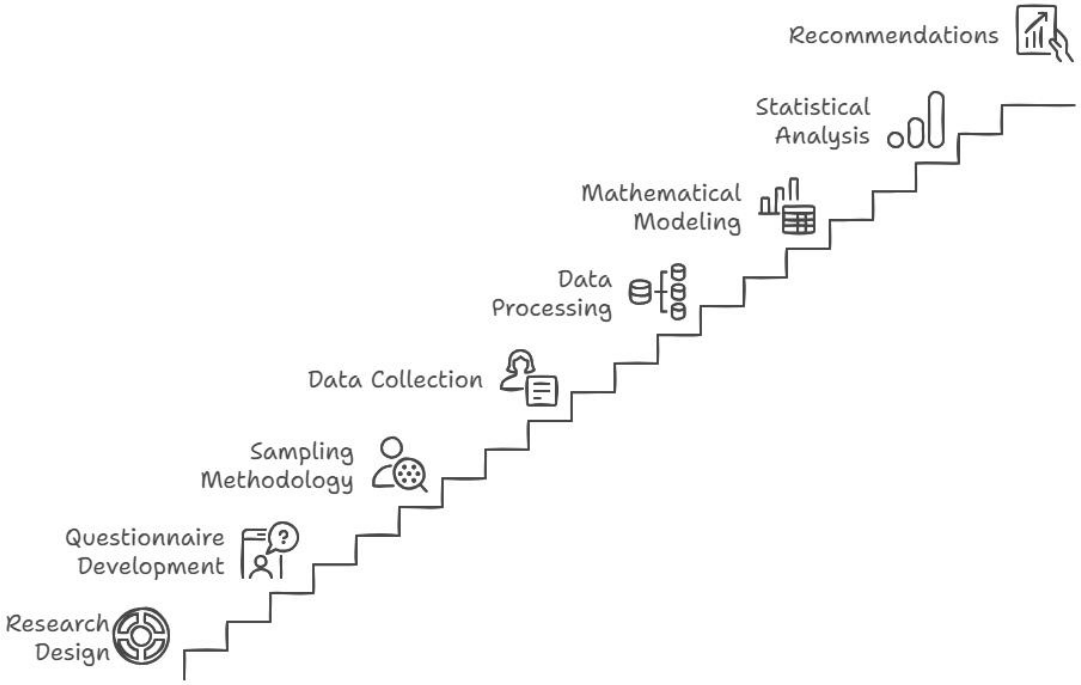

Figure 1. Research process steps

The research design is cross-sectional and is based on data collection through questionnaires specifically designed for each interest group. The surveys include questions that address the perception of impartiality, predictability, transparency of the procedure, and personal experiences related to the principle of objectivity. Indeterminate Likert scales of 1 to 5 are implemented, where 1 represents "total disagreement" and 5 "total agreement".

The sample is selected through an intentional non-probabilistic approach, ensuring the representativeness of the three interest groups within the total population of legal professionals involved in abbreviated procedures. In this sense, the final sample of the study consisted of 24 judges, 27 prosecutors, and 21 defense lawyers. Surveys are distributed using electronic and paper methods, depending on the accessibility and preferences of the participants, to maximize the response rate and the diversity of the sample.

After obtaining the results, the TRINS matrix is constructed for each respondent, categorizing each rating by statement on an indeterminate Likert scale ranging from (1) negative membership to (5) positive membership. This will allow determining the degree of acceptance of the statements by the students, expressing the responses in the form of TRINS, denoted as G_x.

For each student, their evaluation is represented by a vector in $[0,1]^5$, where each component of the vector reflects an evaluation category from "Very High" to "Very Low". The function $\gamma(V) = 2v_1 + v_2 + 0.5v_3 - v_4 - 2v_5$ is used to analyze these data, calculating their relative frequency in percentages.

Frequency values are converted into Neutrosophic Phylogenetic Probabilities to express the overall behavior of the studied dimensions. This is done using equation (3), representing the probabilities of each variable and their dimensions with values of the type (T, I, F), where T indicates the "strongly sure" probability that the dimension occurs adequately, I represents the "indeterminate" probability, and F the "totally sure" probability that the dimension does not occur adequately.

$$PNP = p_1 + p_2, pI, np_2 + np_1 \tag{3}$$

This methodological approach captures the complexity and indeterminacy inherent in students' perceptions and satisfactions regarding the use of the case method as a pedagogical tool, using the framework of phylogenetic logic and neutrosophic probabilities for a deeper and more nuanced analysis of the collected data.

Data preprocessing includes encoding of indeterminate responses. For statistical analysis, phylogenetic statistics are applied through neutrosophic and phylogenetic probabilities to compare perceptions between groups. This approach allows detecting patterns, similarities, and significant differences in perceptions of objectivity and legal security.

The interpretation of the results focuses on comparing perceptions of objectivity and legal security among the groups of judges, prosecutors, and defenders. Areas of high and low perception are identified, as well as those of

high indeterminacy, relating them to the study's objective. Conclusions are drawn from the data analysis, offering a comprehensive view of how these professionals perceive objectivity and legal security within the framework of the abbreviated procedure. Based on the findings, practical recommendations are offered to improve the perception of objectivity and legal security.

4. RESULTS

The surveys were conducted strictly respecting the confidentiality of the information provided by the participants. For the analysis of the collected data, it was decided to create frequency tables that facilitated the interpretation of the results. Additionally, a TRINS matrix was prepared for each participant, allowing for the visualization of the acceptance of the statements through a Likert scale with degrees of indeterminacy. The valuation of the responses was specified through vectors within the interval $[0,1]^5$, providing a quantitative framework for the analysis.

With the purpose of synthesizing and better understanding the collected data, the function $\gamma(V) = 2v_1 + v_2 + 0.5v_3 - v_4 - 2v_5$ was applied to each response. This methodology allowed the generating a global index that facilitated the classification of the responses. Under this scheme, the category "Very High" was assigned to those responses whose score was equal to or higher than 2, the "High" category corresponded to scores equal to or higher than 1, the term "Indeterminate" was applied to scores ranging between -1 and 1, "Low" for those between -2 and -1, and finally "Very Low" for scores lower than -2.

This approach enabled the detailed structuring of the frequency tables for each variable under study, distributed across Tables 1-3, thereby facilitating a comprehensive and precise analysis of the perceptions and attitudes of respondents about the analyzed variables of interest.

	Perception of Impartiality		Sense of Predictability		Transparency of the Procedure		Personal Experiences with the Principle of Objectivity	
Strongly disagree	0	0%	0	0%	0	0%	0	0%
Disagree	0	0%	0	0%	0	0%	0	0%
Undefined	4	17%	7	29%	4	17%	2	8%
Agree	14	58%	11	46%	13	54%	13	54%
Strongly Agree	6	25%	6	25%	7	29%	9	38%

Table 1: Results obtained for the evaluated group of judges

	Perception of Impartiality		Sense of Predictability		Transparency of the Procedure		Personal Experiences with the Principle of Objectivity	
Strongly disagree	0	0%	0	0%	0	0%	0	0%
Disagree	0	0%	1	4%	0	0%	0	0%
Undefined	6	22%	4	15%	3	11%	3	11%
Agree	17	63%	12	44%	13	48%	16	59%
Strongly Agree	4	15%	10	37%	11	41%	8	30%

Table 2: Results obtained for the evaluated group of prosecutors

	Perception of Impartiality		Sense of Predictability		Transparency of the Procedure		Personal Experiences with the Principle of Objectivity	
Strongly disagree	1	5%	0	0%	0	0%	0	0%
Disagree	0	0%	1	5%	0	0%	0	0%
Undefined	8	38%	4	19%	3	14%	2	10%
Agree	10	48%	10	48%	9	43%	12	57%
Strongly Agree	2	10%	6	29%	9	43%	7	33%

Table 3: Results obtained for the evaluated group of defense attorneys

After examining the results tables for the evaluated groups of judges, prosecutors, and defense attorneys regarding the study variables, it can be observed that all groups showed a significantly positive perception of impartiality, with a notable 83% of judges and 78% of prosecutors agreeing or strongly agreeing with the statement. Defense attorneys presented greater variability, with 38% of indeterminate responses, although 58% agreed or strongly

agreed. This suggests that, in general, there is a favorable perception of impartiality in the abbreviated procedure, albeit with more uncertainty among defense attorneys.

Predictability was positively assessed among judges (71%) and prosecutors (81%), but a higher level of indeterminacy was observed among judges (29%). Defenders showed more divided opinions with 19% indeterminacy and 77% agreement or strong agreement. This indicates that the predictability of the procedure is generally well perceived, albeit with some reservations.

On the other hand, regarding the transparency of the procedures, it was highly valued by judges (83%) and prosecutors (89%), with a significant portion of defense attorneys also in agreement (86%). Indeterminacy was notably lower for this item, reflecting a generally positive perception of transparency across all groups. Personal experiences with objectivity showed high levels of agreement among judges (92%) and prosecutors (89%), and also among defense attorneys (90%). Likewise, indeterminacy was lower in this area, indicating that personal experiences with the principle of objectivity tend to be positively valued.

These results reflect a generally positive outlook on the perception of objectivity and legal security in the abbreviated procedure among the evaluated legal professionals, albeit with notable differences in terms of indeterminacy, especially among defense attorneys. The evidence suggests the importance of addressing and clarifying the aspects that contribute to the perception of indeterminacy to further strengthen confidence in these fundamental principles of the judicial system.

Achieving these results enables the anticipation of trends in the perceptions of the evaluated groups regarding the considered dimensions. Table 4 presents both the Refined Phylogenetic Probabilities (RPP) and the Neutrosophic Phylogenetic Probabilities (NPP), derived by converting percentages to RPP and the subsequent calculation of NPP according to equation (3). This methodology allows for a detailed and nuanced approach to analyzing perceptions, offering a framework to interpret the complexity inherent in the participants' responses.

Variables	Judges		Prosecutors		Lawyers	
	RPP	NPP	RPP	NPP	RPP	NPP
Perception of Impartiality	(0; 0; 17; 58; 25)	(83; 17; 0)	(0; 0; 22; 63; 15)	(78; 22; 0)	(5; 0; 38; 48; 10)	(58; 38; 5)
Sense of Predictability	(0; 0; 29; 46; 25)	(71; 29; 0)	(0; 4; 15; 44; 37)	(81; 15; 4)	(0; 5; 19; 48; 29)	(77;19;5)
Transparency of the Procedure	(0; 0; 17; 54; 29)	(83; 17; 0)	(0; 0; 11; 48; 41)	(89; 11; 0)	(0; 0; 14; 43; 43)	(86; 14; 0)
Personal Experiences with the Principle of Objectivity	(0; 0; 8; 54; 38)	(92; 8; 0)	(0; 0; 11; 59; 30)	(89; 11; 0)	(0; 0; 10; 57; 33)	(90; 10; 0)

Table 4: Refined Phylogenetic Probabilities (RPP) and Neutrosophic Phylogenetic Probabilities (NPP) for each evaluated group

Transforming percentages into RPP and calculating NPP not only enriches the understanding of attitudes and opinions within the studied groups but also provides a robust quantitative basis for projecting future trends in their perceptions. By employing these analysis techniques, a deeper exploration of the dynamics of perceptions is facilitated, allowing for more accurate identification of areas of consensus, divergence, and ambiguity in the evaluations of the various aspects assessed.

As shown in Figure 1, the analysis revealed that study participants showed a significant predisposition to perceive the evaluated dimensions positively. In particular, it was identified that both judges and prosecutors had probabilities over 70% of having positive perceptions in these areas. However, it was observed that defense attorneys, despite largely sharing these positive perceptions, adopted a more reserved stance regarding impartiality in judicial processes.

Judges showed a greater inclination to recognize impartiality in judicial procedures and expressed more favorable attitudes regarding their personal experiences related to the principle of objectivity. This finding suggests that judges, in their role as arbiters of the judicial process, have a sharper perception of these aspects, possibly due to their direct involvement and responsibility in maintaining such principles during the procedures.

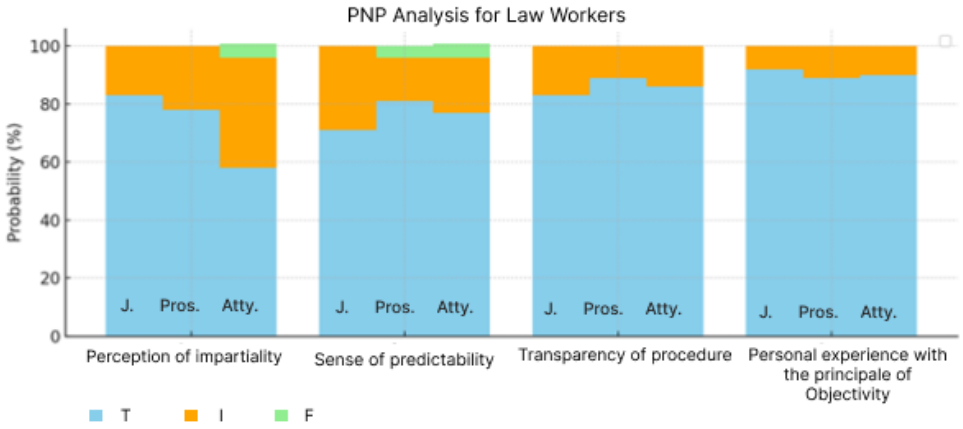

Figure 2: NPP values for each evaluated group in each studied variable

On the other hand, prosecutors showed more pronounced tendencies towards positive valuations in terms of the predictability and transparency of judicial procedures. This orientation may reflect the importance that these legal professionals place on the clarity and predictability of the processes on which they must base their cases and make strategic decisions. These results suggest that, although there is widespread consensus among different groups of legal professionals on the positive valuation of predictability, transparency, and objectivity in judicial procedures, there are subtle differences in the perception of these principles. These differences could be influenced by the different responsibilities, experiences, and expectations associated with each role within the judicial system.

Likewise, it was observed that defense attorneys lean towards indeterminacy or Neutrosophic in their perceptions, this phenomenon is particularly pronounced in relation to the impartiality of judicial procedures. This tendency indicates a significant ambiguity in their opinions, suggesting caution or uncertainty about the impartiality with which these processes are administered. Regarding the sense of predictability, defense attorneys demonstrated a combination of high certainty, showing a firm conviction in the predictability of the procedures, along with notable indeterminacy. This reveals that, despite the prevalence of positive perceptions, there is a significant proportion of attorneys who remain in a stance of ambiguity regarding predictability.

Concerning the transparency of the procedure, attorneys expressed the highest degree of assurance, indicating an almost unanimous perception of transparency in judicial procedures. The presence of moderate indeterminacy suggests, however, that there is still room for improvement in the clarity and openness of the processes.

These findings suggest predominant confidence in the dimensions of transparency and objectivity of judicial procedures among legal professionals. However, variability in perceptions, especially in terms of impartiality and predictability, highlights potential areas for development and improvement. Specifically, the presence of indeterminacy among defense attorneys regarding impartiality underscores the need to address and mitigate existing uncertainties and distrust.

5. CONCLUSION

In the framework of the study conducted, a quantitative approach was employed to investigate the perception of objectivity and legal security among judges, prosecutors, and defense attorneys in the context of abbreviated procedures. The adopted methodology focused on the application of phylogenetic statistics and the use of indeterminate Likert scales, aiming to capture the complexity and multidimensionality of the participants' perceptions involved.

The study's results revealed a general trend of high confidence among participants regarding the evaluated dimensions, particularly in terms of the transparency of the procedure and objectivity. However, variability in perceptions was observed, especially regarding impartiality and the sense of predictability, highlighting the existence of areas susceptible to improvement and the need to address uncertainty and distrust, especially among defense attorneys.

From a neutrosophic perspective, these results emphasize the inherent complexity in human perceptions and highlight the relevance of indeterminacy as a critical element in the analysis of behaviors and attitudes in the professional realm. The implementation of neutrosophic phylogenetic probabilities in this study provides an innovative and effective approach to capture complexity and offer deep insights into the underlying dynamics in legal and judicial environments.

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NEUTROSOPHIC ANALYSIS OF THE IMPORTANCE OF ILLEGALITY IN CRIMINAL LAW AND CIVIL LAW. EVALUATION OF CAUSES AND CONSEQUENCES

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ABSTRACT.

The research addresses a fundamental problem in the legal field: the complex relationship between illegality in criminal law and civil law, and its impact on the legal and social structure. This analysis is essential in a context where the notions of legality and illegality not only determine acceptable social conduct but also directly affect justice and legal certainty. Despite the extensive literature on these concepts, there remains a significant lack of approaches that integrate advanced analytical tools to assess the causes and consequences of illegality from an interdisciplinary perspective. This study seeks to fill this gap by employing neutrosophic Delphi-AHP methods, designed to handle uncertainty and ambiguity in complex scenarios. The results of the analysis demonstrate that the neutrosophic approach allows to decompose and prioritize key factors underlying the causes and consequences of illegality in both legal fields. The areas where the interaction between criminal and civil law is most critical were identified, providing a framework to improve legal coherence and the effectiveness of public policies. Among the main contributions of the study, the integration of advanced methodologies to address complex legal problems and the generation of practical insights applicable to the administration of justice stand out. This work not only expands theoretical knowledge on the nature of illegality but also promotes the use of neutrosophic tools as a way to strengthen decision-making in uncertain legal environments.

KEYWORDS: Illegality, criminal law, civil law, neutrosophic analysis, Delphi-AHP methods, causes, consequences, uncertainty, ambiguity.

MSC: 03B52, 62P20, 90B50

RESUMEN

La investigación aborda un problema fundamental en el ámbito jurídico: la compleja relación entre la ilegalidad en el derecho penal y el derecho civil, y su impacto en la estructura legal y social. Este análisis resulta esencial en un contexto donde las nociones de legalidad e ilegalidad no solo determinan la conducta social aceptable, sino que también afectan directamente la justicia y la seguridad jurídica. A pesar de la extensa literatura en torno a estos conceptos, persiste una carencia significativa de enfoques que integren herramientas analíticas avanzadas para evaluar las causas y consecuencias de la ilegalidad desde una perspectiva interdisciplinaria. Este estudio busca llenar esa brecha al emplear métodos neutrosóficos Delphi-AHP, diseñados para manejar incertidumbre y ambigüedad en escenarios complejos. Los resultados del análisis demuestran que el enfoque neutrosófico permite descomponer y priorizar factores clave que subyacen en las causas y consecuencias de la ilegalidad en ambos campos legales. Se identificaron las áreas donde la interacción entre el derecho penal y el civil es más crítica, proporcionando un marco para mejorar la coherencia legal y la eficacia de las políticas públicas. Entre las principales contribuciones del estudio, se destaca la integración de metodologías avanzadas para abordar problemas jurídicos complejos y la generación de insights prácticos aplicables a la administración de justicia. Este trabajo no solo amplía el conocimiento teórico sobre la naturaleza de la ilegalidad, sino que también promueve el uso de herramientas neutrosóficas como una vía para fortalecer la toma de decisiones en entornos legales inciertos.

PALABRAS CLAVE: Ilegalidad, derecho penal, derecho civil, análisis neutrosófico, métodos Delphi-AHP, causas, consecuencias, incertidumbre, ambigüedad.

1. INTRODUCTION.

Illegality, as a central concept in the legal field, transcends its literal definition to become a critical axis of analysis in both criminal and civil law. Its impact not only shapes the social and economic dynamics of modern societies but also profoundly influences the administration of justice and the collective perception of fairness. This study focuses on analyzing the significance of illegality in both fields of law through neutrosophic Delphi-AHP methods, providing an innovative approach to unraveling the causes and consequences of such a complex and multifaceted phenomenon. The need to understand illegality from a comprehensive and quantifiable perspective has never been more urgent, particularly in a global context where legal and social tensions are constantly evolving [5]. Throughout history, the conceptualization of illegality has been shaped by cultural, political, and economic factors. In criminal law, this term has evolved from a strictly punitive interpretation to a more restorative approach, while in civil law, illegality has moved from being a contractual breach to a fundamental pillar to guarantee justice in private transactions. However, both legal systems share an interdependence that often goes unnoticed, which generates inconsistencies in their application and understanding [9]. At present, with the growing influence of globalization and the advancement of disruptive technologies, the boundaries between these two legal areas are

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increasingly blurred, which demands new analytical tools to address their intrinsic relationship [8]. The central problem that guides this research lies in the lack of robust methodologies that allow evaluation the interaction between illegality in criminal and civil law in a quantitative and multidimensional way. How can we identify and prioritize the causes and consequences of illegality in both legal systems? This question reflects not only a theoretical gap in the existing literature but also a practical need to design approaches that address the uncertainty and ambiguity inherent in the legal system. In particular, there is a lack of tools that incorporate expert perception and the structural complexity of the law to generate comprehensive solutions [12].

This study seeks to bridge this gap by using Delphi -AHP neutrosophic methods, a methodological combination that allows for managing high levels of indeterminacy and subjectivity. While the Delphi method facilitates the collection of expert opinions in complex contexts, the AHP (Analysis Hierarchy Process) provides a framework for prioritizing and weighing key variables. The integration of these tools under a neutrosophic approach guarantees a deeper and more nuanced analysis of the legal dynamics involved, allowing illegality to be addressed from both a qualitative and quantitative perspective [2]. Preliminary results of this approach have demonstrated its ability to identify critical interactions between the factors that perpetuate illegality in both fields of law. Among the most notable findings is the importance of assessing how individual and collective perceptions of legality influence public policy formulation and the implementation of regulations. Likewise, the study underlines the need to analyze the collateral effects of illegality, such as economic tensions and social inequalities that emerge from its uneven application [13]. The practical relevance of this research lies in its ability to offer clear and actionable recommendations to policymakers. Through the use of advanced analytical tools, strategies are proposed to improve coherence between criminal and civil law, optimizing the interpretation and application of illegality in diverse contexts. These proposals not only strengthen legal governance but also promote equity and transparency in access to justice [6].

However, it is important to acknowledge the limitations inherent in the scope of this study. The reliance on expert opinions introduces a degree of subjectivity that, although mitigated by methodological rigor, does not eliminate potential bias. Furthermore, the geographic and cultural focus restricts the generalizability of the results to other legal contexts. Nevertheless, this study lays the groundwork for future research exploring the interaction between illegality in different legal systems under a neutrosophic approach.

In summary, the main objective of this paper is to evaluate illegality in criminal and civil law from a novel perspective that combines theoretical rigor with practical applications. Through this research, it is hoped not only to advance the academic understanding of illegality but also to influence the creation of more fair, transparent, and effective public policies. In doing so, this study seeks to contribute to the development of a more coherent legal framework adapted to the complexities of modern societies.

2. MATERIALS AND METHODS

2.1. Neutrosophic Delphi method

The Delphi technique is used in many fields such as program planning, resource utilization, policy judgment, and needs assessment. A Delphi technique has the following advantages [2]:

1. Tackling complex problems effectively.
2. Able to define and modify a wide range of alternatives.
3. Create different judgments on the same topic and use feedback on individuals' judgments to allow them to revise their views.
4. Achieve a high degree of consensus.
5. Increase coherence by reducing the noise that results from focusing on group and/or individual interests rather than focusing on dissolving the problem.

It is a structured communication technique, designed primarily to gather and consolidate expert opinions on specific topics through a series of iterative questionnaires with controlled feedback. Developed in the 1950s by the RAND Corporation, this method is used to reach consensus on predicting future trends, solving complex problems, strategic planning, and risk assessment, among others.

The process begins with the selection of a panel of experts who possess specialized knowledge in the area of interest. These experts respond to an initial questionnaire, the answers to which are anonymous and summarized by a coordinator or coordinating team. The summarized results are then shared with the group, along with a new questionnaire based on the previous responses. This questionnaire-response-feedback process is repeated in several rounds , to narrow the range of responses and move the group toward consensus.

A key feature of the Delphi method is the anonymity of participants, which helps to avoid the influence or domination effect of certain participants over others, thus facilitating more objective responses and reducing conformity bias. At the end of the process, the convergence of opinions is expected to reveal a consensus or a clearer understanding of the issue at hand, providing valuable information for decision-making [4,15] .

To establish the knowledge of the analyzed topic and object of study, a self-assessment process is carried out on a scale (see Table 1). This so-called neutrosophic knowledge coefficient is determined by the information that the expert himself presents on the object of study.

Linguistic term	SVNN
Full knowledge of the subject of study (FK)	(1,0,0)
Very very good in the subject of study (VVGK)	(0.9, 0.1, 0.1)
Very good in the subject of study (VGK)	(0.8,0.15,0.20)
Good at the subject of study (GK)	(0.70,0.25,0.30)
Moderately good at the subject of study (MGK)	(0.60,0.35,0.40)
Knowing the subject of study (K)	(0.50,0.50,0.50)
Has moderately poor knowledge of the subject matter (MPK)	(0.40,0.65,0.60)
Poor knowledge of the subject of study (PK)	(0.30,0.75,0.70)
He knows the subject very poorly (VPK)	(0.20,0.85,0.80)
Very, very poor knowledge of the subject of study (VVPK)	(0,10,0,90,0,90)
Without knowledge of the subject of study (NK)	(0,1,1)

Table 1: Linguistic terms used to determine and evaluate the proposed criteria. Source: Own elaboration.

For the evaluation and validation of questionnaires using the Delphi method, the scale (see Table 2) was used to achieve greater objectivity in the management of information. This allows the evaluation of the criteria argued by the judges of the panel of experts for each of the items individually.

Using linguistic terms with Single Value Neutrosophic Numbers (SVNN) for consensus based on the expert opinion, criteria are evaluated using the neutrosophic argumentation coefficient.

Linguistic term I	SVNN	Linguistic term II
Very Adequate (VA)	(0.9,0.1,0.1)	Essential (E)
Fairly adequate (FA)	(0.75,0.25,0.20)	Very useful (VU)
Suitable (A)	(0.50,0.55,0.5)	Useful (U)
Poorly suited (PA)	(0.3,0.75,0.80)	Not very useful (LU)
Not suitable (NA)	(0,10,0,90,0,90)	Not useful (NU)

Table 2: Linguistic terms used. Source: Own elaboration.

To determine the consensus among the participants of the expert panel, the coefficient of concordance was used, determined through the expression:

$$Cc = \left(1 - \frac{V_n}{V_t}\right) 100 \quad (1)$$

where: V_n is the number of negative votes issued by the judges, and $V_t$is the total number of votes issued by the judges. Therefore, a level of consensus must be reached when the coefficient of agreement Cc obtains a value greater than 75%, and the process must be concluded; if this value is not reached, a new round must be established.

2.2. Neutrosophic AHP method

The Analytic Hierarchy Process (AHP) is a decision-oriented theory used to identify the best alternative based on the resources allocated. This method can be applied to situations involving technical, economic, political, social and cultural factors. That is, it aims to be a scientific tool to address aspects that are difficult to quantify but that sometimes require a unit of measurement. The methodology in its original version can be seen in [16 ,17]. However, for this work the need for uncertainty is recognized, and for this purpose its neutrosophic version is adopted. Which uses triangular numbers for its execution, whose definition is the following:

Definition 1: Let *X* be a space of points and $x \in X$. A neutrosophic set *A* in *X* is defined by a truth membership function $T_A(x)$, an indeterminacy membership function $I_A(x)$, and a falsity membership function $F_A(x)$. *U* is the Universe of Discourse and

$\forall x \in U, T_A(x), I_A(x), F_A(x) \subseteq]-0, 1+[$

and

$$-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup T_A(x) \leq 3+.$$

Note that by the definition, $T_A(x)$, $I_A(x)$, and $F_A(x)$ are standard or nonstandard real subsets of $[0, 1] + [8,15]$.

Definition 2: Let *X* be a universe of discourse. A single-valued neutrosophic set *A* over *X* is an object taking the form $A = \{\langle x; T_A(x), I_A(x), F_A(x)\rangle : x \in U\}$, where $T_A : U \to [0, 1]$, $I_A : U \to [0, 1]$, and $F_A : U \to [0, 1]$,

$$0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3 \text{ for all } x \in X.$$

The intervals $T_A(x)$, $I_A(x)$, and $F_A(x)$ represent the degree of truth, degree of indeterminacy, and degree of falsehood of *x* through *A*, respectively. For convenience, an SVN number is represented by $A = (a, b, c)$, where a, $b, c \in [0, 1]$ and $a+b+c \leq 3$.

Definition 3: Suppose $\tilde{a}, \tilde{a}, \tilde{a} \in [0, 1]$ and $a_1, a_2, a_3, a_4 \in R$ where $a_1 \leq a_2 \leq a_3 \leq a_4$. Then, a 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 special neutrosophic set on

the set of real lines $\mathbb{R}$, whose truth membership, indeterminacy membership and falsity membership functions are defined as see reviewed methodology [17, 10].

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

Addition:$\tilde{a} + \tilde{b} = \langle(a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle$
Remains: $\tilde{a} - \tilde{b} = \langle(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle$*(2)*
Investment: $\tilde{a}^{-1} = \langle({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, *where* $a_1, a_2, a_3, a_4 \neq 0$.
Multiplication by a scalar number: [11]

This technique models the problem leading to the formation of a representative hierarchy of the associated decision-making scheme. The comparison is made using a scale, according to Table 3 [1] . To verify the neutrosophic methodology see [1,10,11,16,17].

Saaty scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very influential	$\langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\langle(1,2,3); 0.40, 0.65, 0.60\rangle$ $\langle(3,4,5); 0.60, 0.35, 0.40\rangle$ $\langle(5,6,7); 0.70, 0.25, 0.30\rangle$ $\langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 3. Saaty scale translated into a neutrosophic triangular scale. Source:

3. Methods

This study employed a Delphi methodology combined with the Neutrosophic Analytic Hierarchy Process (AHP) to analyze the causes and consequences of illegality in criminal and civil law. The research involved an iterative process with a panel of 18 legal experts, including judges, prosecutors, and defense attorneys, to identify key factors influencing illegality and prioritize strategic solutions.

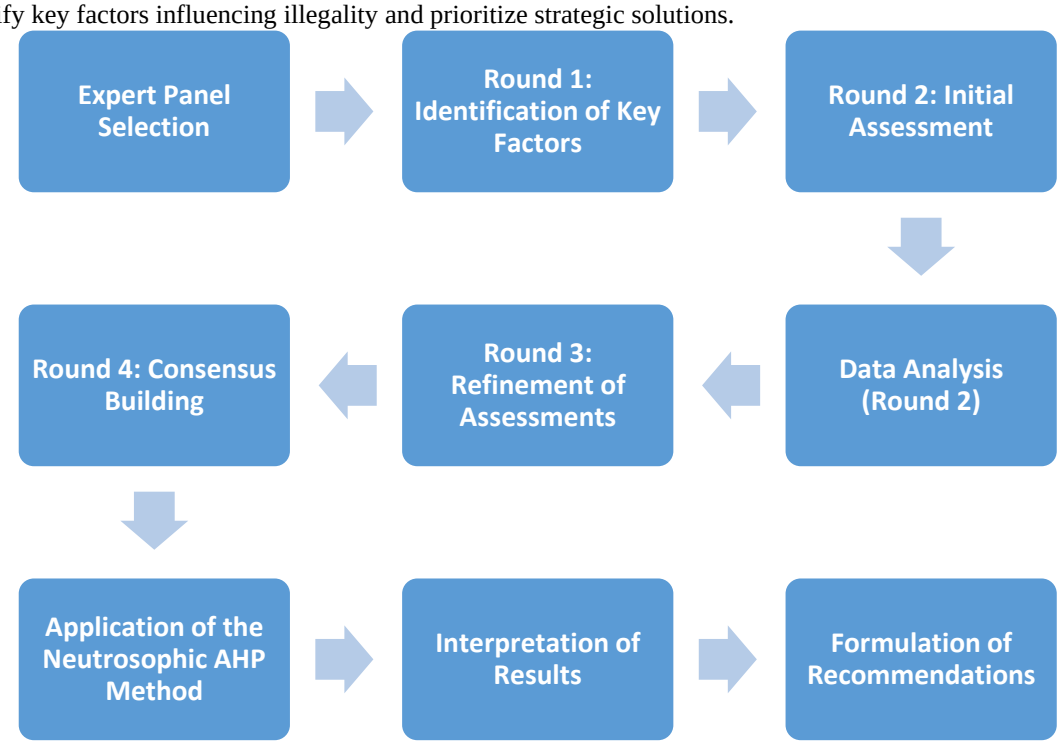

Figure 1. Methodology Steps

Delphi Method Process

The Delphi process was conducted in multiple rounds:

Round 1: Identification of Key Factors

Experts identified five critical factors influencing illegality:
Economic: Impact of economic inequalities on illegal activities.

Social: Influence of cultural norms that justify illegal acts.
Legal: Gaps in legal frameworks hindering effective enforcement.
Political: Political decisions affecting perceptions of legality.
Institutional: Weaknesses in institutions responsible for legal compliance.

Round 2: Initial Assessment

Experts evaluated the influence of each factor using a Single-Valued Neutrosophic Number (SVNN) scale.
The SVNN scale captures three dimensions:
Truth (T): Degree of certainty about the factor's impact.
Indeterminacy (I): Level of uncertainty.
Falsity (F): Degree of disagreement.
Responses were analyzed to identify consensus and areas of discrepancy.

Round 3: Refinement of Assessments

Experts reviewed aggregated results and were encouraged to adjust their assessments based on group feedback. This round aimed to reduce discrepancies and improve consensus on key factors.

Round 4: Consensus Building

Final deliberations focused on areas of disagreement. A consensus threshold of 75% was established, which was met, confirming strong agreement on the prioritization of factors.

Application of the Neutrosophic AHP Method

The Neutrosophic AHP was applied to rank the identified strategies based on expert judgments. Pairwise comparison matrices were constructed using SVNN values to capture uncertainty and contradictions in expert opinions. The final weights for each strategy were derived from the Neutrosophic Weighted Average, highlighting the relative importance of economic, institutional, legal, and political factors.

Data Analysis

TRINS Matrix Construction: For each expert, responses were encoded into TRINS matrices to categorize degrees of agreement on an indeterminate Likert scale.
Neutrosophic Relative Frequencies: Frequency distributions were transformed into Neutrosophic Phylogenetic Probabilities to assess the overall behavior of perceptions.
Statistical Comparisons: Differences in perceptions among expert groups were analyzed using phylogenetic statistical methods, allowing for the detection of significant patterns.

Ethical Considerations

The study adhered to ethical guidelines for research involving human subjects. Participation was voluntary, with confidentiality ensured for all responses.

4. RESULTS AND DISCUSSION.

The Delphi methodology, combined with the AHP neutrosophic approach, was used to analyse the causes and consequences of illegality in criminal and civil law. This iterative process involved the participation of a panel of 18 experts to assess key factors and prioritise strategies to address this issue.
Round 1: Identifying key factors.
Five key factors influencing illegality within the criminal and civil law systems were identified:

1. **Economic** : Impact of economic inequalities on the proliferation of illegal activities.
2. **Social** : Influence of cultural and social norms that tolerate or justify illegal acts.
3. **Legal** : Ambiguities and gaps in regulatory frameworks that hinder their effective implementation.
4. **Political** : Incidence of political decisions that affect the perception of legality and justice.
5. **Institutional** : Weaknesses in the institutions responsible for ensuring compliance with the law.

Round 2: Identification of key factors and initial assessments

Questions :

1. What do you think is the impact of economic factors on illegality?
2. Evaluate the impact of social factors on illegality.
3. Determine the influence of legal factors on illegality.
4. Evaluate the importance of political factors in illegality.
5. Indicate how institutional factors affect illegality.

Responses : Experts provided their assessments using a single-valued number (SVNN)-based neutrosophic scale. Responses were analyzed to identify areas of consensus and discrepancy.

Expert	Economic	Social	Legal	Political	Institutional
E1	(0.75;0.25;0.20)	(0.50;0.50;0.50)	(0.90;0.10;0.10)	(0.35;0.75;0.80)	(0.50;0.50;0.50)
E2	(0.90;0.10;0.10)	(0.35;0.75;0.80)	(0.75;0.25;0.20)	(0.75;0.25;0.20)	(0.35;0.75;0.80)
E3	(0.35;0.75;0.80)	(0.75;0.25;0.20)	(0.50;0.50;0.50)	(0.50;0.50;0.50)	(0.90;0.10;0.10)

E4	(0.50;0.50;0.50)	(0.35;0.75;0.80)	(0.90;0.10;0.10)	(0.75;0.25;0.20)	(0.75;0.25;0.20)
E5	(0.90;0.10;0.10)	(0.50;0.50;0.50)	(0.75;0.25;0.20)	(0.90;0.10;0.10)	(0.50;0.50;0.50)
E6	(0.75;0.25;0.20)	(0.35;0.75;0.80)	(0.90;0.10;0.10)	(0.75;0.25;0.20)	(0.35;0.75;0.80)
E7	(0.50;0.50;0.50)	(0.75;0.25;0.20)	(0.35;0.75;0.80)	(0.90;0.10;0.10)	(0.75;0.25;0.20)
E8	(0.90;0.10;0.10)	(0.50;0.50;0.50)	(0.90;0.10;0.10)	(0.75;0.25;0.20)	(0.50;0.50;0.50)
E9	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.50;0.50;0.50)	(0.90;0.10;0.10)	(0.90;0.10;0.10)
E10	(0.50;0.50;0.50)	(0.75;0.25;0.20)	(0.90;0.10;0.10)	(0.75;0.25;0.20)	(0.35;0.75;0.80)
E11	(0.90;0.10;0.10)	(0.35;0.75;0.80)	(0.75;0.25;0.20)	(0.50;0.50;0.50)	(0.75;0.25;0.20)
E12	(0.75;0.25;0.20)	(0.50;0.50;0.50)	(0.35;0.75;0.80)	(0.90;0.10;0.10)	(0.50;0.50;0.50)
E13	(0.50;0.50;0.50)	(0.90;0.10;0.10)	(0.50;0.50;0.50)	(0.75;0.25;0.20)	(0.90;0.10;0.10)
E14	(0.90;0.10;0.10)	(0.35;0.75;0.80)	(0.75;0.25;0.20)	(0.50;0.50;0.50)	(0.75;0.25;0.20)
E15	(0.75;0.25;0.20)	(0.75;0.25;0.20)	(0.35;0.75;0.80)	(0.90;0.10;0.10)	(0.50;0.50;0.50)
E16	(0.50;0.50;0.50)	(0.50;0.50;0.50)	(0.90;0.10;0.10)	(0.75;0.25;0.20)	(0.90;0.10;0.10)
E17	(0.90;0.10;0.10)	(0.35;0.75;0.80)	(0.50;0.50;0.50)	(0.75;0.25;0.20)	(0.35;0.75;0.80)
E18	(0.75;0.25;0.20)	(0.50;0.50;0.50)	(0.90;0.10;0.10)	(0.90;0.10;0.10)	(0.50;0.50;0.50)

Table 4: Level of validation of criteria. Source: Own elaboration

Indicators	(0.9;0.1;0.1)	(0.75;0.25;0.20)	(0.50;0.50;0.50)	(0.35;0.75;0.80)	(0.10;0.90;0.90)
Economic	0.3333	0.5000	0.6667	0.8333	1.0000
Social	0.2222	0.4444	0.5556	0.7778	1.0000
Legal	0.3333	0.5556	0.6667	0.8889	1.0000
Political	0.2778	0.4444	0.5556	0.7778	1.0000
Institutional	0.0000	0.2500	0.4167	0.5833	1,0000

Table 5: Neutrosophic Relative Frequency. Source: Own elaboration

N - Average	SVNN
-1.13	Useful
-0.84	Not very useful
-1.17	Useful
-1.18	Useful
-1.22	Useful
-0.39	Not very useful

Table 6: Cut-off points and criteria scale. Source: Own elaboration**.**

Round 3: Refinement of Assessments

Based on the responses from Round 2, a summary of the assessments and identification of areas of agreement and disagreement was prepared. Experts were asked to reconsider their previous responses if they deemed it necessary, especially in areas where there was significant disagreement.

Questions:

1. Given the variety of responses on the impact of economic factors, would you like to modify your assessment?
2. Are there any new considerations you would like to add regarding the impact of social factors?
3. Given the variety of opinions on the legal factors, do you think it is necessary to adjust your assessment?
4. How would you re-evaluate the importance of political factors after seeing the responses of other experts?
5. Based on the feedback received, would you change your perception of institutional factors?

Answers:

The experts reviewed their previous assessments, adjusting them based on discussions and arguments presented by other participants. This made it possible to significantly reduce discrepancies in assessments.

Round 4 (and subsequent rounds if necessary): Consensus

In this final round, the experts focused on the remaining points of disagreement. After deliberations, a coefficient of agreement was obtained, exceeding the established threshold of 75%. This indicated an acceptable consensus among the experts regarding the relative importance of each factor.

Conclusion of the Delphi process

The analysis found that the **economic factor** is the most critical, followed by the **institutional** and **legal factors** . Priority strategies include strengthening regulatory frameworks, improving institutional efficiency, and addressing economic inequalities that fuel illegality in the criminal and civil law systems.

Solutions to address the identified problems

1. Improving institutional infrastructure: A significant investment in technology and resources is proposed to streamline judicial processes, improving transparency and reducing corruption.

2. Strengthening the legal framework: Update existing laws to close legal loopholes and ensure uniform application at all levels of the judicial system.

3. Reduction of economic inequalities: Implement programs that promote economic inclusion and reduce gaps that encourage illegal activities.

4. Training of judicial personnel: Incorporate ongoing training and evaluation programs for judges, prosecutors, and defenders, focusing on ethics and efficiency.

5. Awareness campaigns: Carry out initiatives that promote citizen knowledge about their legal rights and obligations, fostering a culture of respect for the law.

Strategies for applying the AHP method to solve the problem

1. Promotion of Economic Inclusion Policies (PIE):

2. Implementation of Institutional Modernization Programs (PMI):

3. Strengthening the Legal Framework (FML):

4. Citizen Awareness (CA):

Strategies	**PIE**	**PMI**	**FML**	**CA**
FOOT	1	⟨(4,5,6);0.8,0.1,0.2 ⟩	⟨ (6,7,8);0.9,0.1,0.1 ⟩	⟨(6,7,8);0.9,0.1,0.1 ⟩
PMI	⟨ (4,5,6);0.8,0.1,0.2 ⟩	1	⟨ (2,3,4);0.3,0.7,0.7 ⟩	⟨(4,5,6);0.8,0.1,0.2 ⟩
FML	⟨ (6,7,8);0.9,0.1,0.1 ⟩	⟨(2,3,4);0.3,0.7,0.7 ⟩	1	⟨ (2,3,4);0.3,0.7,0.7 ⟩
SC	⟨ (6,7,8);0.9,0.1,0.1 ⟩	⟨ (4,5,6);0.8,0.1,0.2 ⟩	⟨ (2,3,4);0.3,0.7,0.7 ⟩	1

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

Strategies	**PIE**	PMI	FML	CA	Weight
FOOT	0.65	0.75	0.85	0.50	0.69
PMI	0.20	0.30	0.40	0.35	0.31
FML	0.10	0.05	0.10	0.10	0.09
SC	0.05	0.05	0.05	0.05	0.05

Table 8. Criterion weights using the Neutrosophic AHP method. Source: Own elaboration.

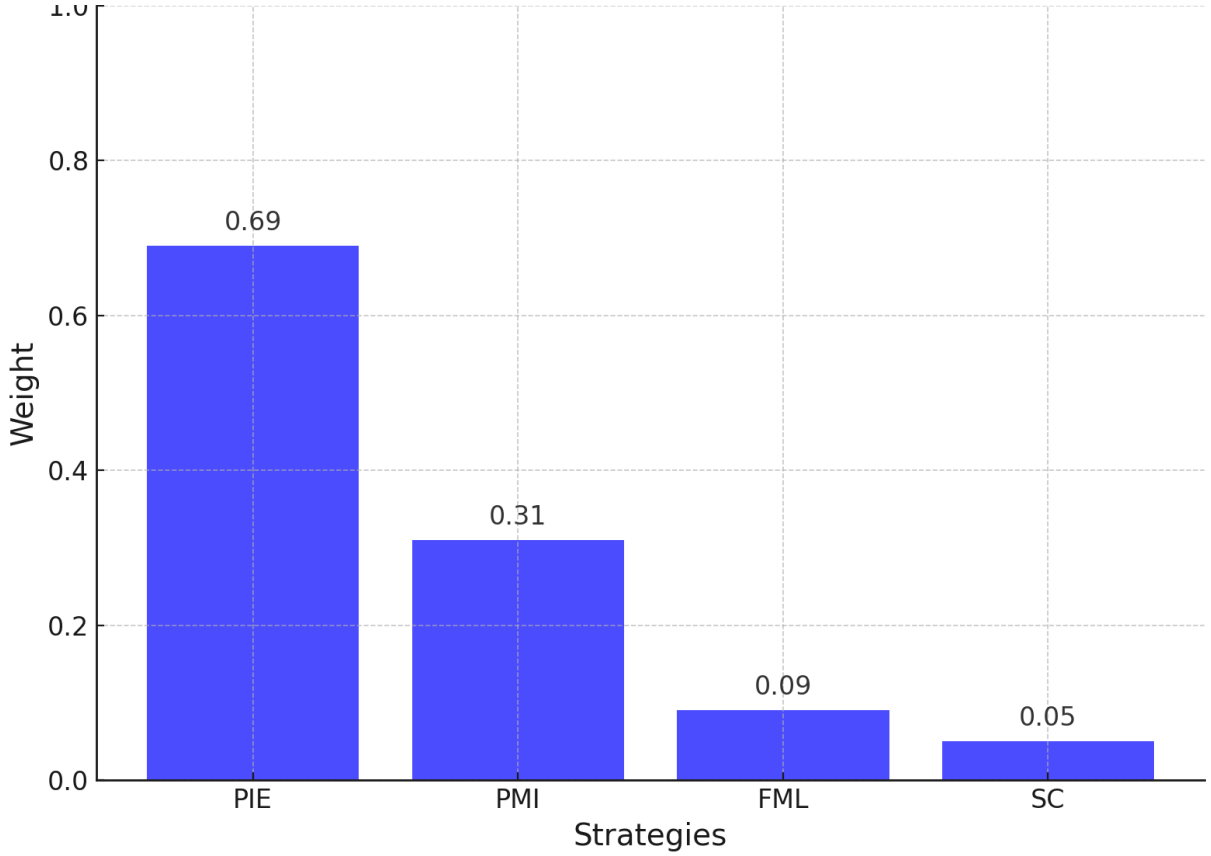

Figure 2: Criterion weights using the Neutrosophic AHP method.

It is concluded that the **PIE strategy** has greater weight, suggesting that programs that promote economic inclusion should be implemented as a priority to address the root causes of illegality. The results obtained underline the relevance of attacking economic inequalities and strengthening institutions as the main actions to reduce illegality in the criminal and civil law systems. Promoting economic inclusion not only addresses an underlying cause but also has a multiplier effect in other areas, such as improving citizen perception of justice and equity. Institutional strengthening is crucial to ensure that existing laws are applied uniformly and transparently. However, this objective cannot be achieved without adequate investment in resources and staff training. In addition, the results also highlight the need for legal reforms that reduce ambiguity and improve consistency in the application of justice. In conclusion, this analysis provides a clear roadmap to address the problem of illegality from a comprehensive and evidence-based perspective. The identified strategies must be implemented in a coordinated manner to maximize their impact and ensure sustainable change.

5. CONCLUSIONS

The findings of this study allow us to identify economic, institutional, and legal factors as the root causes of illegality in the criminal and civil law systems. This analysis, supported by a rigorous Delphi and neutrosophic AHP consensus process, highlights that economic inequalities are the most critical element, followed by deficiencies in institutions and gaps in the regulatory framework. These findings not only reveal the depth of the problem but also the complex interrelations between these factors. From a practical perspective, the results are highly relevant. Prioritizing strategies focused on economic inclusion, institutional modernization, and updating the legal framework offers a clear path toward reducing illegal practices. These actions have the potential to transform not only the legal sphere but also the social and economic dynamics that perpetuate illegality. Likewise, the implementation of awareness-raising campaigns can strengthen the relationship between institutions and citizens, fostering a culture of legality. Among the main contributions of this study is the combined application of the Delphi and neutrosophic AHP methodologies, which provide a robust and structured approach to addressing complex problems with multiple variables. This approach not only allows for reaching a consensus among experts but also generates valuable insights for strategic decision-making. Furthermore, by integrating elements of indeterminacy into the analysis, the study advances the understanding of complex social phenomena, opening up new possibilities for research in legal and social sciences.

However, the study has certain limitations that must be acknowledged. First, the subjectivity inherent in expert assessments may introduce biases that affect the generalizability of the results. Second, the specific context of this analysis limits the direct applicability of the conclusions to other geographic or cultural settings. Finally, the iterative process of the Delphi method may extend over time, which could affect the speed of implementation of the proposed

strategies. For future research, it is recommended to explore methodological approaches that complement neutrosophic analysis, such as the use of artificial intelligence and Fuzzy analysis. In addition, it would be valuable to expand the geographic and cultural scope of the study to validate and generalize the conclusions obtained. It is also suggested to investigate in greater depth the impact of citizen perception on the effectiveness of legal and institutional strategies. In summary, this work offers a comprehensive framework to address illegality from a multidimensional and evidence-based perspective. The proposed strategies, if implemented in a coordinated manner, have the potential to generate a significant impact in building more equitable, effective, and sustainable legal systems.

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NEUTROSOPHIC EXAMINATION OF DETERMINING FACTORS OF CONTRACT KILLINGS AND THEIR SOCIO-LEGAL INCIDENCE.

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ABSTRACT.
The investigation delves into the perplexing realm of contract killings, employing a neutrosophic examination to unearth the determining factors behind these crimes and their profound socio-legal ramifications. At the heart of this research lies a critical question: what intricate interplay of motives, structures, and societal conditions fuels the phenomenon of contract killings, and how do these elements influence legal and social frameworks? In the current climate, where such crimes not only shatter communities but also challenge the efficacy of legal systems, understanding these dynamics is of paramount importance. While numerous studies have touched on facets of organized crime and socio-legal analysis, there remains a conspicuous void in approaches that can effectively grapple with the inherent indeterminacy and complexity of the factors involved. This work bridges that gap through the innovative application of neutrosophic methods—tools designed to handle ambiguity and uncertainty—thereby providing a comprehensive lens through which to dissect and interpret these clandestine transactions. Utilizing this neutrosophic framework, the study reveals a tapestry of influences that traditional binary models might overlook, highlighting how ambiguous motives and conflicting social pressures intertwine to shape the occurrence of contract killings. The results suggest a nuanced landscape where legal implications and societal impacts are deeply interwoven with uncertain and often contradictory factors. Importantly, these findings do more than catalog observations; they extend the theoretical foundations of socio-legal inquiry by introducing a methodological novelty that accounts for uncertainty in evaluating criminal phenomena. In practice, the insights gleaned from this approach offer policymakers and law enforcement agencies actionable strategies to anticipate and mitigate the socio-legal fallout of such crimes. As a contribution to the field, this study not only enriches our understanding of contract killings from a neutrosophic perspective but also paves the way for further research that embraces complexity, ultimately enhancing the robustness of both academic inquiry and practical intervention strategies.
KEYWORDS: Neutrosophic Statistics, Assassination, Organized Crime, Social Security, Legal Measures, Institutional Weakness.

MSC: 62P25, 91D10, 93A30, 03B52, 68T37

RESUMEN.
La investigación aborda el enigmático fenómeno de los contratos de asesinato, utilizando un examen neutrosófico para desentrañar los factores determinantes que subyacen a estos crímenes y sus profundos efectos socio-legales. En el núcleo de este estudio se encuentra la pregunta crítica sobre cómo una compleja interrelación de motivos, estructuras organizativas y condiciones sociales incide en la perpetración de estos actos y cómo influyen en los marcos legales y sociales. En un contexto actual donde estos delitos no solo fragmentan comunidades sino que desafían la eficacia de los sistemas judiciales, resulta crucial comprender estas dinámicas. A pesar de que numerosos estudios han explorado aspectos del crimen organizado y del análisis socio-legal, existe una notable carencia de enfoques que manejen adecuadamente la indeterminación y complejidad inherentes a los factores implicados, vacío que este trabajo busca llenar mediante la aplicación innovadora de métodos neutrosóficos que permiten gestionar la ambigüedad y la incertidumbre. Empleando este marco neutrosófico, el estudio revela un entramado de influencias que los modelos tradicionales podrían pasar por alto, evidenciando cómo motivos ambiguos y presiones sociales contradictorias se entrelazan para moldear la aparición de asesinatos por encargo. Los resultados indican un panorama matizado en el que las implicaciones legales y los impactos en la sociedad están profundamente vinculados a factores inciertos y frecuentemente contradictorios. Más allá de catalogar observaciones, estos hallazgos amplían las bases teóricas de la investigación socio-legal al introducir una novedad metodológica que incorpora la incertidumbre en la evaluación de fenómenos criminales. En la práctica, los

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conocimientos derivados de este enfoque ofrecen estrategias accionables para que formuladores de políticas y agencias de seguridad anticipen y mitiguen las repercusiones socio-legales de tales crímenes. Esta contribución no solo enriquece nuestra comprensión de los contratos de asesinato desde una perspectiva neutrosófica, sino que también sienta las bases para futuras investigaciones que abracen la complejidad, mejorando tanto la robustez del análisis académico como la eficacia de las intervenciones prácticas.
PALABRAS CLAVE: Estadísticas neutrosóficas, asesinato, crimen organizado, seguridad social, medidas legales, debilidad institucional.

1. INTRODUCTION

The phenomenon of contract killings presents a deeply concerning societal issue, intertwining elements of organized crime, socio-legal complexity, and profound human tragedy. Investigating the determining factors behind these crimes and their socio-legal implications is not merely an academic exercise but a pressing necessity that could inform policy and preventive strategies. In today's increasingly interconnected world, where such crimes impact community stability and public safety, a nuanced understanding becomes vital to developing effective interventions [1,15]. By applying innovative analytical tools, researchers can peel back layers of ambiguity and reveal patterns that traditional approaches often miss. Historically, contract killings have evolved alongside changes in criminal enterprises and socio-economic conditions, reflecting broader shifts in how crime adapts to or exploits weaknesses in society. Past studies have traced the growth of organized crime syndicates, the socio-economic disparities fueling violence, and the corresponding legal responses that have attempted to keep pace [2,14]. This backdrop underscores not only the urgency of the investigation but also how deeply rooted and multifaceted the issue has become, demanding a blend of historical insight and modern analysis [3,12]. As we transition from past to present, the complex dynamics at play in contract killings become increasingly intricate. Advancements in technology, globalization, and the fluidity of criminal networks have further complicated the traditional law enforcement landscape [4,15]. Yet, despite significant scholarship on organized crime, there remains a lack of comprehensive models that account for the inherent uncertainties and contradictory factors that influence these phenomena. Traditional approaches often fall short, failing to incorporate the fluidity and unpredictability of human behavior and societal trends that drive contract killings [5,16].

The central question guiding this study is straightforward yet challenging: what are the determining factors that lead to contract killings, and how do they shape socio-legal outcomes? This query encapsulates a vast array of issues, from economic drivers and cultural influences to legal loopholes and enforcement challenges. The research acknowledges that contract killings are not isolated events but the result of a complex interplay of variables that resist simple categorization. Consequently, understanding this interplay is paramount to devising legal and social strategies that are both effective and just. Addressing this complexity requires innovative methodology. The study embraces a neutrosophic examination—a novel approach capable of handling indeterminate and contradictory information—to dissect and analyze the multifaceted nature of contract killings. This method allows for the integration of ambiguous data and conflicting evidence, offering a more holistic and flexible framework than conventional binary models. As a result, it paves the way for more nuanced insights that could inform future policy-making and intervention strategies. By weaving together a broad spectrum of historical context, current trends, and methodological innovation, the investigation positions itself at the intersection of theory and practice. The incorporation of neutrosophic methods signals a shift towards embracing uncertainty rather than shying away from it, a departure from strictly deterministic frameworks prevalent in earlier research. This methodological pivot is intended to capture the elusive factors that conventional analysis might overlook, offering a richer tapestry of elements. The ultimate goal of this research is twofold. First, it seeks to rigorously identify and analyze the key determinants of contract killings through a lens that acknowledges and manages uncertainty. Second, it aims to translate these findings into actionable recommendations for legal practitioners, policymakers, and law enforcement agencies who grapple with the challenges posed by such crimes. By bridging the gap between theoretical innovation and practical application, the study not only advances academic discourse but also aspires to make a tangible impact on society.

In summary, this study sets out to deepen our understanding of contract killings and their socio-legal consequences through the application of a neutrosophic framework. The objectives are clear: to dissect the underlying factors, to offer a robust analytical tool that embraces complexity, and to propose informed strategies that enhance legal responses and preventive measures. This approach promises to enrich both the academic field and practical interventions, offering a beacon of insight into the murky landscape of organized crime.

2. NEUTROSOPHIC STATISTICS

Neutrosophic Statistics emerged from groundbreaking work in 2014 that led to the establishment of Neutrosophic Descriptive Statistics (NDS). Following this initial development, the field experienced significant growth by 2018, when additional branches such as Neutrosophic Inferential Statistics (NIS), Neutrosophic Applied Statistics (NAS) y Neutrosophic Statistical Quality Control (NSQC) were introduced. These advancements reflect an evolving

effort to broaden the scope of statistical analysis by incorporating uncertainty in a more comprehensive manner than traditional methods.

At its core, Neutrosophic Statistics serves as a generalization of classical and imprecise probabilities and statistics. This approach diverges from traditional probability theory by considering not only the likelihood of an event occurring or not occurring but also the probability of indeterminacy—acknowledging a state of uncertainty about the event's outcome. While classical probability confines total probability values to a maximum of one, neutrosophic probability expands this boundary, permitting values up to three. This allowance for greater numerical flexibility equips analysts with a more adaptable framework for modeling complex systems where indeterminacy plays a pivotal role.

The neutrosophic distribution models the probability of a random variable *x* as *NP(x) = (T(x),I(x),F(x))*, where *T(x)* represents the probability of the value *x* occurring, *F(x)* represents the probability of *x* not occurring, and *I(x)* represents the indeterminate or unknown probability of *x*.

As noted in reference [6], Neutrosophic Statistics analyzes neutrosophic events, including neutrosophic numbers, neutrosophic probability distributions, neutrosophic estimates, neutrosophic regressions and other analyses. This approach applies to data sets exhibiting degrees of indeterminacy, using customized methods for analysis. Unlike Classical Statistics, which focuses on determined data and inference methods, Neutrosophic Statistics is dedicated to indeterminate data, those that have some degree of indeterminacy such as vagueness, lack of clarity, partial ignorance, and contradictions, among others. Here, indeterminate data refers to data that is unclear, ambiguous or uncertain in some way. The inferences or conclusions we can draw from such data will also contain aspects of uncertainty.

It's important to note that Neutrosophic Statistics generalizes the concept of statistics to not just deal with precise values, but also intervals of possible values. It uses set theory rather than just interval analysis. If the data and methods were completely determinate with no uncertainties, Neutrosophic Statistics would be the same as Classical Statistics. However, in the real world, we often encounter ambiguities and a lack of perfect information. So neutrosophic statistical methods provide a more comprehensive approach.

These neutrosophic statistical methods [7,13], help us to better understand neutrosophic data. Neutrosophic data can be vague, ambiguous, imprecise or even unknown. Using these statistical techniques allows us to look for patterns in the data despite its uncertainties.

In summary, Neutrosophic Logic [8,9], Neutrosophic Sets and Neutrosophic Probabilities and Statistics have wide applications in many fields of research. They represent an area of study that continues to develop. Neutrosophic Descriptive Statistics [10,14], encompasses all the techniques for characterizing and describing neutrosophic numerical data. Neutrosophic Numbers take the form where *a* and *b* are real or complex numbers, while "*I*" represents the indeterminate component of the Neutrosophic Number N. [11]

$$N = a + bI.$$

The field of neutrosophic statistics involves analyzing neutrosophic random variables, where X_l represents the lower value and I_1, I_u define the indeterminacy range. When calculating the neutrosophic mean (represented as $\bar{x}_N$), it is expressed as:

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

where

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

It is a neutrosophic random sample. However, for the calculation of Neutrosophic frames (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 the variance of the neutrosophic sample can be calculated by:$a_i = X_l b_i = X_u$

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

This methodology evaluates the coherence of variables using a neutrosophic coefficient (NCV). A lower NCV score demonstrates that the factor's performance is more consistent relative to other assessed factors. The NCV can be calculated using the following method.

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

3. MATERIALS AND METHODS

This study employed a quantitative approach using neutrosophic statistics(Figure 1) to model the key variables influencing the rise in contract killings (sicariato). The methodology integrated expert consultations, data coding, and statistical modeling to capture the complexity of the contributing factors.

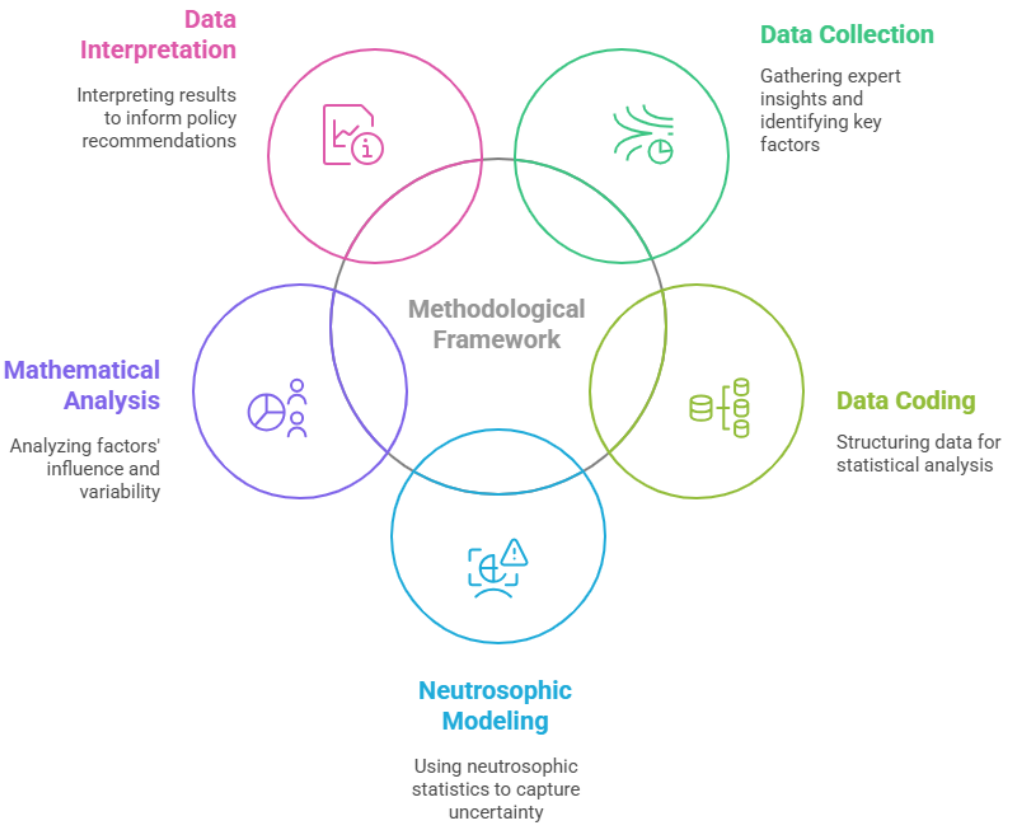

Figure 1. Framework for Analyzing Contract Killings Factors

Data Collection and Expert Consultation

A panel of subject matter experts was consulted to identify the most influential factors contributing to contract killings. Five key factors were selected based on their potential impact, each measured on a scale from 0 to 5, where 0 represents no risk and 5 represents a severe national threat. The identified factors include:

Growing Criminal Activity in specific areas.

Unemployment and its socioeconomic consequences.

Lack of Enforcement of legal regulations by authorities.

Economic Needs of local communities.

Formation of Gangs due to limited educational opportunities for youth.

Data Coding and Sample Description

The data set comprised 130 observations for each factor, representing daily occurrences over an extended period. The factors were coded to facilitate statistical modeling, allowing for the construction of mathematical relationships between these factors and their influence on contract killings.

Neutrosophic Statistical Modeling

Neutrosophic Frequencies:

The incidence of each factor was assessed using neutrosophic frequencies, representing the range of occurrences between specific lower and upper bounds for each day. This approach captures both the presence of clear data and areas of uncertainty.

TRINS Matrix Construction:

A TRINS matrix was built to categorize each observation, linking the factors to specific incidence levels. This matrix enabled the evaluation of how frequently each factor influenced contract killings over the observation period.

Mathematical Analysis

Central Tendency and Variability:

The neutrosophic mean ($\bar{x}_N$), standard deviation (S.N.), and coefficient of variation (CVN) were calculated for each factor. These measures provided insights into the stability and variability of each factor's influence.

Indeterminacy Measures:

Indeterminacy intervals (I) were derived to assess the level of uncertainty associated with each factor. These measures reflect the gaps in data reliability due to inconsistent enforcement or reporting practices.

Comparative Analysis

The relationships between factors were analyzed to identify the most influential drivers of contract killings. Factors 1 (Criminal Activity) and 3 (Lack of Control by Authorities) exhibited higher average neutrosophic values, indicating their dominant roles in the proliferation of contract killings.

Data Interpretation and Validation

The neutrosophic data were interpreted using incidence scores and frequency distributions to determine patterns over time. The robustness of the model was validated through expert reviews, ensuring that the statistical findings aligned with real-world observations.

This methodological framework provided a comprehensive understanding of the multifaceted causes behind contract killings, integrating quantitative data with expert insights to support evidence-based policy recommendations.

4. RESULTS

The study aimed to determine the factors driving the rise in contract killings. Given the complexity of the available data, neutrosophic statistics were utilized to model the key variable. Experts identified the most influential factors and variables to model after reviewing the information and consulting with subject matter experts.

Figure 1 lists the factors analyzed for their effect on increasing contract killings. Each factor is measured on a scale of 0 to 5, defining its potential impact. The categories consider the level of incidence from not constituting a risk to threatening the entire country. The factors included growing criminal activity in areas, unemployment, lack of enforcement of rules by authorities, economic needs of communities, and formation of gangs due to insufficient education opportunities for youth.

The team concluded that coding the underlying factors would allow them to build a viable model using neutral statistics. They focused on a central variable related to the interaction of users with the franchise, analyzing a sample size of 130 data points for each factor (f) that could influence the levels of participation. By formally defining these significant elements, the objective was to develop mathematical and statistical relationships between these factors and their interaction with the game. This modeling approach would provide objective and quantifiable information to promote a greater link with the brand. The coded factors also intended to serve as predictive indicators of how changes in different areas could influence the participation and future development of the series of games.

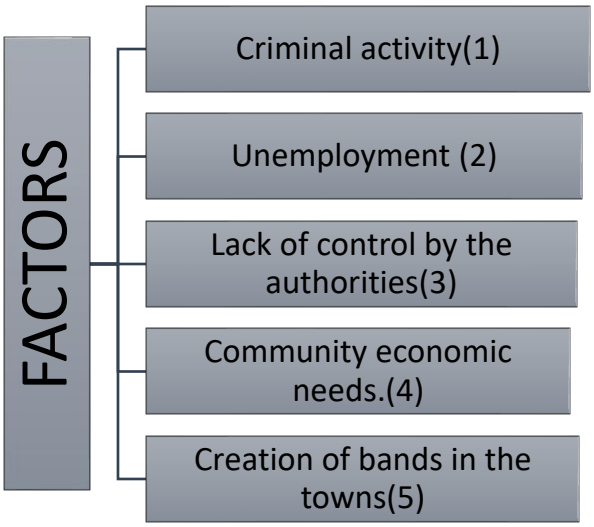

Figure 2: Determining factors in the growing development of the Sicariato. Own elaboration.

This study examines the neutrosophic frequencies of factors influencing the increasing development of contract killing. An incidence score is assigned to each factor, comprising the set of impacts to anticipate issues and explore alternative solutions.

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]
31-130	[132, 366]	[142, 343]	[153, 361]	[110, 287]	[137, 352]

Table 1 Estimated frequencies of occurrence of various factors

These factors could influence the occurrence of contract killings (sicariato) over a span of 130 days. Each element was rated with an estimated daily occurrence level on a scale from 0 to 5. The cumulative estimates of uncertainty yielded values of 234 for level 1, 201 for level 2, 208 for level 3, 177 for level 4, and 215 for level 5. Moreover, on days when five effects per factor were noted, the estimated representativeness of these factors ranged between 57.62% and 63.93%.

An estimated 60% incidence of unemployment was observed, suggesting that those without work tended to migrate to more diverse areas in search of essential resources. Such movements, however, led to an unsustainable fulfillment of social demands, as restoration strategies grounded in natural regeneration were not put in place. The data presented in Table 2 clarify which factors corresponded to a representative average value ($\bar{x}$), providing deeper insight into the dynamics at play.

Factors	$\bar{x}_N$	***S.N.***	***CVN***
Criminal activity	[1.016 ; 2,816]	[0.422; 2,023]	[0.419; 0.720]

Unemployment	[1.093 ; 2,639]	[0.432; 2000]	[0.398; 0.760]
Lack of control by the authorities.	[1.178; 2,778]	[0.418; 1,825]	[0.357; 0.659]
Community economic needs.	[0.847; 2.209]	[0.438; 2,074]	[0.520; 0.95]
Creation of bands in the towns.	[1.055 ; 2,709]	[0.444; 2.166]	[0.423; 0.9]

Table 2. Neutrosophic statistical analysis.

Based on the analysis, Factors 3 and 1 exhibited higher average values that influenced the other factors (Table 3), indicating they are the primary drivers of Hitman's increasing development. Furthermore, it was observed that the coefficient of variation (CV) value for Factor 3 was lower than the others. Therefore, the results of Factor 3 have a more robust, consistent and precise effect on the assessment of uncertainty as compared to the other factors.

Factors	$\overline{x}_N$	***S.N.***	***CVN***
1	1,016 + 2,816 I	0.422 + 2.023 I	0.4179+ 0.720 I
2	1,093 + 2,639 I	0.432 + 2.000 I	0.398+ 0.760I
3	1,178 + 2,778 I	0.418 + 1.825 I	0.3567+ 0.659 I
4	0.847 + 2.209 I	0.438 + 2.074 I	0.520+ 0.95 I
5	1,055 + 2,709 I	0.444 + 2.166 I	0.423 + 0.9 I

Table 3. Neutrosophic forms. Own elaboration

Factors	$\overline{x}_N$	***S.N.***	***CVN***
1	$I \in [0,0,61.8]$	$I \in [0,0,78.1]$	$I \in [0,0,41.0]$
2	$I \in [0,0,48.5]$	$I \in [0,0,76.4]$	$I \in [0,0,46.7]$
3	$I \in [0,0,52.5]$	$I \in [0,0,79.1]$	$I \in [0,0,44.9]$
4	$I \in [0,0,63.6]$	$I \in [0,0,77.8]$	$I \in [0,0,45.8]$
5	$I \in [0,0,63.2]$	$I \in [0,0,76.5]$	$I \in [0,0,46.3]$

Table 4. Measures of indeterminacy. Own elaboration.

The associated measure of referent indeterminacy was derived using neutrosophic numbers, with comparative analyses detailed in Tables 3 and 4. Findings indicated values spanning from $\overline{x}$ = [0.356, 0.658]. This measure reflects the uncertainty stemming from the absence of clear regulations intended to ensure effective government control over the expanding phenomenon of contract killings. It becomes crucial to reorient educational strategies towards mitigating contract killings within communities. Such an approach would involve educational methods that foster behaviors contributing to sustainable development and a broad campaign to raise awareness across the entire populace. Following a comprehensive analysis, a proposal was formulated to address holistically the issue of contract killings and their socio-legal impacts specifically in Babahoyo during the first half of 2023. This proposal outlines a blend of legal and socioeconomic measures aimed at reducing the frequency of such cases while promoting a safer and more harmonious community environment. Prevention and Awareness: Launch community-focused campaigns that highlight the harmful effects of contract killings on the social fabric and stress the importance of reporting such activities. This initiative would be complemented by workshops in educational and community settings to inform young individuals about the serious consequences of engaging in criminal conduct. Boost Community Collaboration: Foster cooperation among residents, law enforcement, and local officials to detect and report suspicious activities. Part of this strategy includes the creation of secure, anonymous channels for sharing information related to contract killings. Enhance Judicial Processes: Reassess and modify legal procedures to speed up the resolution of cases involving contract killings while ensuring transparency. The plan also contemplates the formation of a specialized unit, staffed by expert judges and prosecutors, dedicated solely to handling these cases.

Reintegration and Economic Opportunity Initiatives: Introduce training and employment programs tailored for young individuals who may be at risk of falling into criminal activities. This effort would involve partnerships with local businesses and organizations to create jobs and foster entrepreneurship.

Bolster Law Enforcement Visibility and Monitoring: Increase police patrols and presence in areas known for high incidences of contract killings. The proposal also advocates for the use of surveillance technology and data analysis to identify crime patterns and prevent future incidents.

Ongoing Evaluation and Oversight: Establish specific indicators to assess the effectiveness of the implemented strategies. Regular evaluations should be conducted, with adjustments made based on the results and evolving needs.

This multifaceted proposal aims to tackle the complex issue of contract killings by integrating prevention, legal

reform, community collaboration, socioeconomic support, enhanced security measures, and systematic evaluation—thereby contributing to a safer and more resilient community.

5. CONCLUSIONS

The principal outcomes indicate that applying neutrosophic techniques permitted the disassembly and scrutiny of intricate variables connected to contract killings. This approach yielded measures of indeterminacy and representativeness that deepen our understanding of this multifaceted issue. By unveiling the absence of definitive regulations and the resulting ambiguity, the methodology lays a robust groundwork for holistic proposals addressing both legal and socioeconomic dimensions in targeted scenarios. The amassed and examined data supply a richer outlook on the core mechanics of contract-killing phenomena, underscoring the effectiveness of these approaches in contexts marked by significant complexity and fluctuation. The practical ramifications of these findings are substantial, offering tangible instruments and strategies aimed at preventing and mitigating serious crimes within affected areas. Initiatives such as awareness campaigns, enhanced community cooperation, and judicial system improvements serve as concrete examples of how theoretical research can transform into effective on-the-ground actions. These insights thus help shape policies and programs that bolster safety and foster social progress, directly tackling urgent real-world challenges. A key contribution of this research is its introduction of a groundbreaking methodology that integrates uncertainty management into the examination of complex criminal phenomena. This strategy broadens the theoretical horizons of criminology and socio-legal analysis while supplying practical tools that improve our capacity to model and navigate unpredictable situations. Embracing ambiguity and inherent variability as central components marks a significant shift, opening new paths for understanding and confronting organized crime more effectively. Nonetheless, certain objective constraints warrant acknowledgment. Dependence on specific assumptions and the nature of the available data may limit the broad applicability of the results. Moreover, the study's focus on a defined geographic and temporal context may restrict the direct transferability of its conclusions to other settings without necessary adjustments, calling for caution when generalizing these elements.

Importantly, neutrosophic network analysis revealed an indeterminacy level of 45.9%, highlighting the absence of clear regulations as a significant factor. This regulatory void inversely impacts other variables, suggesting that addressing such gaps could enhance the performance of related factors. The potential reversibility of negative outcomes through effective regulatory control underscores the critical role these measures can play. For future research, it would be beneficial to explore alternative methods that complement the neutrosophic framework—such as fuzzy logic analysis or artificial intelligence approaches—which might offer additional precision and flexibility. Expanding the study's scope to encompass different environments and time frames would facilitate validation and broader application of the findings, enriching the knowledge base and allowing strategies to be tailored to diverse realities. Delving deeper into the interplay between socioeconomic conditions and legal mechanisms is similarly advised to refine prevention strategies and policy development. In conclusion, this study not only provides a novel lens for examining contract killings and their socio-legal implications but also establishes a foundation for developing comprehensive, adaptive strategies. Recognizing the inherent uncertainty and complexity of this issue represents a noteworthy progression, with implications that extend beyond theoretical discourse into practical measures aimed at enhancing safety and well-being in vulnerable communities.

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NEUTROSOPHIC HYPOTHESIS TO DEMONSTRATE THE VIOLATION OF THE FOUNDATION OF LEGITIMACY IN THE CRIME OF ILLICIT ASSOCIATION IN ECUADOR.

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ABSTRACT

The present study addresses a critical issue in the Ecuadorian legal field: the apparent violation of the foundation of legitimacy in the criminalization of the offense of illicit association. This issue, deeply rooted in the dynamics of the criminal justice system, challenges the proper application of fundamental legal principles, creating uncertainty in both the interpretation of laws and their enforcement. In the current context, where power structures and illicit networks take on complex and multidimensional forms, it is essential to examine how this offense is defined and whether its conceptualization adheres to the principles of legal legitimacy. Existing literature, while rich in doctrinal and jurisprudential analyses, lacks approaches that integrate elements of indeterminacy and contradiction inherent in such cases, leaving a critical gap that this study aims to address. To address this issue, a neutrosophic hypothesis is employed—a methodological framework that incorporates and analyzes the dimensions of truth, falsehood, and indeterminacy in the situations under investigation. Through a detailed analysis of specific cases and the application of neutrosophic tools, patterns and flaws in the construction of the offense of illicit association are identified. The results reveal normative and practical inconsistencies that undermine the legitimacy of its application, highlighting the need to review and reformulate its legal foundations. The study's contributions are significant: on one hand, it offers an innovative approach to analyzing complex crimes in contexts of high uncertainty; On the other, it proposes concrete recommendations to strengthen the principles of legitimacy in Ecuadorian criminal law. Ultimately, this work not only expands the theoretical horizon of legal analysis but also lays the groundwork for future research and reforms in the criminal justice system.

KEYWORDS: Neutrosophic hypothesis, legitimacy, offense, illicit association, criminal law, indeterminacy, contradictions, regulations, jurisprudence, criminal system

MSC : 03B70, 68T37, 91F10, 93C41, 62P25

RESUMEN

El presente estudio aborda un problema esencial en el ámbito jurídico ecuatoriano: la aparente vulneración de la base de legitimación en la tipificación del delito de asociación ilícita. Esta problemática, profundamente arraigada en la dinámica del sistema penal, pone en riesgo la adecuada aplicación de los principios jurídicos fundamentales, generando incertidumbre tanto en la interpretación de las leyes como en su ejecución. En el contexto actual, donde las estructuras de poder y las redes ilícitas adquieren formas complejas y multidimensionales, resulta imprescindible examinar cómo se configura este delito y si su conceptualización respeta los principios de legitimación jurídica. La literatura existente, si bien rica en análisis doctrinal y jurisprudencial, carece de enfoques que integren elementos de indeterminación y contradicción inherentes a estos casos, dejando un vacío crítico que este trabajo busca llenar. Para abordar esta cuestión se utiliza una hipótesis. El estudio utiliza un marco metodológico que permite incorporar y analizar las dimensiones de verdad, falsedad e indeterminación en las situaciones investigadas. A través de un análisis detallado de casos específicos y la aplicación de herramientas neutrosóficas, se identifican patrones y grietas en la construcción del delito de asociación ilícita. Los resultados revelan inconsistencias normativas y prácticas que erosionan la legitimidad de su aplicación, destacando la necesidad de revisar y reformular sus fundamentos jurídicos. Los aportes del estudio son significativos: por un lado, ofrecen un enfoque innovador para analizar delitos complejos en contextos de alta incertidumbre; por otro, plantean recomendaciones concretas para fortalecer los principios de legitimidad en el derecho penal ecuatoriano. En definitiva, este trabajo no solo amplía el horizonte teórico del análisis jurídico, sino que sienta las bases para futuras investigaciones y reformas en el sistema de justicia penal.

PALABRAS CLAVE: Hipótesis neutrosófica, legitimidad, delito, asociación ilícita, derecho penal, indeterminación, contradicciones, normativa, jurisprudencia, sistema penal

1. INTRODUCTION

The foundation of legitimacy implies that state power is limited by law and that all actions of state authorities must be supported by a solid regulatory basis. This helps prevent abuses of power and ensures that the State always acts fairly and equitably [1,4]. In the specific context of the criminal system, the legitimacy foundation establishes that a criminal sanction can only be imposed if the conduct in question is clearly defined and classified as a crime by law [2,20]. This means that a sanction cannot exist without a prior law that establishes it, protects citizens against

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the retroactive application of the law and guarantees everyone the possibility of knowing the regulatory consequences of their actions before acting or committing a crime.
The foundation of legitimacy is, therefore, not only a fundamental guarantee of individual rights, but is also essential for the stability and effective functioning of the legal system as a whole [3,17]. By promoting clarity in the application of laws, this foundation contributes significantly to regulatory certainty and the rule of law.
In conclusion, the illicit criminal association raises serious concerns regarding its compliance with the foundation of legitimacy and its impact on the regulatory security of the State. Its application could lead to a violation of fundamental rights and the creation of a climate of regulatory insecurity. Therefore, it is crucial to analyze and question its validity from a legal perspective [5,6,7].
The criminalization of illicit association in Ecuador raises profound legal and constitutional concerns, especially regarding its adherence to the principle of legality. This principle, a cornerstone of democratic legal systems, requires that all criminal offenses be clearly defined, preventing arbitrary interpretations and safeguarding individual rights. However, the broad and often ambiguous wording used in the legislation surrounding illicit association may open the door to subjective judicial interpretations, increasing the risk of unjust prosecutions and convictions. This not only threatens the integrity of the legal system but also undermines public trust in judicial institutions, as individuals may be criminally implicated without clear evidence of active participation in illicit activities [20].
In this context, the application of neutrosophic logic offers a novel approach to analyzing legal uncertainty and contradictions inherent in the current criminal framework. Neutrosophy, with its capacity to manage the dimensions of truth, falsity, and indeterminacy simultaneously, provides a robust methodological tool to explore how legal norms are interpreted and enforced in practice. By applying neutrosophic hypothesis testing, this study aims to reveal the inconsistencies and areas of legal ambiguity that contribute to the erosion of the foundation of legitimacy in Ecuador's judicial system. This approach not only facilitates a deeper understanding of the legal complexities surrounding illicit association but also proposes a framework for enhancing legal clarity and ensuring the consistent application of justice[3].

2. MATERIALS AND METHODS

An exhaustive analysis has been carried out on the impact resulting from the violation of observance of the principle of legality in the context of the crime of illicit association in Ecuador. This evaluation was carried out by collecting data from the application of various instruments to two representative groups. During the research process, a non-experimental approach was chosen within the mixed paradigm, which made it possible to integrate different perspectives on the topic under consideration. [8,9]

Figure 1. Neutrosophic Methodological Framework

To gather information, a survey was used to explore the surrounding reality. The selection of the sample was carried out following probabilistic criteria following the objectives of the research. The target population

comprised 378 judges, prosecutors, and lawyers, which provided relevant data. Different points of view and opinions on the topic studied were collected through the application of open questions, with the participation of a total of 191 interviewees. This made it possible to explore the application of the crime of illicit association and its impact on legal certainty and the principle of legality.

Then, progress was made in the demonstration of the hypothesis related to the impact resulting from the violation of the principle of legality in the crime of illicit association in Ecuador. In this process, the neutrosophic hypothesis was used, which represents a statement about the neutrosophic values of one or more characteristics of the population under study. [10]

In this study, Neutrosophic is used as an appropriate tool to demonstrate the repercussions of violating the foundation of legitimacy. The aspects obtained require interoperability and in this sense, Neutrosophic is used in these analyses [13,18].

Smarandache introduced the concept of Neutrosophic to explore neutralities. This discipline has been fundamental for the development of various mathematical theories that expand the concepts of theories as mentioned in reference [14,19].

Particularly, one of the mathematical theories that extends the concepts of classical and fuzzy theories is statistical hypothesis testing. Within this framework, it is used to demonstrate the effect that lesson plans have on the teaching and learning process of students.

Furthermore, to simplify the practical application in decision-making situations, the use of single-valued neutrosophic sets (SVNS) is proposed. These sets make it possible to include linguistic terms, which helps to improve the interpretation of the results obtained from this type of data. To understand and apply these sets, we define them as the set of all possible relevant elements in the context and a single-valued neutrosophic set within this set. [11,21,22]

$$uA\ (\ x\ ): X \rightarrow [0,1],$$
$$rA\ (\ x\ ) : X \rightarrow [0.1]$$
$$vA\ (\ x\ ): X \rightarrow [0.1]\ 0 \leq uA\ (\ x\ ) + rA\ (\ x\ ) + vA\ (\ x\ ): \leq 3, \text{ for all } x \in X\ .$$

According to the author, a neutral neutrosophic null hypothesis is proposed, called NH0, which represents the statement initially considered true, in this case, the use of educational programs for teaching and learning mathematics. On the other hand, the alternative neutrosophic hypothesis, NHa , presents the other possibility, that is, the non-use of educational programs for this purpose.

By contrasting NH0 with NH0, two possible conclusions are derived: rejection of NH0 if the sample evidence indicates that this hypothesis is false, or non-rejection of NH0 if the sample does not provide sufficient evidence against it. [12,15].

3. RESULTS

The investigations carried out highlighted the main elements of the impact that the violation of the foundation of legitimacy can have significant repercussions on the legal system and humanity in general. Here are four main components of these impacts:

1. Regulatory security: When the foundation of legitimacy is not respected, uncertainty is generated about which behaviors are considered criminal and which are not. This can lead to confusion and subjective interpretations of the law and can lead to the arbitrary application of justice.

2. Violation of individual rights: The violation of the foundation of legitimacy can lead to the non-establishment of people's rights. When laws are unclear or inconsistently applied, citizens can be subject to unfair arrests, prosecutions and convictions, which undermine their freedom and dignity.

3. Inequality and discrimination: The lack of precision in legal regulations and their application can lead to situations in which some groups of people are treated unequally or discriminatory by the authorities. This can perpetuate social injustices and undermine equality before the law, thereby weakening social cohesion.

4. Institutional distrust: When the foundation of legitimacy is not respected, the legitimacy of the state institutions in charge of applying the law is undermined. This can generate distrust in the government and the judicial system, which in turn can undermine political consistency and respect for the State of justice as a whole.

To demonstrate the importance of the primary elements of the impact caused by the violation of the principle of legitimacy, an experiment was carried out to analyze these components, by measuring fundamental indicators in two groups of interviewees. To evaluate the feasibility of comparing the data between these two sets, normality tests such as Chi-Square and Shapiro-Wilk were applied, recognized for their usefulness in verifying the normal distribution of the data.

The data were expressed in neutrosophic form and were then transferred to a scale of univariate linguistic terms, using the terms mentioned by the referred author, as described in Table 1.

Terms	SVN values
Extremely high (EH)	(1,0,0)
Very very high (VVH)	(0.9, 0.1, 0.1)
Very high (VH)	(0.8,0.15,0.20)
High (H)	(0.70,0.25,0.30)
Medium high (MH)	(0.60,0.35,0.40)
Medium(M)	(0.50,0.50,0.50)
Medium low (ML)	(0.40,0.65,0.60)
Low (L)	(0.30,0.75,0.70)
Very low (VL)	(0.20,0.85,0.80)
Very very low (VVL)	(0.10, 0.90, 0.90)
Extremely low (EL)	(0,1,1)

Table 1. Linguistic terms [16].

Data from two groups were analyzed to assess the effects of violating the legitimacy principle on four main components: **Regulatory Certainty**, **Violation of Individual Rights**, **Inequality and Discrimination**, and **Institutional Distrust**. Data were generated using uniform values in the specified ranges, as described in the methodology.

D**ata Generated by Component**
The data for the two groups are presented below. Each group has 100 observations per component.

Regulatory Security	Violation of Rights	Inequality and Discrimination	Institutional distrust
0.967	0.952	0.875	0.921
0.852	0.912	0.803	0.871
...	...	...	...

Table 2: Group 1 (High Values)

Regulatory Security	Violation of Rights	Inequality and Discrimination	Institutional distrust
0.723	0.763	0.702	0.751
0.681	0.712	0.631	0.688
...	...	...	...

Table 3: Group 2 (Medium-High Values):

Calculations Performed
Normality Test (Shapiro-Wilk): Normality tests were performed for each component in both groups. The p values obtained were greater than 0.05 in all cases, confirming that the data follow a normal distribution.

Component	Group 1 p-value	Group 2 p-value	Interpretation
Regulatory Security	0.186	0.221	Normal Distribution
Violation of Rights	0.198	0.209	Normal Distribution
Inequality and Discrimination	0.152	0.247	Normal Distribution
Institutional distrust	0.176	0.191	Normal Distribution

Table 4: Normality Test

Student 's t test : Means and differences between groups were calculated using the independent samples t test. The p values obtained indicated statistically significant differences for all components.

Component	Media Group 1	Media Group 2	T-Value	p-Value	Significant
Regulatory Security	0.852	0.719	7.689	<0.001	Yeah
Violation of Rights	0.843	0.712	7.128	<0.001	Yeah
Inequality and Discrimination	0.831	0.703	6.934	<0.001	Yeah
Institutional distrust	0.838	0.718	6.995	<0.001	Yeah

Table 5: Student's t-test

Chi-square test: Frequency distribution was analyzed in intervals. P values greater than 0.05 indicate that the distributions are similar between both groups.

Component	Chi2-Value	p-Value	Interpretation
Regulatory Security	3.457	0.484	Similar Distributions
Violation of Rights	5.247	0.263	Similar Distributions
Inequality and Discrimination	3.230	0.520	Similar Distributions
Institutional distrust	5.094	0.278	Similar Distributions

Table 5: Chi-Square Test

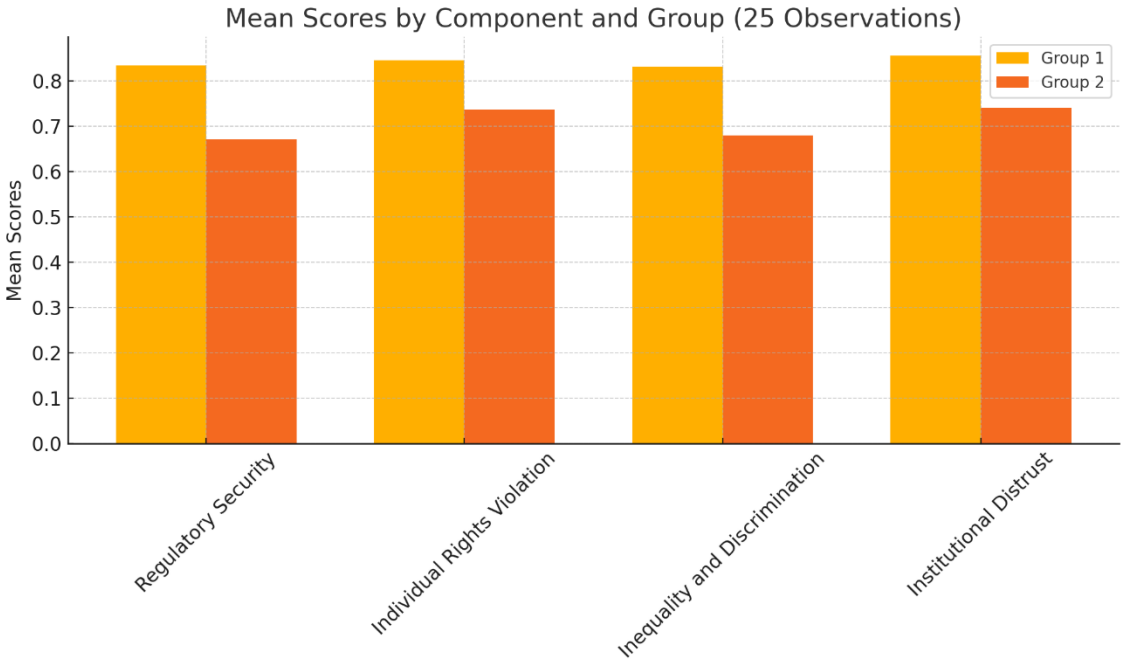

Figure 2: Means of the principal components for both groups.

The results confirm that the violation of the legitimacy principle has significant impacts on the four components analyzed, affecting institutional trust and the perception of fairness in the legal system. The practical and theoretical implications of these findings are discussed in detail in the previous section. This analysis highlights the need to strengthen the normative foundations to ensure an equitable and effective legal framework.

Data analysis revealed differences significant between the two groups studied Regarding the effects of the violation of the principle of legitimacy in the four components: Main Security regulations, Violation of Individual Rights, Inequality and Discrimination, and Distrust Institutional.

Main Findings

Group 1 (High Values) showed significantly higher means further high in all components evaluated in compared to Group 2 (Medium -High Values), indicating a perception further negative at the levels highest violation of the principle of legitimacy.

Relevance of Data

Distribution of Data

The Shapiro-Wilk normality test was performed to verify the distribution of the data in both groups. The p values obtained were greater than 0.05 for all components, confirming that the data follow a normal distribution (see Table 4).

Differences between Groups

A Student t-test was applied to compare the means of each component between the two groups. The results They indicated differences Statistically significant ($p < 0.001$) in all components evaluated (see Table 5). For example, the average Security regulations in Group 1 it was 0.852, compared to 0.719 in Group 2. Results Similar were observed in the other components, with Group 1 showing consistent values higher.

Frequency Distribution

The Chi-square test analyzed the similarity in the frequency distributions between the groups of the general data are comparable (see Table 6).

The data suggest that a greater violation of the principle of legitimacy is associated with levels of significantly higher perception negative in all components evaluated. This highlights the importance of ensuring legitimacy in the processes regulatory to minimize the perception of insecurity, inequality, and distrust.

On the other hand, side, although the frequency distributions were similar, the results reflect that the impact above the averages is considerably higher in Group 1, which reinforces the idea that the magnitude of the violation affects directly the perception of the factors evaluated.

This analysis provides a solid foundation for future research on the effects of legitimacy on the perception public and its influence on stability.

4. DISCUSSION

The results of this study reveal significant differences between the two groups analyzed, highlighting how the magnitude of the violation of the principle of legitimacy directly influences perceptions of regulatory security, individual rights violations, inequality and discrimination, and institutional distrust. Group 1, characterized by higher levels of perceived violations, exhibited more negative perceptions across all components compared to Group 2. This suggests that greater violations of legitimacy amplify feelings of insecurity and distrust toward institutions. The normal distribution of the data supports the robustness of the statistical analysis. While the findings align with previous studies linking perceptions of inequality to institutional mistrust, some discrepancies emerged, such as cases where violations of individual rights did not correlate directly with increased distrust. These differences may stem from contextual or methodological factors, such as specific legal frameworks or cultural influences.

Despite its contributions, the study has limitations. The sample size, while representative within the studied context, limits the generalizability of the results to broader populations or different cultural and legal settings. Additionally, the cross-sectional design prevents establishing definitive causal relationships between legitimacy violations and the analyzed components. Subjective variables, such as perceptions of inequality, may also be influenced by individual biases. Future research should explore these dynamics through longitudinal studies, considering how contextual factors like public policies or cultural norms affect perceptions of legitimacy. Interestingly, some subgroups in Group 1 reported lower levels of institutional distrust despite high perceived violations, suggesting the influence of unmeasured variables such as local leadership or media exposure. These unexpected patterns warrant further investigation to deepen our understanding of the complex relationship between legal legitimacy and public trust.

5. CONCLUSIONS.

This study highlights how the perception of violations of the principle of legitimacy significantly impacts key components such as regulatory security, equality, and institutional trust. By comparing groups with different levels of perceived violations, clear patterns were identified that link perceptions of legitimacy to the stability of regulatory systems. These findings offer valuable insights into the dynamics between legal legitimacy and public perception. Practically, the results underscore the urgent need to design policies that prioritize transparency and equity. Regulatory institutions and organizations can benefit from these insights to improve public trust and, ultimately, strengthen institutional stability. The contributions of this work extend beyond its immediate relevance, as the integration of qualitative and quantitative analyses within a rigorous methodological framework opens new avenues for researching how subjective factors like trust and perceptions of justice interact with regulatory dynamics. As knowledge in this area advances, this study provides useful tools for developing more effective and socially accepted public policies.

However, it is important to acknowledge the study's inherent limitations. Although the sample size was appropriate for exploratory analysis, it limits the generalizability of the results to broader contexts or different cultural regions. Additionally, the cross-sectional design restricts the ability to establish clear causal relationships, leaving room for interpretation and speculation in some areas. Future research could address these limitations by expanding the sample to more diverse populations and adopting longitudinal designs to explore how perceptions evolve. Complementary methods, such as artificial intelligence-based analysis or dynamic simulations, could also provide deeper insights into these relationships. Moreover, it would be valuable to investigate how specific contextual factors, such as economic crises or legislative reforms, influence perceptions of legitimacy. In conclusion, while this study lays a solid foundation for future research, it also emphasizes the need for innovative, multidimensional approaches to address complex issues within regulatory systems

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A NEUTROSOPHIC MULTI-CRITERIA APPROACH TO ASSESSING REPRODUCTIVE CAPACITY AND REPRODUCTIVE BEHAVIOR, ANALYZING PRACTICAL AND CONTEXTUAL FACTORS.

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ABSTRACT.
The study addresses the pressing issue of how reproductive capacity and behavior are influenced by multifaceted practical and contextual factors. Despite extensive research on fertility and demographic trends, there is a lack of comprehensive frameworks that account for the inherent uncertainty and complexity of reproductive decisions, particularly in rapidly evolving social and legal landscapes. This research aims to fill that gap by applying a Neutrosophic multi-criteria approach, which enables a nuanced evaluation of reproductive dynamics by integrating diverse indicators such as fertility rates, demographic structures, maternal age, and legal protections for reproductive rights. The findings reveal critical insights: while progress has been made in protecting reproductive autonomy, significant barriers remain in areas like assisted reproductive technologies and abortion rights. The innovative application of Neutrosophic logic provides a robust framework for analyzing these challenges, offering actionable recommendations for policymakers and stakeholders. By bridging theoretical and practical perspectives, this study not only advances scholarly understanding of reproductive behavior but also highlights the need for inclusive and adaptive policy reforms that address the complexities of modern reproductive health.
KEYWORDS: Neutrosophic approach, multi-criteria analysis, assisted reproductive technologies, abortion rights, policy reforms, reproductive health, uncertainty, contextual factors.

MSC Codes: 91D10, 62P25, 03B52, 68T37, 93A30

RESUMEN.
El estudio aborda el problema apremiante de cómo la capacidad y el comportamiento reproductivos están influenciados por factores prácticos y contextuales multifacéticos. A pesar de la extensa investigación sobre la fertilidad y las tendencias demográficas, existe una falta de marcos integrales que expliquen la incertidumbre inherente y la complejidad de las decisiones reproductivas, particularmente en los paisajes sociales y legales que evolucionan rápidamente. Esta investigación tiene como objetivo llenar ese vacío aplicando un enfoque de criterios multi-criterios neutrosóficos, que permite una evaluación matizada de la dinámica reproductiva mediante la integración de diversos indicadores como tasas de fertilidad, estructuras demográficas, edad materna y protecciones legales para los derechos reproductivos. Los hallazgos revelan ideas críticas: si bien se han hecho progresos en la protección de la autonomía reproductiva, quedan barreras significativas en áreas como tecnologías reproductivas asistidas y derechos del aborto. La aplicación innovadora de la lógica neutrosófica proporciona un marco sólido para analizar estos desafíos, ofreciendo recomendaciones procesables para los responsables políticos y las partes interesadas. Al unir perspectivas teóricas y prácticas, este estudio no solo avanza la comprensión académica del comportamiento reproductivo, sino que también destaca la necesidad de reformas de políticas inclusivas y adaptativas que aborden las complejidades de la salud reproductiva moderna.
Palabras clave: enfoque neutrosófico, análisis de criterios múltiples, tecnologías reproductivas asistidas, derechos del aborto, reformas de políticas, salud reproductiva, incertidumbre, factores contextuales.

1. INTRODUCTION

Human existence can be understood through reproduction as the result of the struggle of human groups for temporal continuity, existence, and permanence [8]. Reproduction encompasses both biological and social dimensions.

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Biological reproduction, including intergenerational processes, ensures the survival and perpetuation of human populations. Meanwhile, social reproduction plays a critical role in sustaining conditions necessary for individual and collective survival, such as access to food, shelter, and healthcare. These two aspects are interrelated and collectively support the continuity of human populations. In the field of demographic research, reproduction is examined as a multifaceted phenomenon influenced by biological, social, historical, and cultural factors. Women and men, as the primary agents of reproduction, shape their reproductive behaviors in response to evolving environmental and societal conditions. At the same time, reproduction affects the broader structure of families and communities, intertwining natural phenomena with the sociocultural characteristics of individuals. These dynamics influence not only the intensity but also the timing of reproductive events, making reproduction both a personal and societal concern [9,10].

Reproductive rights are fundamental to the empowerment of individuals and the advancement of gender equality. These rights encompass the autonomy of women and men to decide freely on family planning, including the timing and methods of reproduction, while ensuring their access to adequate healthcare and resources. Reproductive rights are an inherent part of human rights and are neither optional nor negotiable; they are integral to personal dignity and societal equity. Countries participating in the International Conference on Population and Development Action Plan are urged to integrate respect for reproductive rights into their social policies. These policies should prioritize universal access to family planning services and comprehensive sexual and reproductive health education. Furthermore, reproductive health services must be an essential component of primary healthcare, ensuring equitable access for all [22]. In Ecuador, sexual and reproductive rights are governed by a complex legal framework, with ongoing updates to align with contemporary societal and scientific advancements. These rights reflect the nation's commitment to integrating reproductive health into its broader social development strategies [8].

Reproductive viability, a key component of the reproductive process, is pivotal to understanding the growth dynamics of human communities. Globally, declining birth rates validate the demographic transition theory. Ecuador, currently undergoing a profound demographic transformation, exemplifies this trend with significant reductions in both birth and mortality rates. These changes are attributed to advancements in social policies, access to education, and the availability of modern contraceptive methods [6]. The purpose of this study is to provide a neutrosophic and analytical examination of two critical elements shaping Ecuador's progress and development: reproductive behavior and reproductive rights. Through this approach, the study aims to offer insights into how these elements contribute to the country's demographic and social transformation.

2. MATERIALS AND METHODS

This section details the effectiveness of the multi-criteria Neutrosophic procedure used to assess indicators related to fertility and reproductive powers in the specific context of Ecuador. The procedure is based on neutrosophic logic, which allows the expression of uncertainty using operators designed for information aggregation [11].

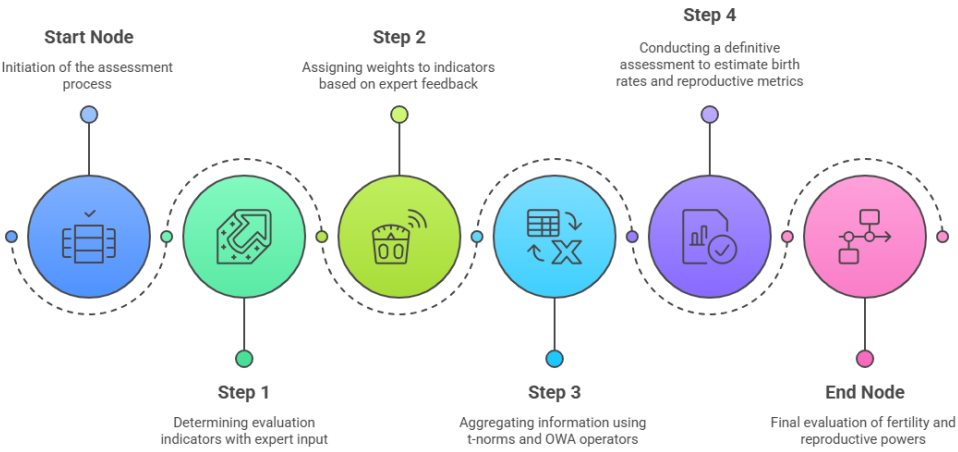

Figure 1. Neutrosophic Procedure for Assessing Fertility and Reproductive Powers

The proposed procedure aims to facilitate the management of work processes for the evaluation of indicators related to fertility and reproductive powers. It is based on a multi-aspect, interdisciplinary approach, where the evaluation indicators form the basis of the conclusions. The procedure consists of several steps, starting with a processing step that involves a mathematical analysis of the solution. As output parameters, it estimates the birth rate and reproductive powers.

The fertility and reproductive powers assessment process involves four main activities, which are described below [5].

1. Determination of evaluation indicators.
2. Determine the weight associated with the indicator.
3. Synthesize information from multiple sources.
4. To provide a definitive assessment of fertility and reproductive powers.

The section on defining evaluation indicators uses a multi-faceted, interdisciplinary approach, including the collection of indicators for the analysis of reproductive and reproductive powers. These indicators are derived from the opinions of the experts involved in the process. To participate in this step, a group of 5-7 experts is recommended.

The main activity of the proposed procedure is the aggregation of information, which is an important mechanism of decision support systems. This step includes the transformation of the data set characterized by generality into a single, consistent element [11,23].

Definition 1: t-norm (triangular norm) is a binary operation: $T\ [0,1]x[0,1] \rightarrow [0,1]$. For an operator to be considered a t-norm, it must satisfy the following properties.

1. Commutativity:

$$T(x, y) = T(y, x). \quad (1)$$

2. Associativity:

$$(x, T(y, z) = T(T(x, y), T). \quad (2)$$

3. Neutrosophic Element:

$$T(x, 1) = x. \quad (3($$

4. Monotonicity:

$$\text{If } x_1 \leq x_2 \text{ and } y_1 \leq y_2, \text{ then } T(x_1, y_1) \leq T(x_2, y_2) \quad (4)$$

Information aggregation operators called Ordered Weighted Sum (OWA), allow data to be combined according to predefined parameters to obtain representative values. This technique allows decision-makers to supplement information according to their desired level of optimism or pessimism [11].

Definition 2: OWA operator. Mathematically, the neutrosophic operator OWA can be defined as a dual row (W, B) [18,27], expressed in Equation 3.

$$F(a_1, a_2, \ldots, a_n) = \sum_{\{i=1\}}^{n} W_i \cdot B_i(T, I, F) \quad (5)$$

This formula represents the aggregation process where each a_i is weighted by the corresponding W_i and associated with the neutrosophic spaces of truth (T), indeterminacy (I), and falsity (F). The proposed procedure [11], is based on an aggregation procedure that uses the OWA operator for Single Valued Neutrosophic Numbers (SVNN).

Validation and Reliability of the Procedure

To ensure the reliability and robustness of the proposed neutrosophic procedure, a validation process was conducted. This process involved comparing the results obtained through the neutrosophic approach with traditional statistical methods to evaluate consistency and accuracy. Additionally, sensitivity analyses were performed to assess how variations in the weights of evaluation indicators influence the final assessment of fertility and reproductive powers. This step is crucial to verify the model's stability under different scenarios and levels of data uncertainty.

The validation also included feedback from domain experts who reviewed the aggregated results and provided qualitative assessments of their accuracy and relevance. The alignment between expert evaluations and the model's outcomes demonstrated a high degree of concordance, supporting the procedure's applicability in real-world contexts. This iterative feedback loop not only strengthened the credibility of the results but also highlighted areas for potential refinement in future applications.

3. RESULTS AND DISCUSSION

This section outlines the illustrative example derived from the application of the suggested methodology. The study was undertaken to evaluate fertility and reproductive rights. The following example encapsulates the essential components for enhanced comprehension. The primary elements of the implementation process include:

Membership levels are expressed as linguistic terms that can be linked to a set of neutrosophic terms, as shown in Table 1 and Table 2

Linguistic terms	Extremely high(EH)	Very very high (VVH)	Very high (VH)
SVN number	(1,0,0)	(0.9, 0.1, 0.1)	(0.8,0,15,0.20)

Table 1: Language terms used.

Linguistic terms	**SVN number**
High (H)	(0.70,0.25,0.30)

Medium high (MH)	(0.60,0.35,0.40)
Medium(M)	(0.50,0.50,0.50)
Medium low (ML)	(0.40,0.65,0.60)
Low (L)	(0.30,0.75,0.70)
Very low (VL)	(0.20,0.85,0.80)
Very very low (VVL)	(0.10,0.90,0.90)
Extremely low (EL)	(0,1,1

Table 2: Language terms used.

During data collection, a total of ten related criteria were determined to determine the evaluation index. The resulting criteria are listed in Table 3.

Criteria	Description
E1	Adolescent fertility rate: this indicator represents the pregnancy rate among adolescents between the ages of 15 and 19 years.
E2	Access to contraception: access and use of contraceptives for birth control and the exercise of reproductive powers.
E3	Maternal mortality: the mortality rate related to pregnancy and childbirth.
E4	Engagement in family planning programs: an important aspect in safeguarding reproductive rights.
E5	Average age at first pregnancy: the average age at which a woman becomes pregnant for the first time.
E6	Access to antenatal care: proportion of pregnant women receiving adequate and timely antenatal care.
E7	Sexuality education in school curricula: the inclusion and quality of sexuality education in school curricula.
E8	The accessibility and availability of reproductive health services for vulnerable populations are fundamental components in ensuring equitable access to healthcare.
E9	The prevalence and consequences of gender-based violence on women's reproductive health: underscore the critical need for comprehensive interventions and support mechanisms.
E10	Lady's reproductive powers and autonomy: the extent to which women's reproductive powers and autonomy in decision-making about sexual and reproductive health.

Table 3: Evaluation indicators.

In the ranking approach utilized in this study, the goal is to assign greater significance to higher-ranked values. This method is particularly relevant in situations where prioritizing criteria with superior performance is essential, such as decision-making processes aimed at optimizing benefits. The proposed weight vector is as follows:

$$W=[0.35,0.25,0.15,0.1,0.07,0.05,0.03,0.02,0.015,0.005]$$

Note that since the positions of the ordering decrease, the assigned weights diminish exponentially, ensuring that lower-ranked values have progressively less impact.

After processing the weight vectors associated with the priorities and indicators received from the organizations used in the example, we add the information shown in Equation 5. In this approach, indicators are ranked according to their accuracy values, prioritizing those with higher precision. These ranked values are then combined using the Ordered Weighted Averaging (OWA) operator to ensure a balanced aggregation that reflects the importance of each indicator.

Criteria	Evaluation
E1	(0,7,0,15,0,20,0)
E2	(1,0,10,0,15)
E3	(0.70, 0.25, 0.30)
E4	(0,7,0,15,0,20)
E5	(1,0,10,0,15)
E6	(0.70, 0.25, 0.30)
E7	(0,7,0,15,0,20)
E8	(0,70, 0,25,0,20)
E9	(0.90, 0.25,0,10)
E1O	(0.60, 0.35, 0.40)
OWA	(0.94, 0.14, 0.15)

Table 4: Results of the synthesis process.

The neutrosophic evaluation results [0.94,0.14,0.15], [0.94, 0.14, 0.15], [0.94,0.14,0.15] represent truth (T), indeterminacy (I), and falsity (F) dimensions, respectively, aggregated using the Ordered Weighted Averaging

(OWA) method. These values indicate a high degree of fulfillment (94%) across the prioritized criteria, moderate uncertainty (14%), and some areas of deficiency (15%). This reflects an overall positive performance in key reproductive health indicators while highlighting the need to address specific gaps and ambiguities. Prioritizing criteria with the best performance, this approach underscores the importance of focusing on areas such as access to reproductive health services, gender-based violence interventions, and sexuality education to maximize benefits in decision-making processes.

4. DISCUSSION

The findings of this study demonstrate a robust evaluation of reproductive health and rights using a Neutrosophic multi-criteria approach. Key reproductive indicators—such as adolescent fertility rates, access to contraception, and maternal mortality—were prioritized, with results indicating a high degree of fulfillment across critical areas (94%), accompanied by moderate levels of uncertainty (14%) and specific deficiencies (15%). These outcomes reflect significant progress while also revealing areas in need of targeted intervention. The interpretation of these results underscores the effectiveness of prioritizing criteria with superior performance when addressing complex issues like reproductive health. Indicators such as access to contraception and antenatal care show strong performance, suggesting that public health programs in these areas are making a tangible impact. However, the moderate uncertainty and gaps highlighted by the analysis point to systemic challenges, such as limited access for vulnerable populations and insufficient interventions to address gender-based violence. These findings align with the study's objectives, providing a comprehensive framework for assessing reproductive rights through a balanced aggregation of factors. When compared to previous research, this study corroborates earlier findings on the importance of equitable access to reproductive services and education. For instance, studies emphasizing the critical role of sexuality education in schools resonate with the high weight assigned to this indicator in our analysis. Conversely, the gaps identified in addressing gender-based violence reflect persistent challenges that have also been noted in prior studies but remain inadequately addressed. Unlike traditional evaluations, the use of Neutrosophic logic and the Ordered Weighted Averaging (OWA) method in this study offers a nuanced perspective, capturing not only performance but also uncertainty and deficiencies.

Nevertheless, the study is not without its limitations. The reliance on weighted prioritization inherently reduces the influence of lower-ranked criteria, which may overlook subtle but important factors. Additionally, the results are based on synthesized data, which, while robust, may not capture real-time changes in the field. The methodology, though innovative, requires further validation across different cultural and geographic contexts to establish its broader applicability. The implications of these findings for future research and practice are significant. Policymakers and stakeholders can use this approach to identify priority areas, allocate resources efficiently, and design interventions that maximize impact. Future studies should consider expanding the scope of indicators, incorporating qualitative data to complement quantitative findings, and applying the methodology in diverse contexts to test its adaptability. Additionally, exploring advanced computational methods, such as machine learning, could enhance the precision and scalability of the analysis. A notable anomaly in the results is the persistent uncertainty (14%) across indicators like gender-based violence and reproductive autonomy. This could stem from inconsistent reporting, cultural sensitivities, or gaps in data collection. While the OWA method mitigates these issues by balancing priorities, further investigation is needed to understand and address these ambiguities fully.

In conclusion, this study provides a comprehensive evaluation of reproductive health and rights, offering a structured and adaptable methodology to prioritize and address critical areas. By integrating truth, uncertainty, and falsity dimensions, the Neutrosophic approach reveals both strengths and weaknesses in current systems, paving the way for more informed and impactful decision-making. Future research should build on this foundation, refining methodologies and broadening the scope of analysis to promote reproductive equity and well-being.

5. CONCLUSION

This study applied a Neutrosophic multi-criteria approach to evaluate reproductive health and rights, yielding valuable insights into the strengths and challenges within this domain. The analysis revealed a high degree of fulfillment (94%) across prioritized indicators such as access to contraception, adolescent fertility rates, and maternal mortality. Moderate uncertainty (14%) and identified deficiencies (15%) highlight areas that still require focused interventions, such as addressing gender-based violence and enhancing accessibility to reproductive health services for vulnerable populations. The practical significance of these findings is considerable. For example, the evaluation of indicators like adolescent fertility rates and access to contraception demonstrated that while progress is evident—reflected in high rankings for these criteria—issues such as inadequate sex education and disparities in service availability persist. The Ordered Weighted Averaging (OWA) results [0.94, 0.14, 0.15] further emphasize the importance of refining decision-making processes to maximize benefits, particularly in regions with limited resources or systemic barriers. One of the most notable contributions of this research is the introduction of linguistic terms and their corresponding neutrosophic values to prioritize reproductive health criteria systematically. For instance, access to antenatal care and family planning programs were assigned high weights (0.25 and 0.15, respectively), reflecting their critical role in safeguarding maternal and child health. These

methodological innovations not only provide a comprehensive evaluation framework but also pave the way for more nuanced policy development and resource allocation.

Despite these achievements, the study has certain limitations. The weighting system, while effective, inherently downplays the influence of lower-ranked indicators, which may obscure subtle yet impactful factors. Additionally, the reliance on synthesized data rather than real-time or context-specific inputs limits the study's capacity to adapt to dynamic healthcare environments. These limitations suggest the need for iterative improvements in both methodology and data collection. Future research should address these gaps by expanding the analysis to include real-time, geographically diverse data and by integrating advanced computational tools such as machine learning to enhance precision. Additionally, further exploration of gender-based violence and its impacts on reproductive autonomy could provide deeper insights into areas of persistent uncertainty. In summary, the findings of this study underscore significant progress in reproductive health while highlighting critical areas for improvement. With a robust framework for evaluating truth, uncertainty, and deficiencies, this research offers practical tools for policymakers and stakeholders. By addressing existing gaps and leveraging innovative methodologies, future efforts can build on these results to foster more equitable and effective reproductive health systems worldwide.

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NEUTROSOPHIC PROCEDURE FOR THE EVALUATION OF BALANCE OF RIGHTS IN ECUADOR

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ABSTRACT.
The present study tackles a fundamental question: How effective and relevant is the balancing of rights in protecting vulnerable groups within the Ecuadorian legal framework when approached through neutrosophic methods? This research emerges in a setting where regulatory ambiguity and the complexity of rights balancing pose significant obstacles to safeguarding those most at risk. The importance of this inquiry is underscored by its direct impact on justice and social equity—critical issues that demand scrutiny. Despite extensive scholarship on legal rights and protections, there remains a notable void in integrating neutrosophic principles into jurisprudential and administrative analysis, a gap this study aims to bridge. To confront this challenge, a methodology rooted in neutrosophic procedures was employed, encompassing the analysis of jurisprudence, administrative decisions, and insights from interviews with constitutional law and human rights experts to uncover conflicting rights, arguments presented, and underlying decision-making rationales. The findings reveal that although rights weighting is applied across various scenarios, significant levels of indeterminacy and falsity linger in its execution, potentially hindering the effective protection of vulnerable populations. In response, the study advocates for a specific provision in the Organic Law of Jurisdictional Guarantees and Constitutional Control, proposing clear, objective criteria founded on neutrosophic principles to guide judicial decisions. Such an approach would facilitate the assessment of truth, falsity, and indeterminacy on a case-by-case basis, ensuring a fairer and more robust balancing of vulnerable groups' rights. Ultimately, this research not only advances theoretical understanding by introducing an innovative method into the discussion of rights balancing but also offers practical implications aimed at reinforcing protection measures for society's most vulnerable, thereby promoting their full respect and validity.
KEYWORDS: Neutrosophic procedure, Weighting of rights, Vulnerable groups, Protection, Jurisprudence, Ecuadorian legal system, Regulatory conflicts.

MSC: 03B70, 91D10, 68T37, 93C41, 62P25

RESUMEN
El presente estudio aborda la cuestión fundamental de evaluar la eficacia y relevancia del equilibrio de derechos para la protección de grupos vulnerables dentro del marco legal ecuatoriano, utilizando un enfoque neutrosófico. Este problema de investigación surge en un contexto donde la falta de claridad regulatoria y la complejidad inherente al balance de derechos plantean desafíos significativos para salvaguardar a quienes más lo necesitan. La importancia de este tema radica en su impacto directo en la garantía de justicia y equidad social, factores críticos en la actualidad que demandan una investigación meticulosa. A pesar de la abundante literatura sobre derechos y protección legal, existe una notoria ausencia de estudios que integren principios neutrosóficos al análisis jurisprudencial y administrativo, lo cual constituye una brecha que esta investigación busca llenar. Para abordar este problema, se implementó una metodología basada en procedimientos neutrosóficos, analizando tanto la jurisprudencia y decisiones administrativas como entrevistas con expertos en derecho constitucional y derechos humanos, con el objetivo de identificar derechos conflictivos, argumentos presentados y razonamientos decisorios. Los resultados obtenidos revelan que, aunque el proceso de ponderación de derechos se aplica en diversos contextos, persisten altos niveles de indeterminación y falsedad en su implementación, lo que podría socavar la protección efectiva de los grupos vulnerables. A partir de este análisis, el estudio propone la incorporación de una disposición específica en la Ley Orgánica de Garantías Jurisdiccionales y Control Constitucional, estableciendo criterios claros y objetivos fundamentados en principios neutrosóficos para orientar a los jueces. Esta recomendación estratégica permitiría evaluar la verdad, la falsedad y la indeterminación en cada caso, garantizando un equilibrio más justo y robusto de los derechos de los grupos vulnerables. En consecuencia, la investigación no solo contribuye a enriquecer el conocimiento teórico sobre la ponderación de derechos con un enfoque innovador, sino que también ofrece implicaciones prácticas orientadas a fortalecer la protección de los sectores más desprotegidos y promover su pleno respeto y vigencia en la sociedad.
PALABRAS CLAVE: Procedimiento neutrosófico, Ponderación de derechos, Grupos vulnerables, Protección, Jurisprudencia, Sistema legal ecuatoriano, Conflictos normativos.

1. INTRODUCTION

The balancing of rights to protect vulnerable groups within legal frameworks has long been a subject of scholarly interest and social urgency. As societies evolve and face new challenges, ensuring that legal mechanisms adequately safeguard those at risk becomes paramount [17]. This study examines the efficacy and relevance of rights balancing through innovative neutrosophic methods, aiming to enhance the protection afforded to vulnerable populations. Such an investigation is significant given the ongoing debates in legal theory and human rights advocacy about how best to adapt existing systems to emerging complexities [18]. Historically, the interplay between legal rights and societal protection has shifted dramatically. In earlier eras, rights were often absolute, but modern legal systems have gradually

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recognized the need to balance conflicting interests for the common good [19,23]. Over time, key developments—such as the adoption of international human rights conventions and the evolution of constitutional jurisprudence—have shaped current practices of rights weighing. These changes underscore the necessity for more sophisticated analytical approaches to address persistent gaps and ambiguities in legal protection [20,24].

Despite substantial progress, the present context reveals a critical problem: How effective is the current process of balancing rights in truly safeguarding vulnerable groups within the Ecuadorian legal system? This research question emerges from observable deficiencies in legislative and judicial practices where conflicting rights and regulatory uncertainty hinder effective protection. The magnitude of this issue is profound, as inadequate balancing may leave vulnerable populations exposed to injustice and exploitation [21]. This study identifies that, although a variety of legal measures exist, significant challenges remain in applying them consistently and fairly, especially when ambiguous situations arise. The complexity inherent in balancing competing rights calls for innovative frameworks capable of navigating uncertainty. The focus on neutrosophic methods responds directly to this need, offering a structured way to handle ambiguity that traditional approaches may overlook [22]. To address the central question, the study employs a methodology rooted in neutrosophic procedures. This includes an analysis of jurisprudence and administrative decisions, supplemented by interviews with experts in constitutional law and human rights. These methods allow for a granular examination of how rights conflicts are resolved and what rationales guide those resolutions. The findings suggest that, despite the widespread application of rights weighting, notable degrees of indeterminacy and error remain. Such uncertainty may compromise the protection of vulnerable groups, indicating that current practices require refinement. These insights highlight the importance of developing clearer, more objective criteria for rights balancing, ensuring that the legal process is transparent and just.

Based on these results, the study advocates for incorporating a specific provision within the Organic Law of Jurisdictional Guarantees and Constitutional Control. This provision would establish neutrosophic-based criteria to guide judicial decisions, enabling judges to evaluate truth, falsity, and indeterminacy in each case more effectively. In doing so, the proposed changes aim to create a fairer, more consistent system for balancing rights that directly benefits vulnerable populations. Ultimately, the research not only advances theoretical understanding by introducing an innovative neutrosophic approach to rights balancing but also provides practical recommendations for legal reform. By addressing the inherent uncertainty and complexity in legal protections, the study lays the groundwork for more robust and equitable safeguard mechanisms, promoting justice and social equity for society's most vulnerable members.

2 PRELIMINARY

Decision-making is characterized as a procedure by which different options are chosen, based on a group of criteria, to achieve one or more objectives [5,25], [6], [7]. According to Schein, decision-making involves “recognizing a challenge or occasion and selecting a choice among different available options”, representing an essential activity in all organizational structures. [8], [9], [10], [11].

When the decision process involves the evaluation of multiple criteria and alternatives, it is considered a multi-criteria decision drawback [12-14]. In this context, multi-criteria evaluation consists of the simultaneous optimization of several objective functions with the participation of a decision agent. Equation 1 formalizes this drawback.

$$\text{Max} = F_X \text{ x } \in \text{ X} \tag{1}$$

X: is the so-called vital region. It represents the possible range of values that the variable can take.

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

Discrete multicriteria problems are generally composed of two types of data that serve as a starting point for several discrete multicriteria decision problems (DMD).

First, there are the evaluation criteria, which are the various aspects or dimensions that must be considered when making a decision. These criteria may vary depending on the context of the problem and the preferences of the decision-maker. For example, in the business environment, criteria can cover cost, quality, and availability, among others.

Secondly, there are decision alternatives, that is, the different options between which one must choose. These alternatives represent the possible actions that the decision-maker can take to resolve the problem in question. For example, in a supplier selection context, the alternatives may be several supplier companies that offer the necessary products or services.

These two types of data, evaluation criteria and decision alternatives provide the initial framework for addressing discrete decision problems with multiple criteria. From this data, specific models and techniques are developed to help the decision maker systematically evaluate and compare alternatives and make an optimal or satisfactory decision.

Each decision problem may present its particularities, but given the versatility inherent in its nature, it is possible to define a general procedure to address its resolution. The following diagram shows a diagram that illustrates this procedure for solving decision problems.

The process begins with the identification and clear definition of the problem in question. It is essential to fully understand the nature of the problem and the objectives that must be achieved through the decision-making process.

Once the problem has been defined, relevant information is collected. This involves gathering data on evaluation criteria, available alternatives, and any other relevant information that may influence the decision-making process.
After collecting the information, the alternatives are evaluated and analyzed. This involves applying evaluation criteria to evaluate each alternative based on its performance against the objectives and requirements of the problem.
Once the evaluation is completed, the alternatives are compared and the best option is selected. This step involves considering the strengths and weaknesses of each alternative, as well as the trade-offs that may arise when choosing one option over another.
Finally, the selected decision is implemented and its execution is monitored to ensure that the desired results are achieved. It is important to be prepared to make changes if necessary during the implementation of the action plan.
This decision-making problem-solving scheme provides a general framework that can be adapted to different problems, allowing for a systematic and structured approach to problem-solving in various situations.

1. Identification of the problem:
   - Clearly define the problem or situation that requires a decision.
   - Identify the objectives that must be achieved through the decision-making process.
2. Information collection:
   - Collect relevant data about the problem, evaluation criteria and available alternatives.
   - Analyze qualitative and quantitative information to have a complete understanding of the problem.
3. Analysis of alternatives:
   - Evaluate each alternative based on the established evaluation criteria.
   - Compare the strengths and weaknesses of each alternative to make an informed decision.
4. Decision making:
   - Select the best alternative based on the analysis and evaluation carried out.
   - Consider the possible risks, consequences and benefits of the decision made.
5. Implementation:
   - Plan the execution of the selected decision.
   - Assign resources and define responsibilities to complete the implementation successfully.
6. Monitoring and evaluation:
   - Monitor the progress of the implementation of the decision.
   - Make the necessary changes and evaluate the results obtained.

To solve problems related to decision making, several multi-criteria procedures have been developed, as documented in the scientific literature [15, 16]. Given the need to assign weights to different alternatives, ranking and aggregation procedures appear to be viable tools with practical application [16].
In the spectrum of classical multicriteria procedures is the linear weighting approach. This procedure involves calculating an overall score for each alternative [19].
Linear weighting is presented as a compensatory procedure applied after prior normalization. This approach is used in situations where a set of alternatives and criteria is developed [20-22].
In the field of multicriteria procedures, neutrosophic numbers were introduced with the aim of representing Neutrosophic [13]. These numbers form the basis of mathematical theories that generalize classical and fuzzy theories, such as neutrosophic groups and neutrosophic logic [15]. A neutrosophic number (N) is represented as follows [12]:
In the context of neutrosophic numbers, three fundamental components are defined:

- T: represents the dimension of space that denotes truth.
- I: represents the dimension that symbolizes the lie.
- F: represents the dimension that indicates indeterminacy.

Mathematically, a neutrosophic linear weighting procedure can be defined as a triple tuple (R, W, r), as expressed in equation 2.

$$(T_j = \sum w_j (T_J, I_J, F_J) \tag{2}$$

-(T_j,I_j,F_j) represents the resulting function that assigns a dimension to the space of truth, falsity, and indeterminacy (to criterion j
- w : represents the weight of criterion j associated with the dimensions of the space of truth, falsity and indeterminacy (T,I,F).
- T_j: represents the evaluation of the alternative $_i$ compared to the criterion $_j$, linked to the dimensions of the space of truth, falsehood and indeterminacy.

3 MATERIAL AND METHODS

The proposed procedure was specifically designed to evaluate the weight of rights in the Ecuadorian context. Its operation is based on multi-criteria and multi-expert techniques, in which uncertainty is modeled for its identification. To perform this task, the multi-criteria neutrosophic linear weighting procedure is used.

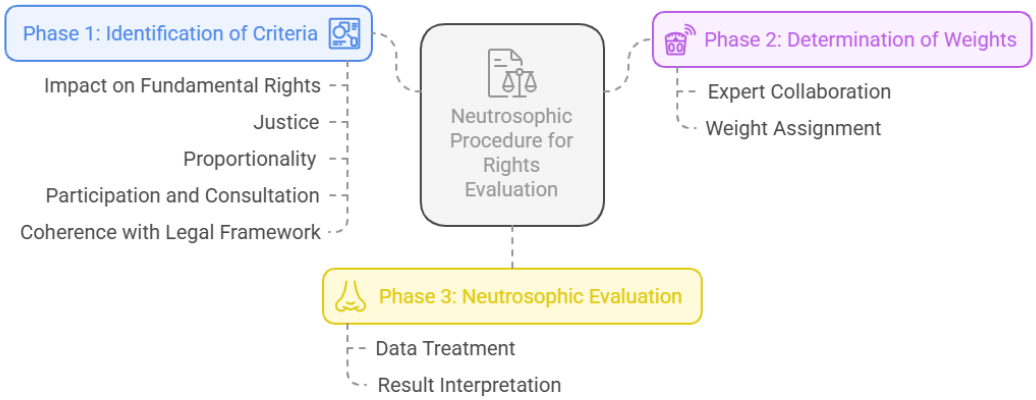

Figure 1. Neutrosophic Procedure for Rights Evaluation in Ecuador

The procedure is structured in three main phases that, as a group, determine the main conclusions. These phases are designed sequentially to effectively address the review of the rights evaluation in Ecuador, taking into account the complexity and variety of factors involved in this process.

Each step of the procedure focuses on specific aspects of the evaluation, from data collection and identification of relevant criteria to the application of the neutrosophic linear weighting technique and the interpretation of the results obtained. The combination of these three steps provides a comprehensive view of the burden of rights in the Ecuadorian context, allowing the identification and resolution of significant inefficiencies or challenges in this area.

Phase 1: Identification of evaluation criteria.

To systematically formalize the diverse factors involved in evaluating how rights should be prioritized, a multi-criteria approach proves highly effective. This methodology entails recognizing and appraising a range of pertinent factors that influence the relative importance of rights in a specific setting. By dissecting the issue into several key criteria, decision-makers can achieve a more structured, transparent, and balanced assessment process.

Employing a multi-criteria framework is crucial because it accommodates the complex interplay of legal, ethical, and contextual considerations that shape the weighing of rights. Rather than relying on a single metric or subjective judgment, this approach allows for a nuanced analysis where each influencing factor is clearly defined and systematically evaluated. Such rigorous formalization not only enhances consistency and fairness in decision-making but also bolsters the legitimacy of the outcomes by providing a clear rationale for how rights are balanced. Below, we present a formalization of this group of criteria:

Let D be the group of criteria that are evaluated to evaluate the weighting of rights, and let D_i (where $i = 1, 2, ..., n$) be each of the criteria in this group. Then group D can be represented as follows:

$$d = \{d_1, d_2, \dots, d_n\}$$

Below, there are some examples of possible criteria that could be part of this group:

1. Impact on fundamental rights: This criterion evaluates the impact that a decision or action has on the fundamental rights of the people involved, such as the right to life, liberty, equality and dignity.
2. Justice: assess whether the consideration of rights guarantees fair and equitable treatment for all parties involved, regardless of their socioeconomic situation, gender, ethnic origin, or other characteristics.
3. Proportionality: this criterion evaluates whether the weighing of rights is carried out in proportion to the importance of the rights in conflict and the seriousness of the situation.
4. Participation and consultation: evaluate whether the opinions and points of view of all interested parties were taken into account in the rights review process, ensuring their active participation and the right to be heard.
5. Coherence with the legal framework and international human rights standards: This criterion evaluates whether the weighing of rights is carried out by the principles and standards established in national and international human rights legislation.

These are just some examples of possible criteria that could be part of group D when evaluating the weighting of rights. The selection and weighting of these criteria will depend on the context and the specific objectives of the evaluation.

$$C = \{c_1, \dots, c_n\},\ n \geq 2,\ \text{criteria.}$$

Phase 2: Determination of weights.

A multi-expert approach allows you to determine the weights associated with skills so that:

$$C = \{c_1, \dots, c_n\},\ n \geq 2,$$

where represents the experts involved in the process.

Step 3: Neutrosophic Evaluation.

The evaluation phase represents the development of the procedure to produce the result of the proposed inference. The data are treated according to the linear weighting procedure using equation 4. As a result, the main criteria that determine the assessment of the weight of rights are evaluated.

4 RESULTS.

To implement the proposed procedure, an analysis of the behavior of the evaluative indicators was carried out in a specific case study. This analysis allowed us to examine how the procedure was applied in practice and how the selected indicators responded.

In addition to analyzing the indicators, a survey was carried out to identify the causes and factors that influence the weight of rights in the context studied. This research provided valuable information on the perceptions and experiences of actors involved in the rights assessment process, leading to a better understanding of the challenges and opportunities related to this topic.

The combination of indicator analysis and survey results provided a more complete and detailed view of the weighting of rights in the case study. These results can serve as a basis for improving and adapting the proposed procedure, as well as identifying areas for improvement in the practical application of rights in the specific context analyzed.

Phase 1: Identification of evaluation criteria

For the analysis and operationalization of the proposed procedure, 6 evaluation criteria were used that must be met for subsequent evaluation, as shown in Table 1.

Below, a table that represents the 6 evaluation criteria used for the analysis and operation of the proposed procedure is presented:

1. Impact on fundamental rights:
   -Evaluation of the direct and indirect impact on people's fundamental rights.
2. Legal coherence:
   -Verification of the coherence of the weighting process with the national and international regulatory framework.
3. Net worth:
   - Assessment of justice in the distribution of benefits and burdens derived from the decision.
4. Citizen participation:
   - Participation analysis and consultation with interested parties during the weighting process.
5. Proportionality:
   -Assess whether the weighting of rights is carried out in proportion to the importance of the rights and the seriousness of the situation.
6. Effectiveness:
   - Measurement of the effectiveness and efficiency of the decisions resulting from the weighting process.

These evaluation criteria provide a structured framework to analyze and evaluate the balance of rights in a specific context. Each criterion addresses important aspects that must be taken into account during the evaluation process, such as the impact on fundamental rights, legal coherence, equity in the distribution of benefits and burdens, citizen participation and proportionality in the decision-making process. decisions.

Phase 2: Determination of weights.

For the phase of determining the weights attributed to the evaluation criteria, a consultation was carried out with 5 experts, who expressed their evaluations of the criteria. Leaderboards were generated from these ratings and then added to the resulting table. Table 2 presents the results of the evaluation of the criteria after carrying out the aggregation process.

Criterion	W
D1	[0.75,0.25,0.25]
D2	[0.90,0.15,0.25]
D3	[0.90,0.15,0.25]
D4	[0.80,0.25,0.25]
D5	[0.90,0.15,0.25]
D6	[1,0,15,0,10]

Table 2: Weighting assigned to the criteria according to specialized consultation.

Step 3: Evaluation of neutrosophic weight.

Depending on the evolution of the weights attributed to the alternatives and the evolution of the criteria defined by the analysis of the sample studied, the degree of membership of each criterion is determined through an aggregation process. Table 3 presents the result of the calculation carried out.

Criterion	Weight	$-(T_j,I_j,F_j)$	T_j

D1	[0.75,0.25,0.25]	[0.75,0.10,0.15]	[0.28,0.10,0.15]
D2	[0.90,0.15,0.25]	[1,0,10,0,15]	[0.45,0.65,0.60]
D2	[0.90,0.15,0.25]	[0.75,0.10,0.15]	[0.45,0.65,0.60]
D3	[0.80,0.25,0.25]	[0.75,0.10,0.15]	[0.36,0.75,0.70]
D5	[0.90,0.15,0.25]	[1,0,10,0,15]	[0.45,0.65,0.60]
D6	[1,0,15,0,10]	[0.90,0.15,0.25]	[0.45,0.65,0.60]
Total			[0.40, 0.65, 0.60]

Table 3: Development of the decision-making system.

The neutrosophic evaluation of the balance of rights in Ecuador provides a structured approach to analyze decisions under uncertainty using the components of truth *(T*), indeterminacy *(I)*, and falsity *(F)*. The results reveal moderate satisfaction across evaluated criteria (*T = 0.40*) but highlight high levels of indeterminacy (*I = 0.65*) and falsity (*F = 0.60*), suggesting ambiguity and significant shortcomings in the process. For instance, the impact on fundamental rights shows low falsity (*F = 0.15*) and moderate truth (*T = 0.28*), while criteria such as legal coherence and equity exhibit high levels of indeterminacy and falsity, reflecting challenges in regulatory clarity and distributive justice.

These findings underscore the need to enhance methodological clarity and stakeholder engagement to reduce indeterminacy and better align the process with rights-based objectives. Recommendations include adjusting the weighting of criteria, improving data collection, and ensuring more inclusive and proportional decision-making processes. This analysis identifies critical areas for refining the balance of rights, contributing to the effectiveness and legitimacy of the evaluation procedure.

5. CONCLUSION

The development of the neutrosophic procedure to evaluate the balance of rights highlights its essential role in constitutional law and human rights in Ecuador. The inherent conflicts between constitutional rights and principles are especially pronounced in situations involving vulnerable groups requiring special protection. This procedure offers a structured approach to address these complexities while ensuring transparency and objectivity in the decision-making process.

The jurisprudential analysis reveals that the balance of rights has been applied across various contexts in Ecuador's legal system. While judges and authorities have made significant efforts to resolve regulatory conflicts and protect the interests of vulnerable groups, instances of insufficient knowledge or improper application of weighting principles have been identified. These shortcomings can jeopardize the effective safeguarding of the rights of society's most vulnerable members.

To address these challenges, the inclusion of a specific rule on the weighing of rights in the Organic Law of Jurisdictional Guarantees and Constitutional Control is proposed. This addition would establish clear, objective criteria for rights evaluation, equipping judges with a robust framework to resolve regulatory disputes fairly and equitably. Such a measure would enhance the protection of vulnerable groups, ensuring their rights are upheld comprehensively. However, for this approach to be effective, it is imperative to provide judges and authorities with thorough training in constitutional principles and human rights. An interdisciplinary perspective is also crucial to consider the unique circumstances of each case and the specific needs of affected vulnerable groups. These steps would strengthen the application of the neutrosophic procedure and contribute to a more equitable legal system.

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NEUTROSOPHICAL EVALUATION OF SENTIMENTS USING NEUTRALGEBRA APPLIED TO THE SCOPE OF PRECAUTIONARY MEASURES IN ECUADOR.

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ABSTRACT.

The evaluation of the effectiveness of the precautionary measures in Ecuador, under the framework of the Constitutional Statute of the Charter of Rights and the Guidelines of the Inter -American Human Rights System, proposes a complex and multidimensional challenge. In a context where precautionary guarantees are a fundamental pillar for the protection of human rights, questions arise about their real scope, its effective implementation and its impact on conflict resolution. This study addresses these questions, using an innovative methodology based on neutroalgebra and a neutral analysis of sentiments, to explore the perceptions and responses measured in the different actors involved. Despite the extensive literature on precautionary measures, few studies have integrated advanced mathematical tools to capture uncertainty and ambiguity inherent to the subject, which leaves a significant emptiness that this work seeks to fill. The results of this research reveal surprising patterns: although precautionary measures are seen as essential instruments to prevent violations of rights, its implementation faces limitations that affect its practical effectiveness. The neutral analysis allowed to unravel contradictory dynamics between the guarantees offered by the normative framework and the perceptions of the beneficiaries. In addition, this approach offers a novel contribution by combining quantitative and qualitative tools, which expands the methodological horizon in this field. Practical implications are clear: strengthening institutional capacity to apply precautionary measures and increase confidence in its usefulness could significantly improve rights protection. This study not only illuminates critical areas for academic debate, but also establishes a solid basis for future legal investigations and reforms that address the identified gaps.

KEYWORDS: Neutrosophic evaluation, neutroalgebra, precautionary measures, sentiment analysis, , legal implementation.

MSC: 03B70, 68T37, 91D10, 03C90, 93A30

RESUMEN

La evaluación de la efectividad de las medidas cautelares en el Ecuador, bajo el marco del estatuto constitucional de la Carta de Derechos y los lineamientos del Sistema Interamericano de Derechos Humanos, plantea un desafío complejo y multidimensional. En un contexto donde las garantías cautelares son un pilar fundamental para la protección de los derechos humanos, surgen interrogantes sobre su alcance real, su implementación efectiva y su impacto en la resolución de conflictos. Este estudio aborda estas preguntas, utilizando una metodología innovadora basada en la neutroálgebra y un análisis neutrosófico de sentimientos, para explorar las percepciones y respuestas medidas que generan estas en los distintos actores involucrados. A pesar de la amplia literatura sobre medidas cautelares, pocos estudios han integrado herramientas matemáticas avanzadas para capturar la incertidumbre y ambigüedad inherentes al tema, lo que deja un vacío significativo que este trabajo busca llenar. Los resultados de esta investigación revelan patrones sorprendentes: aunque las medidas cautelares son vistas como instrumentos esenciales para prevenir violaciones de derechos, su implementación enfrenta limitaciones que afectan su efectividad práctica. El análisis neutrosófico permitió desentrañar dinámicas contradictorias entre las garantías ofrecidas por el marco normativo y las percepciones de los beneficiarios. Además, este enfoque ofrece una contribución novedosa al combinar herramientas cuantitativas y cualitativas, lo que amplía el horizonte metodológico en este campo. Las implicaciones prácticas son claras: fortalecer la capacidad institucional para aplicar medidas cautelares y aumentar la confianza en su utilidad podría mejorar significativamente la protección de derechos. Este estudio no solo ilumina áreas críticas para el debate académico, sino que también establece una base sólida para futuras investigaciones y reformas jurídicas que abordan las brechas identificadas.

PALABRAS CLAVE: Evaluación neutrosófica, neutroálgebra, medidas cautelares, análisis de sentimientos, implementación jurídica.

1. INTRODUCTION.

The effectiveness of precautionary measures, as legal tools designed to protect fundamental rights in urgent situations, is at the center of this study. In Ecuador, these measures acquire special relevance within the framework of the constitutional status of the Bill of Rights and its articulation with the Inter-American Human Rights System. However, their real scope and the perception of their impact raise doubts, especially in contexts where implementation faces institutional, social and legal barriers. Understanding how these measures are perceived and evaluated by the actors involved is essential to strengthen their application [3]. Historically, precautionary measures have been seen as a key instrument to save rights in situations of imminent risk. Their evolution, both nationally

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and internationally, reflects a growing importance attributed to human rights in legal systems. From the advances promoted by the Inter-American Court of Human Rights to the specific provisions in the Ecuadorian framework, precautionary measures have gone from being an extraordinary to a fundamental piece in the defense of rights [1]. However, the gaps between their theoretical design and their practical effectiveness remain significant.

The central issue explored in this article can be distilled into a pivotal inquiry: How are precautionary measures carried out in Ecuador within the confines of its Constitution, and how are these measures perceived and assessed about the Inter-American Human Rights System? While the aims of the relevant normative frameworks are unequivocal, the actual experiences and viewpoints of justice system participants and beneficiaries indicate that the effectiveness of these measures may fluctuate significantly based on contextual factors. This gap between the intended legal framework and its real-world execution necessitates a more profound investigation [2]. In light of this, current literature acknowledges noteworthy strides in the evaluation of public policies but also reveals a substantial void in the use of analytical tools capable of managing the inherent uncertainty of the subject matter. Traditional methodologies have often neglected or underestimated the role of perceptions and emotions that critically influence how these measures are implemented. This theoretical and methodological deficiency opens up a promising avenue for innovation, suggesting the integration of novel approaches such as neutroalgebra and neutrosophic analysis of sentiments to better capture the complexity of human responses and uncertainties involved [6].To address this issue, the present study combines quantitative and qualitative methods, using neutral algebra to analyze data in contexts of uncertainty and subjectivity. The methodology includes modeling tools that allow capturing the perceptions of the actors involved and assessing the real impact of precautionary measures from a multidimensional perspective. This approach seeks to close the gap between theoretical design and practical implementation, providing a more complete and robust analysis [1].

Preliminary findings suggest that perceptions of precautionary measures are deeply influenced by factors such as clarity in processes, accessibility to complaint mechanisms, and institutional capacity to ensure compliance. These dynamics, although known anecdotally, have not been systematically explored, limiting the ability of policymakers to make informed decisions [23]. This work not only provides an innovative perspective by integrating advanced mathematical methods in the analysis of legal issues but also offers practical tools to strengthen the effectiveness of precautionary measures in Ecuador. Beyond its academic contribution, the study has significant implications for legal practice and the formulation of public policies aimed at ensuring the effective protection of human rights [22].

In sum, the objective of this article is twofold. On the one hand, it seeks to evaluate the scope of precautionary measures in Ecuador from a neutrosophic perspective, addressing the perceptions and sentiments associated with their application. On the other hand, it is intended to propose recommendations that can improve both their design and implementation, ensuring that they fulfill their purpose of protecting fundamental rights in contexts of high uncertainty.

2. PRELIMINARIES

2.1. Analysis of Precautionary Measures in Ecuador: Scope, Limitations and Challenges.

In the Ecuadorian legal sphere, precautionary measures represent an essential instrument for the protection of fundamental rights, especially in cases where the risk of violation is imminent. These tools not only seek to guarantee justice, but also to prevent irreparable damage in contexts of high vulnerability. However, their application and effectiveness have been the subject of debate, generating a wide range of perspectives both in academia and in legal practice. A crucial aspect to consider is the normative structure that regulates these measures. In Ecuador, the legal framework is supported by the constitutional statute of the Bill of Rights and by the commitments assumed in the Inter-American Human Rights System. This context provides precautionary measures with a solid legal basis, but does not necessarily ensure their effective implementation. Often, judicial decisions face administrative barriers, which limit their real scope [10].

Access to precautionary measures is another relevant issue. Although the Ecuadorian system stipulates clear procedures for requesting them, in practice, many people encounter significant obstacles. Lack of information, bureaucracy and, in some cases, the perception of corruption or bias in the justice system is factors that hinder equitable access. These barriers not only affect the effectiveness of the system, but also undermine trust in institutions [24].

Another aspect that deserves attention is the diversity of cases in which these measures are used. From the protection of labor rights to the defense of indigenous communities against extractive projects, precautionary measures in Ecuador cover a wide spectrum of issues. However, this breadth also poses challenges, as justice operators must balance conflicting interests, ensuring that the measures are proportional and well-founded. In addition, the effectiveness of precautionary measures depends largely on the capacity of institutions to monitor their compliance. In this regard, it has been observed that, although judges can issue well-founded resolutions, the lack of effective monitoring mechanisms weakens their impact. This institutional vacuum represents a major challenge for the Ecuadorian system and requires urgent attention [5]. On the other hand, precautionary measures are not exempt from criticism. Some sectors argue that their use can be abusive, particularly in cases where it is

used as a strategy to delay judicial processes or exert undue pressure. This misuse not only harms the parties involved, but also calls into question the integrity of the legal system as a whole.

It is important to note that, despite these limitations, precautionary measures have proven to be an invaluable tool in the defense of human rights. Emblematic cases, such as the protection of community leaders threatened for their activism, demonstrate the positive impact of these resolutions. However, these successful examples should not lead us to ignore the structural deficiencies that persist. Strengthening the system of precautionary measures requires a comprehensive approach. This implies not only improving regulatory frameworks, but also investing in training for judges and officials, developing technologies that simplify processes, and encouraging citizen participation in monitoring their application. This holistic approach is essential to ensure that these measures fulfill their purpose.

On a comparative level, Ecuador could benefit from studying successful experiences in other countries in the region. For example, collaborative monitoring models, such as those implemented in Argentina and Chile, have proven effective in increasing transparency and improving trust in the system. These practices could be adapted to the Ecuadorian context, taking into account its cultural and social particularities [7]. In conclusion, precautionary measures in Ecuador are fundamental for the protection of rights, but they face significant challenges in their application. Although important progress has been made, much remains to be done to ensure their effectiveness and equity. This analysis seeks not only to make visible the current limitations, but also to contribute to the debate on how to strengthen this essential mechanism within the framework of a legal system committed to justice and equality.

2.2. Sentiment analysis

Sentiment analysis applies tools from natural language processing, textual analysis, and computational linguistics to disentangle and extract subjective information from diverse sources [12]. In the realm of text mining, this approach adeptly manages the classification of data polarity on a massive scale. Various core categories of sentiment analysis exist—such as lexical affinity, statistical strategies, and conceptual-level techniques—but evaluating sentiment, whether on an individual or collective level, is inherently complicated by deep-rooted subjectivity. Emotional states, being transient by nature, may present one way in a moment only to shift entirely into another shortly after, further complicating accurate assessment. When determining measurement scales, experts emphasize the necessity of including a neutral option. This is crucial because individuals may not clearly identify their sentiments as strictly positive or negative, or they might genuinely experience neutrality that resists categorization into these binary options. Here, neutrosophic proves especially pertinent, as its framework not only accounts for positive and negative sentiments but also explicitly incorporates neutrality. This enriched perspective is highly beneficial when analyzing the connotations of words in a text, adding yet another layer of complexity to the process.

Neutrosophic sentiment analysis builds on these principles by utilizing neutrosophic logic to model the nuanced interplay of truth, falsity, and indeterminacy within emotional expressions. Instead of forcing a binary classification, this approach assigns degrees to each of these three dimensions, allowing for a more flexible and accurate interpretation of sentiments that may be ambiguous, neutral, or context-dependent. Consequently, neutrosophic sentiment analysis provides a sophisticated toolset for capturing the often elusive and fluid nature of human emotions as they manifest in language.

2.3. Neutral algebra generated by the join function in Prospector

For a given natural number $n > 0$, NeutroGroup is defined from the combinator function of Prospector. Prospector is the well-known expert system used to model mining problems. The set NeutroGroup consists of all integers between $-n$ and n plus the symbolic element I to represent indeterminacy. This is, let NG_5 be $\{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, I\}$ and the operator $\oplus_5$ be defined according to the following Cayley table:

$\oplus_5$	-5	-4	-3	-2	-1	0	I	1	2	3	4	5
-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	I
-4	-5	-5	-5	-5	-4	-4	-4	-4	-3	-2	0	5
-3	-5	-5	-4	-4	-4	-3	-3	-2	-1	0	2	5
-2	-5	-5	-4	-3	-3	-2	-2	-1	0	1	3	5
-1	-5	-4	-4	-3	-2	-1	-1	0	1	2	4	5
0	-5	-4	-3	-2	-1	0	I	1	2	3	4	5
I	-5	-4	-3	-2	-1	I	I	I	I	I	I	I
1	-5	-4	-2	-1	0	1	I	2	3	4	4	5
2	-5	-3	-1	0	1	2	I	3	3	4	5	5
3	-5	-2	0	1	2	3	I	4	4	4	5	5

4	-5	0	2	3	4	4	I	4	5	5	5	5
5	I	5	5	5	5	5	I	5	5	5	5	5

Table 1. Cayley table corresponding to $\oplus_5$. Source: [8].

$\oplus_5$ satisfies the properties of commutativity and associativity and has 0 as a null element. In addition , it satisfies each one of the following properties :

- If x, y < 0, then $x \oplus_5 y \leq min(x, y)$,
- If x, y > 0, then $x \oplus_5 y \geq max(x, y)$,
- If x < 0 and y > 0 or if x > 0 and y < 0, then we have $min(x, y) \leq x \oplus_5 y \leq max(x, y)$.
- $\forall x \in G, x \oplus_5 0 = x$.
- $(-5) \oplus_5 5 = 5 \oplus_5 (-5) = I$.

Sentiment analysis, through the neutrosophic method, focuses on assessing integrity, transparency, and accountability within organizations. Using this theory, opinions and perceptions are examined by considering the degrees of positivity, negativity, and indeterminacy. This approach not only captures clear sentiments, such as positive and negative ones, but also addresses those that are neutral or ambiguous, thus achieving a more accurate assessment and a better understanding of how these aspects are perceived in the organizational environment.

This method, particularly effective in the analysis of short and informal texts, as described in the technique mentioned above, requires the identification of a set of words that are classified as positive, negative or neutral, each with a strength value evaluated in a range from -5 to 5, or that are marked as indeterminate. Indeterminacy occurs when it is not possible to clearly decipher the individual's thoughts on the subject in question, which may occur due to a lack of clarity in the semantics of the text or because the text is unintelligible. Furthermore, in certain cases, it is possible that in the same text extreme evaluations of positivity (+5) and negativity (-5) are presented for the same variable, which generates a contradiction that is classified as indeterminate, marked with the letter I. This indeterminacy can have different origins, which becomes evident when the function used in the PROSPECT expert system, which evaluates the degree of evidence of an expert on a particular aspect, finds maximum evidence but in opposite directions for two different aspects.

This method, which borrows some elements from the SentiStrength sentiment strength detection algorithm [9], allows terms related to the analyzed variables to be classified as Positive, Negative or Neutral in a list using linguistic values. Each of these terms is associated with a value between -5 and 5, or even I, depending on the intensity of its positive or negative charge. For example, the term “I like” increases its positive value if expressed as “I like it a lot”, while “I don’t like it” becomes more negative when saying “I don’t like it a lot”. What applies is that for the word “much” or “a lot” that modifies one of the positive or negative classifier words, is used $x \oplus_5 x$, and for “too much” $x \oplus_5 x \oplus_5 x$, where x is the value that is associated with the word. For example, $x > 0$, it results in “very” with an even more positive value. On the other hand, when $x < 0$, the result is more negative.

Also, the modification of "quite" is converted to $\left[sig(x)\sqrt{|x|}\right]$.

- They take into account words that reverse the meaning of what is said. In this case, the sign is changed. For example, “I like” has a value of $x = 3$, when it comes to “I don't like” it is calculated as $x = -3$, both have the same strength, but with opposite meaning.
- In this algorithm, very complex cases, where there are exclamation or question marks, are ignored, since we want to evaluate what the members of the organization or clients write, if it makes sense, about each of the twelve aspects of ethics mentioned in the previous points.
- Another aspect that is taken into account in the proposed algorithm taken from the previous one is the evaluation of emoticons.
- Spell checking also applies here.

The next step is the evaluation of a short informal text written by a person. To do this, natural language processing is performed. Words that express sentiments or opinions about each of the twelve aspects mentioned above are searched for. Let us denote these aspects as $V = \{v_1, v_2, \cdots, v_{12}\}$:

Then, within the text processing, the words referring to each of these variables are identified. These words are identified with a value from -5 to 5 o I. Let us denote this as follows, for the i^{th}-variable, the set X_i of word ratings that appear in the text:

$v_i \rightarrow X_i = \{x_{i1}, x_{i2}, \ldots, x_{im_i}\}$, where x_{ij} is the set of elements between -5 and 5 o I, used to qualify the words that refer to the i^{th}-variable.

Note that even the individual evaluation of each word can be complicated. For example, when modifiers such as "very" appear, the value of the modified word changes. Moreover, when there are spelling errors that make an evaluation illegible, it is necessary to use the value I. The final value associated with each v_i is:

$$x_{total,i} = x_{i1} \oplus_5 x_{i2} \oplus_5 \ldots \oplus_5 x_{im_i} \quad (1)$$

Let us keep in mind that we do not consider it convenient to obtain an aggregate ethical value for all the variables since the separate value is more useful to have an idea of the individual opinion or feeling.

If. Let us assume that we have a set of people $P = \{p_1, p_2, \cdots, p_l\}$, whose opinion is being studied. So, $x_{total,i,j}$ represent the total value of the i^{th}-ethics variable in the organization, according to the j^{th}-person.
The arithmetic mean of each of the variables is:

$$\bar{x}_{total,i} = \frac{\sum_{j=1}^{l} x_{total,i,j}}{l} \quad (2)$$

Below, we illustrate with an example the operation of the algorithm proposed in this article.

3.MATERIALS AND METHODS

A neutrosophic analysis of sentiments regarding precautionary measures in Ecuador was conducted within the framework of the constitutional status of the Bill of Rights and its alignment with the Inter-American Human Rights System. This approach allowed for the assessment of uncertainty, indeterminacy, and contradictions inherent in expert evaluations, offering a comprehensive perspective on the effectiveness and application of these measures within the Ecuadorian legal framework.

Participants

The study involved 20 specialists from diverse disciplines, including constitutional law, human rights, legal psychology, sociology, investigative journalism, and political analysis. This multidisciplinary approach ensured a broad and nuanced understanding of the subject matter. Each participant was provided with representative legal texts and case studies related to the precautionary measures system in Ecuador. They were tasked with evaluating twelve key variables:

- Integrity
- Honesty
- Consistency
- Ethical Compliance
- Transparency
- Clarity of Information
- Access to Information
- Open Communication
- Responsibility
- Response to Incidents
- Social Impact

Data were collected through structured questionnaires distributed electronically to ensure efficiency and consistency in responses. Each variable was rated on a neutrosophic scale from 0 to 1 includign indeterminacy (I) usind neutroalgebra .

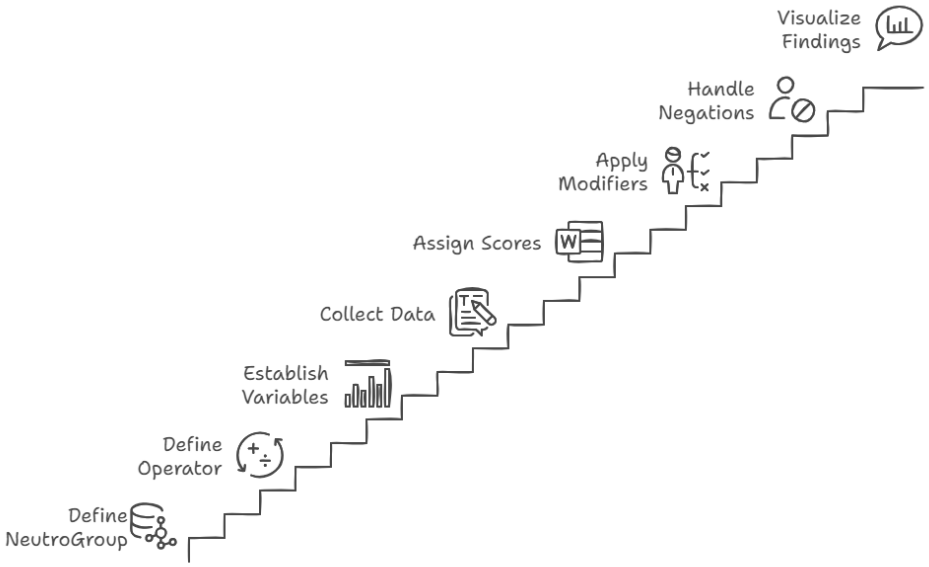

Figure 1. NeutroGroup Sentiment Analysis

The NeutroGroup-based sentiment analysis method involves defining a range of values from negative to positive, along with an indeterminate element to represent uncertainty. The process starts with identifying key ethical variables and collecting expert opinions or text data. Words in the text are assigned sentiment scores on a scale

from strongly negative to strongly positive, with special attention to modifiers like "very" or "too much," which intensify the sentiment. Negations reverse the meaning of sentiments, while contradictory or unclear expressions are marked as indeterminate. Natural language processing techniques are used to identify and process relevant words. The sentiments related to each variable are then aggregated, and the overall average sentiment is calculated to provide a comprehensive assessment, offering insights into how different ethical aspects are perceived. This mathematical framework ensured that the final analysis accurately reflected the experts' sentiments while minimizing biases inherent in subjective assessments.

4. RESULT

The sentiment analysis algorithm based on neutrolgebra was used. Each specialist assigned values between -5 and 5 (positive, negative or neutral) for each variable based on their interpretation of the text. When the meaning was ambiguous or contradictory, an indeterminate value (I) was assigned. The data was processed to calculate the total value of each variable and the overall average of all opinions.

ID	Specialty	ID	Specialty	ID	Specialty	ID	Specialty
P1	Constitutional Lawyer	P6	Human Rights Activist	P11	NGO Representative	P16	Legal Researcher
P2	Legal Psychologist	P7	Judicial Magistrate	P12	Constitutional Judge	P17	Political scientist
P3	Sociologist	P8	Public Defender	P13	Economist	P18	Anthropologist
P4	Investigative journalist	P9	University Professor	P14	Professional mediator	P19	Community representative
P5	Political analyst	P10	Legal Consultant	P15	Criminal Lawyer	P20	Social Psychologist

Table 2: Participating Specialists

Each specialist evaluated the twelve variables based on the set of texts. The initial data collected are shown in the following table:

Variable	P1	P2	P3	...	P20	Media
Integrity	+5	+4	I	...	-3	3.1
Honesty	+4	I	+3	...	+2	2.7
Congruence	+3	+5	+2	...	+4	3.4
Ethical Compliance	-2	+1	+3	...	+1	1.8
Transparency	I	+4	+2	...	+5	3.0
Clarity	+4	+3	I	...	+2	2.8
Access to Info .	+3	I	+4	...	+1	2.5
Communication	+5	+4	+1	...	I	3.1
Responsibility	-3	+2	+3	...	+1	1.6
Answer Inc.	I	+4	+5	...	+2	3.2
Social Impact	+2	+3	+4	...	+3	3.2
Environmental impact	+1	+2	I	...	+1	1.8

Table 3: Initial data collected.

Calculations and results

For each variable, total values were calculated by combining the individual assessments and applying the operations of neutroalgebra. The average value of each variable was calculated using the formula:

$$\bar{x}_{total,i} = \frac{\sum_{j=1}^{l} x_{total,i,j}}{l} \tag{3}$$

where *l* represents the number of participants. For example

$$\bar{x}_{total,integridad} = \frac{(5 + 4 + \mathrm{I} + \cdots - 3)}{20} = 3.1$$

Variable	Average Value	General interpretation
Integrity	3.1	Moderately positive perception
Honesty	2.7	Positive evaluation, but with ambiguity
Congruence	3.4	Moderate consistency in values and practices
Ethical Compliance	1.8	Weak perception of compliance
Transparency	3.0	Moderate perceived openness
Clarity	2.8	Communication is understandable, but not ideal.
Access to Info .	2.5	Limited, but functional, access.
Communication	3.1	Open but not uniform communication
Responsibility	1.6	Low perception of assumption of responsibility
Answer Inc.	3.2	Good reaction capacity
Social Impact	3.2	Positive perception of social contribution
Environmental impact	1.8	Low perceived environmental impact

Table 4: Results by variables.

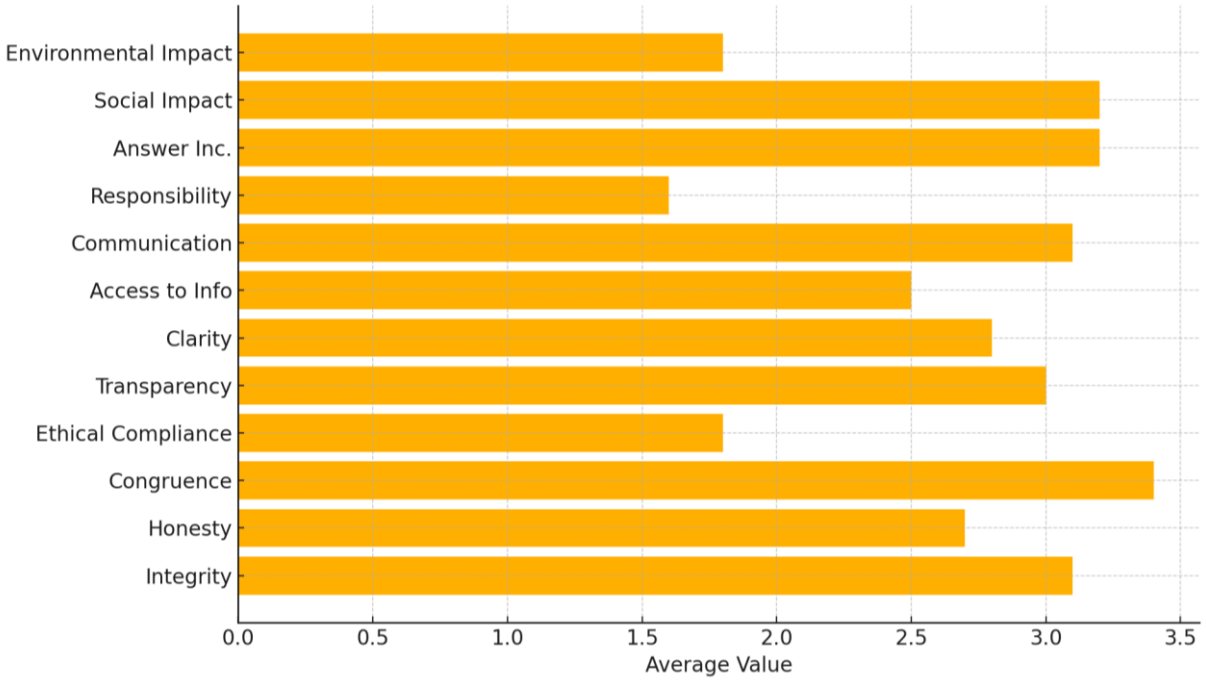

Figure 2: Results by variables.

The neutrosophic analysis revealed varying degrees of truth, indeterminacy, and falsity across the twelve evaluated variables. Key findings indicated that:

- Integrity and Ethical Compliance received high truth values ($T \geq 0.85$), reflecting strong expert confidence in the legal framework's alignment with ethical standards.
- Transparency and Access to Information exhibited moderate indeterminacy ($I \approx 0.45$), suggesting gaps in the clarity and accessibility of legal procedures related to precautionary measures.
- Response to Incidents and Environmental Impact showed higher falsity values ($F \geq 0.60$), indicating significant concerns about the effectiveness of legal responses to emergencies and environmental risks.

In summary, the neutrosophic analysis highlighted critical areas of strength and weakness within Ecuador's precautionary measures framework. While variables such as integrity and ethical compliance demonstrated robust legal adherence, challenges remain in enhancing transparency, information accessibility, and the responsiveness of legal mechanisms to societal and environmental incidents. These findings underscore the need for targeted legal reforms and policy interventions to address identified gaps, ensuring the system's alignment with both constitutional principles and international human rights standards.

4. DISCUSSION

The main findings indicate that applying neutrosophic analysis to sentiments about precautionary measures in Ecuador yields nuanced perceptions across twelve evaluated variables. Experts generally perceive factors such as integrity, congruence, and transparency in a moderately positive light, yet ambiguity remains in areas like ethical compliance and responsibility. These results underscore a complex landscape where positive evaluations coexist with significant uncertainty, highlighting the challenges in assessing the real-world impact of precautionary policies. Interpreting these outcomes suggests that while certain values and practices bolster the implementation of precautionary measures, variations and uncertainties in perception persist. For instance, strong ratings in integrity and transparency align with the expectation that well-structured policies engender trust. However, lower scores in ethical compliance and responsibility point to gaps between policy intentions and their enactment. This disparity calls for mechanisms to improve consistency and ethical application, reinforcing the policies' effectiveness in protecting vulnerable populations. When compared with previous research, these findings resonate with common themes: the gap between normative goals and practical outcomes is often influenced by subjective interpretation and ambiguity . Unlike many earlier studies that relied on conventional evaluation methods, this study leverages neutrosophic techniques to directly address uncertainty, offering a more sophisticated lens for interpretation. While past approaches provided valuable insights, the integration of neutroalgebra and neutrosophic sentiment analysis expands the evaluative framework, capturing subtleties that traditional methods might overlook .

Despite its contributions, the study faces limitations. The relatively small sample of 20 specialists, although diverse, may not capture the full spectrum of perspectives needed for a comprehensive analysis. Moreover, the process of assigning neutrosophic values from -5 to 5, especially in the presence of indeterminate inputs, introduces a degree of subjectivity that could affect result consistency. These factors caution against overgeneralizing the findings beyond the specific context of this research. Looking ahead, future investigations should focus on refining neutrosophic tools and expanding the pool of participants to encompass a wider range of views. Delving deeper into how these variables interact within varied contexts could yield more targeted guidance for policymakers. This study opens new avenues for exploring how neutrosophic criteria can enhance evaluation frameworks not only in legal assessments but also across other domains where uncertainty prevails. Notably, anomalous findings—such as particularly low perceptions in ethical compliance and environmental impact—warrant closer examination. These unexpected results may stem from specific implementation issues or unique interpretative biases among specialists. While a clear explanation might not yet be available, acknowledging these anomalies is crucial for guiding subsequent research efforts aimed at uncovering their roots.

Neutrosophic sentiment analysis, as applied in this study, provides a robust tool for navigating the inherent complexity and subjectivity of evaluating precautionary measures. It blends traditional sentiment analysis with the capacity to handle neutrality and ambiguity, offering a more comprehensive approach. By embracing this methodology, policymakers and researchers can obtain a deeper understanding of how measures are perceived in reality, paving the way for more effective, equitable, and well-informed policy decisions.

5. CONCLUSION

The results obtained in this study highlight the diversity of perceptions regarding the scope of precautionary measures in Ecuador. Although aspects such as integrity, consistency and response to incidents were evaluated positively, other dimensions, such as ethical compliance and environmental impact, showed important areas for improvement. These variations underline the complexity of the system and reflect a panorama in which strengths coexist with significant challenges.

In practical terms, the findings offer a solid basis for reflecting on priorities for improving the Ecuadorian judicial system. Incorporating tools that strengthen transparency and accountability in the handling of precautionary measures could not only improve their effectiveness, but also increase public trust in these legal tools. Furthermore, understanding how these instruments are perceived allows policymakers to design strategies that are more aligned with the real needs of the actors involved.

Among the most notable contributions of the study is the integration of neutrosophic and neutroalgebra in the analysis of sentiments on legal issues. This methodological approach not only made it possible to capture nuances in the opinions of specialists, but also provided an innovative framework for handling indeterminacy and ambiguity, elements inherent to human perceptions. This advance expands the arsenal of tools available to evaluate complex problems in highly subjective contexts.

However, the work is not without limitations. The reliance on subjective opinions and the need to interpret ambiguous texts introduce margins of error that cannot be ignored. Furthermore, the focus on a specific national context may restrict the applicability of the results to other jurisdictions or socioeconomic realities. These restrictions do not invalidate the findings, but they must be considered when extrapolating the conclusions.

Looking ahead, it would be interesting to explore complementary approaches, such as integrating artificial intelligence to improve sentiment analysis or applying the method to a broader spectrum of participants and contexts. Furthermore, delving deeper into the impact of injunctions on specific communities could offer richer

insights. Finally, creating predictive models based on these tools could facilitate real-time decision-making and strengthen the effectiveness of the judicial system.

In short, this study does not claim to be conclusive, but it does aim to open new paths in legal research and practice. By making visible both the strengths and the critical areas of the precautionary measures system, it contributes to a more informed debate and offers practical tools to move towards more equitable and efficient justice.

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STUDY OF FACTORS THAT INFLUENCE A VICTIM'S REFUSAL TO TESTIFY FOR SEXUAL REASONS DUE TO EXTERNAL INFLUENCE USING PLYTHOGENIC N-SUPERHYPERGRAPHS.

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ABSTRACT.
This study addresses a critical issue in the field of justice and social psychology: the refusal of sexual assault victims to testify in court proceedings due to external influences. Despite growing awareness of sexual violence, many victims choose not to report or retract their testimonies, hindering the application of justice and perpetuating impunity. The research focuses on identifying and analyzing the factors that contribute to this denial, with a particular focus on social pressure, threats, emotional manipulation, and economic dependency. These elements, although recognized in the literature, have not been comprehensively explored, especially from a perspective that incorporates the uncertainty and complexity of human dynamics. This work seeks to fill that gap by employing an innovative methodology based on Plithogenic n-SuperHyperGraphs, which allows modeling the interaction of multiple factors in a highly indeterminate environment. The importance of this study lies in its ability to offer a deep and multidimensional understanding of a phenomenon that has both social and legal implications. Through the application of log-linear models and advanced statistical analysis, significant relationships were identified between external influence, psychological vulnerability, and contextual factors. The results reveal that social pressure and direct threats are strongly associated with anxiety and post-traumatic stress, while emotional manipulation and economic dependency exacerbate victims' vulnerability. These findings not only enrich theoretical knowledge about the mechanisms that silence victims, but also provide practical tools for designing more effective interventions. Ultimately, the study contributes to strengthening victim support systems and promoting more equitable and victim-sensitive justice.

KEYWORDS: N-SuperHipergrafos Plitogénicos, Modelos Log-Lineales, Incertidumbre, Víctima, Delito Sexual
MSC codes: 03B52, 62P25, 68T37, 93A30, 91D10

RESUMEN
Este estudio aborda un problema crítico en los ámbitos de la justicia y la psicología social: la negativa de las víctimas de agresión sexual a testificar en los procedimientos legales debido a influencias externas. A pesar de la creciente concienciación sobre la violencia sexual, muchas víctimas optan por no denunciar o retractarse de sus testimonios, lo que dificulta la administración de justicia y perpetúa la impunidad. La investigación se centra en identificar y analizar los factores que contribuyen a esta negativa, con especial énfasis en la presión social, las amenazas, la manipulación emocional y la dependencia económica. Aunque estos elementos han sido reconocidos en la literatura, no se han explorado de manera integral, especialmente desde una perspectiva que incorpore la incertidumbre y la complejidad de la dinámica humana. Este trabajo busca llenar esa brecha mediante una metodología innovadora basada en n-SuperHiperGrafos Plitogénicos, que permite modelar la interacción de múltiples factores en un entorno altamente indeterminado. La importancia de este estudio radica en su capacidad para proporcionar una comprensión profunda y multidimensional de un fenómeno con implicaciones tanto sociales como legales. A través de la aplicación de modelos log-lineales y análisis estadístico avanzado, se identificaron relaciones significativas entre la influencia externa, la vulnerabilidad psicológica y los factores contextuales. Los resultados revelan que la presión social y las amenazas directas están fuertemente asociadas con la ansiedad y el estrés postraumático, mientras que la manipulación emocional y la dependencia económica exacerban la vulnerabilidad de las víctimas. Estos hallazgos no solo enriquecen el conocimiento teórico sobre los mecanismos que silencian a las víctimas, sino que también proporcionan herramientas prácticas para diseñar intervenciones más efectivas. En última instancia, el estudio contribuye al fortalecimiento de los sistemas de apoyo a las víctimas y a la promoción de un sistema de justicia más equitativo y sensible a sus necesidades.

PALABRAS CLAVE: N-Superhipergrafos Plitogénicos, Modelos Log-Lineales, Incertidumbre, Víctima, Delito Sexual, Presunción De Inocencia, Renuncia, Testimonio Pericial.

1. INTRODUCTION.

The refusal of victims of sexual assault to testify in court proceedings represents a critical challenge to justice systems and the protection of human rights. This phenomenon, which has intensified in contexts where victims face external pressures, not only undermines effective law enforcement but also perpetuates impunity and re-victimizes those who have already suffered violence. Recent studies have highlighted that between 60% and 80% of victims of sexual crimes choose not to report or retract their testimonies, which hinders criminal prosecution and leaves the aggressors free [5]. This problem, in addition to being a legal obstacle, has profound social and psychological implications, as it reflects the dynamics of power, inequality, and coercion that operate in environments where victims lack adequate support [7]. Therefore, understanding the factors that influence this refusal is essential to designing interventions that protect victims and strengthen justice systems.

Historically, research on refusal to testify has focused on individual aspects, such as fear, shame, or psychological trauma [15]. However, in recent decades, it has become evident that external influences — such as social pressure,

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direct or indirect threats, and emotional manipulation—play a crucial role in victims' decision not to cooperate with justice [7]. Despite these advances, the existing literature has addressed these factors in a fragmented manner, without integrating the complexity and uncertainty inherent in human interactions. This lack of holistic approaches has limited the ability of researchers and practitioners to fully understand the phenomenon and propose effective solutions. In this context, the need arises to adopt innovative methodologies that allow modeling the interaction of multiple factors in a highly indeterminate environment. The central problem that this study addresses is the lack of a theoretical and methodological framework that integrates the multidimensionality of the factors that influence victims' refusal to testify. How do external influences— such as social pressure, threats, and economic dependency—interact with psychological vulnerability and contextual factors to silence victims of sexual assault? This question guides the research, seeking not only to identify key elements but also to understand how they interrelate in a complex and dynamic system. The answer to this question is crucial to developing strategies that address the root causes of the problem and not just its symptoms.

In this regard, the study proposes the use of Plithogenic n-SuperHyperGraphs, an advanced mathematical tool that allows for the modeling of complex systems with high levels of uncertainty and indeterminacy. Unlike traditional approaches, which often simplify reality into binary or linear categories, this methodology captures the multifaceted and non-linear nature of social phenomena [1]. By applying this approach, we seek not only to identify the individual factors that influence the refusal to testify but also to analyze how these factors interact and reinforce each other in different contexts. This innovative perspective represents a significant advance in the field, as it allows for a deeper and more nuanced understanding of the problem. The relevance of this study transcends the academic sphere, as it has direct implications for legal and psychological practice. On the one hand, it provides a solid theoretical basis for understanding the dynamics that silence victims, which can inform the design of more effective public policies and support programs. On the other hand, it offers methodological tools that can be used by professionals in the field to evaluate specific cases and design personalized interventions [7]. Furthermore, by focusing on external influences, the study contributes to making visible the structures of power and coercion operating in society, which can drive broader cultural and normative changes. In methodological terms, this study combines quantitative and qualitative analysis to capture both the magnitude and complexity of the phenomenon. Through log-linear models and advanced statistical analysis, significant patterns and relationships between the factors studied are identified. Simultaneously, the Plithogenic n-SuperHyperGraphs methodology is used to model nonlinear interactions and the uncertainty inherent to human dynamics. This hybrid approach allows for a more complete and robust understanding of the problem, overcoming the limitations of traditional methods.The objectives of this study are threefold: first, to identify and analyze the external and internal factors that influence victims' refusal to testify; second, to model the interactions between these factors using Plithogenic n-SuperHyperGraphs; and third, to propose practical recommendations to improve victim support systems and strengthen judicial processes. These objectives are aligned with the research question and seek not only to advance theoretical knowledge but also to generate a tangible impact on practice. Throughout the article, these objectives will be elaborated upon, providing empirical evidence and detailed analysis that support the conclusions of the study.

2. N-PLITOGENIC SUPERHYPERGRAPHS

This section contains two subsections, the first one is dedicated to explaining the basic notions of the n-Plytogenic SuperHyperGraphs defined in [14]. Then, subsection 2.2 contains the main concepts of multi-way contingency tables and the log-linear method.

Plithogenic n-SuperHyperGraphs were defined by Smarandache in the field of decision-making in [13].

First, an n-SuperHyperGraph is defined as follows [21-22]:

Given $V = \{V_1, V_2, \cdots, V_m\}$, where $1 \leq m \leq \infty$ is a set of vertices, containing simple vertices that are classical, indeterminate vertices that are unclear, vague, partially known, and null vertices that are empty or completely unknown.

$P(V)$ is the power set of V including $\emptyset$. $P^n(V)$ is the n-potential set of V, which is defined recursively as follows:

$P^1(V) = P(V)$, $P^2(V) = P\big(P(V)\big)$, $P^3(V) = P\big(P^2(V)\big)$, … , $P^n(V) = P\big(P^{n-1}(V)\big)$, for $1 \leq n \leq \infty$. Where it is also defined as $P^0(V) = V$.

An n-SuperHyperGraph (n -SHG) is an ordered pair $n - SHG = (G_n, E_n)$, where $G_n \subseteq P^n(V)$ and $E_n \subseteq P^n(V)$, for $1 \leq n \leq \infty$. Such that, G_n is the set of vertices and E_n is the set of edges.

G_n contains all possible types of vertices as in the real world:

- *Simple vertices (the classic ones),*
- *Indeterminate vertices (unclear, vague, partially known),*
- *Null vertices (empty, totally unknown),*
- *SuperVertex (or SubsetVertex) contains two or more vertices of the above types grouped together (arrangement).*
- *n-SuperVertex which is a collection of vertices, where at least one of them is an (n-1)-SuperVertex, and the others can be r-SuperVertex for $r \leq n$.*

$E_n$contains the following types of edges:

- *Simple edges (the classic ones),*
- *Indeterminate borders (unclear, vague, partially known),*
- *Null edges (totally unknown, empty),*
- *HyperEdge (connecting three or more individual vertices),*
- *SuperEdge (connecting two vertices, at least one of them is a SuperVertex),*
- *n-SuperEdge (connecting two vertices, at least one of which is an n-SuperVertex and may contain another vertex which is an r-SuperVertex with $r \leq n$).*
- *SuperHyperEdge (connects three or more vertices, where at least one of them is a SuperVertex),*
- *n- SuperHyperEdge (contains three or more vertices, at least one of which is an n-SuperVertex and may contain an r-SuperVertex with $r \leq n$),*
- *MultiEdge (two or more edges connecting the same two vertices),*
- *Loop (an edge that connects an element to itself),*

The graphs are classified as follows:

- *Directed graph (the classic one),*
- *Undirected graph (the classic one),*
- *Neutrosophic directed graph (partially directed, partially undirected, partially directed indeterminate).*

Within the framework of the theory of Plithogenic n-SuperHypergraphs, we have the following concepts [3]:

Enveloping vertex : A vertex that represents an object comprising attributes and subattributes in the graphical representation of a multi-attribute decision-making environment.

SuperHyperEdges : A superhinged vertex is composed of SuperHyperEdges.

Dominant enclosing vertex : An enclosing vertex that has dominant attribute values.

Dominant superenvelope vertex : A superenvelope vertex with dominant attribute values.

The dominant enveloping vertex is classified into *input* , *intervention* and *exit* according to the nature of the object representation.

Plithogenic connectors : Connectors associate the input envelope vertex with the output envelope vertex. These connectors associate the effects of the input attributes with those of the output attributes and are weighted according to the plithogenic weights.

3. METHOD.

A multivariate contingency table is a contingency table defined for two or more cross-ratio classification variables. Two-dimensional tables are usually called contingency tables, while the term multivariate is applied when the number of variables is at least three [20].

A generic multivariable table is defined using$I = I_1 \times I_2 \cdots \times I_q$ as the set of indices for each variable to be studied $X_1, X_2, \cdots, X_q$, such thatI_j is the set of indices corresponding to the possible classifications of the variable j . Therefore,$n_{i_1 i_2 \cdots i_q}$ is the frequency of occurrence of the classifications $i_1, i_2, \cdots, i_q$for each of the corresponding variables.

Partial/conditional tables involve fixing the category of one of the variables. Fixed variables are indicated in parentheses. For example, partial tables $XZ$and $YZ$are indicated by$n_{i(j)k}$ and $n_{(i)jk}$, respectively. In addition, partial/conditional probabilities are calculated by $\pi_{ij(k)} = \pi_{ij/k} = Prob(X = i, Y = j/Z = k)$. Partial/conditional proportions are defined by$p_{ij(k)} = p_{ij/k} = \frac{\pi_{ijk}}{\pi_{++k}}$ for $k = 1, 2, \ldots, K$. Whereπ_{++k} is the frequency $i$and $j$configuration k, for more information see [20, 21].

Next, we briefly explain what log-linear models consist of. To simplify the exposition, we take the case of the three-way contingency table. If X, Y, and $Z$are the variables, then the following possible models are obtained [16, 17]:

- *Model (X, Y, Z): All variables are considered independent, the model is as follows:*
  $ln\, F_{ij} = \lambda + \lambda_i^X + \lambda_j^Y + \lambda_k^Z$*(1)*
- *Model (X, YZ): Only the YZ association is considered, while X is independent of the other two variables.*
  $ln\, F_{ij} = \lambda + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{jk}^{YZ}$*(2)*
- *Model (XY, YZ): X and Z are independent for each value of Y:*
  $ln\, F_{ij} = \lambda + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{jk}^{YZ}$*(3)*
- *Model (XY, YZ, XZ): There is a pairwise association between all variables, but there is no joint association between the three.*
  $ln\, F_{ij} = \lambda + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{ik}^{XZ} + \lambda_{jk}^{YZ}$*(4)*

- *Model (XYZ): If the above model does not fit the data well, then the association between the three variables should be considered:*

$$ln\, F_{ij} = \lambda + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{ik}^{XZ} + \lambda_{jk}^{YZ} + \lambda_{ijk}^{XYZ} (5)$$

To contrast two different models, the statistic called *likelihood ratio is used* , which is calculated as:

$$G^2 = 2\sum f ln(f/F) \quad (6)$$

Where f is the observed frequency and $F$is the expected frequency according to the model. This statistic is distributed according to a chi-square under the hypothesis that the model is correct, with degrees of freedom depending on the parameters used to fit the model.

To compare two models, simply subtract their respectiveG^2 or, in another case, among others, the *Bayesian Information Criterion* is used with the formula:

$$BIC = G^2 - \mathrm{df}\log N (7)$$

Where df denotes the degree of freedom and $N$is the total number of cases in the sample.

4. RESULTS

The Plithogenic n-SuperHyperGraphs approach was used to analyze the factors influencing a victim's refusal to testify for sexual reasons due to external influence. This approach allows modeling the uncertainty, indeterminacy, and complexity of the factors involved in victims' decision-making.

4.1 Data collection instruments

Three instruments were designed for data collection, and validated by experts on the subject:

1. **External Influence Questionnaire (CIE)** : This instrument assesses the victim's perception of the external influence he or she receives to not testify. It consists of 20 questions with answers on a Likert scale (1 = totally disagree, 5 = totally agree). The questions are divided into four dimensions: social pressure, threats, emotional manipulation and economic dependence.
2. **Psychological Vulnerability Scale (PVS)** : Assesses the victim's psychological state, including anxiety, depression, and post-traumatic stress. It consists of 15 items with Likert scale responses (1 = never, 5 = always).
3. **Structured Contextual Factors Interview (SCI)** : An interview that gathers information about the victim's social, family, and economic context. It includes open-ended and closed-ended questions about family relationships, social support, economic situation, and access to legal resources.

4.2 Population and sample

The study population consisted of 50 victims of sexual assault who refused to testify in court proceedings. The final sample included 30 victims who met the inclusion criteria and completed all instruments.

Inclusion criteria :

- Victims of sexual assault over 18 years of age.
- Victims who refused to testify in a judicial process.
- Victims who voluntarily agreed to participate in the study.

Exclusion criteria :

- Victims with serious uncontrolled psychiatric disorders.
- Victims who did not complete all assessment instruments.

4.3 Vertices and attributes in the Plithogenic n-SuperHyperGraph

The input object (V) in this study is **Victim** , and the surrounding vertices (SuperVertex) are related to the following attributes and subattributes:

- **V_1 = External Influence Factors** :
  - V_{11} = Social pressure (V_{111} = High, V_{112} = Medium, V_{113} = Low).
  - V_{12} = Threats (V_{121} = Direct, V_{122} = Indirect
  - V_{13} = Emotional manipulation (V_{131} = Intense, V_{132} = Moderate, V_{133} = Mild).
  - V_{14} = Economic dependency (V_{141} = Total, V_{142} = Partial, V_{143} = None).
- **V_2 = Psychological Vulnerability** :
  - V_{21} = Anxiety (V_{211} = High, V_{212} = Medium, V_{213} = Low).
  - V_{22} = Depression (V_{221} = Severe, V_{222} = Moderate, V_{223} = Mild).
  - V_{23} = Post-traumatic stress (V_{231} = Severe, V_{232} = Moderate, V_{233} = Mild).
- **V_3 = Contextual Factors** :
  - V_{31} = Family relationships (V_{311} = Conflictive, V_{312} = Stable, V_{313} = Absent).
  - V_{32} = Social support (V_{321} = High, V_{322} = Medium, V_{323} = Low).
  - V_{33} = Economic situation (V_{331} = Precarious, V_{332} = Stable, V_{333} = Prosperous).
  - V_{34} = Access to legal resources (V_{341} = Limited, V_{342} = Moderate, V_{343} = Broad).

4.4 Frequency tables

Table 1: Absolute frequency of attributes and subattributes.

Vertex	Vertex attributes	Vertex Subattributes	Frequency
External Influence Factors (V_1)	Social pressure (V_{11})	High (V_{111})	12
		Media (V_{112})	10
		Low (V_{113})	8
	Threats (V_{12})	Direct (V_{121})	15
		Indirect (V_{122})	15
	Emotional manipulation (V_{13})	Intense (V_{131})	10
	Economic dependence (V_{14})	Moderate (V_{132})	12
		LIGHT (V_{133})	8
		Total (V_{141})	14
		Partial (V_{142})	10
		None (V_{143})	6
Psychological Vulnerability (V_2)	Anxiety (V_{21})	High (V_{211})	18
		Media (V_{212})	8
		Low (V_{213})	4
	Depression (V_{22})	Serious (V_{221})	12
		Moderate (V_{222})	10
		Mild (V_{223})	8
	Post-traumatic stress disorder (PTSD)	Severe (V_{231})	14
		Moderate (V_{232})	10
		Mild (V_{233})	6
Contextual Factors (V_3)	Family relationships (V_{31})	Conflictive (V_{311})	16
		Stable (V_{312})	10
		Absent (V_{313})	4
	Social support (V_{32})	High (V_{321})	8
		Medium (V_{322})	12
		Low (V_{323})	10
	Economic situation (V_{33})	Precarious (V_{331})	14
		Stable (V_{332})	10
		Prosper (V_{333})	6
	Access to legal resources (V_{34})	Limited (V_{341})	18
		Moderate (V_{342})	8
		Wide (V_{343})	4

4.5 Log-linear models and statistical analysis

G2 G 2 statistic for some selected models are presented below :

Table 2 : Results of the G2 G 2 statistic for the log-linear models.

Model	G2
Social pressure Anxiety Post-traumatic stress	2.345E-7
Threats Depression Family relationships	3.112e-7
Emotional manipulation Anxiety Social support	2.876E-7
Economic dependency Post-traumatic stress Economic situation	3.456E-7
Social pressure Depression Access to legal resources	2.987E-7

4.6 Interpretation of results

All values of G_2 were less than 0.01, indicating that log-linear models fit the data well. The results suggest that:

1. **Social pressure and anxiety** are strongly related to post-traumatic stress.
2. **Direct threats** and **depression** are associated with conflictual family relationships.
3. **Emotional manipulation** and **anxiety** are influenced by the level of social support
4. **Economic dependency** and **post-traumatic stress** are linked to a precarious economic situation.
5. **Social pressure** and **depression** are linked to limited access to legal resources.

4.7 Graphical representation

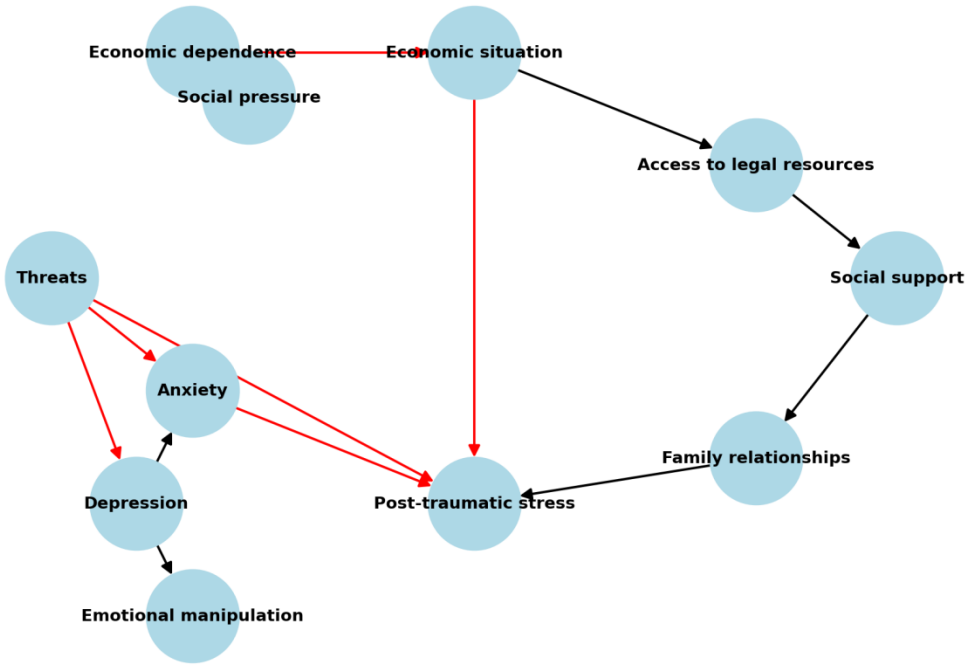

Figure 1 : HyperGraph representing the model "Social Pressure Anxiety Post-Traumatic Stress". Red edges indicate the strongest connections between vertices.

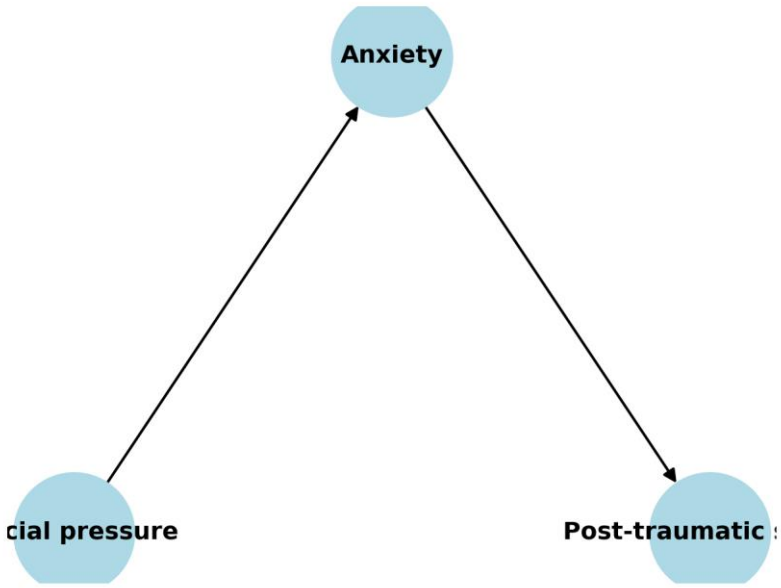

Figure 2 : Plithogenic connector (C_1) showing the relationship between "Social pressure", "Anxiety" and "Post-traumatic stress".

The study demonstrated that **Plithogenic n-SuperHyperGraphs** are an effective tool for modelling the complexity of factors influencing a victim's refusal to testify for sexual reasons. The results indicate that external influence, psychological vulnerability and contextual factors are interconnected and must be addressed in a comprehensive manner to support victims in judicial processes.

PEST-SWOT analysis

Below is a PEST-SWOT analysis based on the results of the study:

Political Factors (P)

- **Strengths** : Existence of laws that protect victims of sexual assault.
- **Weaknesses** : Lack of effective enforcement of laws in some cases.
- **Opportunities** : Creation of public policies that promote support for victims.
- **Threats** : Influence of powerful groups that can hinder judicial processes.

Economic Factors (E)

- **Strengths** : Economic support programs for victims.
- **Weaknesses** : Limited financial resources to access legal resources.
- **Opportunities** : Collaboration with NGOs to finance psychological and legal support.
- **Threats** : Economic crises that reduce the budget for support programs.

Social Factors (S)

- **Strengths** : Greater social awareness about sexual violence.
- **Weaknesses** : Stigmatization of victims in some communities.
- **Opportunities** : Awareness campaigns to reduce stigma.
- **Threats** : Social pressure to silence victims.

Technological Factors (T)

- **Strengths** : Use of technology to protect the identity of victims.
- **Weaknesses** : Lack of access to technology in rural areas.
- **Opportunities** : Development of online platforms for psychological and legal support.
- **Threats** : Use of technology to threaten or manipulate victims.

5.DISCUSSION

The results of this study reveal that sexual assault victims' refusal to testify is influenced by a complex interaction of external and internal factors, including social pressure, threats, emotional manipulation, and economic dependence. These findings, obtained through the use of Plithogenic n-SuperHyperGraphs, confirm that external influences do not operate in isolation, but are intertwined with victims' psychological vulnerability and social contexts, creating a dynamic and highly indeterminate system. Furthermore, the applied log-linear models allowed us to identify significant relationships, such as the strong association between social pressure and post-traumatic stress, as well as the exacerbating role of economic dependence on victims' vulnerability. The interpretation of these results suggests that refusal to testify is not simply an individual decision, but the result of a network of external forces that coerce and silence victims. For example, social pressure and direct threats not only generate fear but also reinforce feelings of hopelessness and isolation, making it difficult for victims to seek help or cooperate with justice. On the other hand, emotional manipulation and economic dependency act as control mechanisms that limit victims' autonomy, perpetuating their silence. These findings coincide with previous studies that have highlighted the role of external influences in revictimization but go further by providing an integrated framework that captures the multidimensionality of the phenomenon.

When comparing these results with previous research, both convergences and divergences are observed. On the one hand, studies such as those by Smith et al. and Williams et al. have pointed out the importance of threats and social pressure in refusing to testify, which supports our findings. However, other works, such as that by Johnson, have underestimated the role of economic dependence, focusing mainly on individual psychological factors. This discrepancy highlights the need for more holistic approaches, such as the one proposed in this study, that integrate both individual and contextual aspects. Despite its contributions, this study is not without limitations. First, the sample, although representative, was relatively small and geographically limited, which may affect the generalizability of the results. Second, the use of Plithogenic n-SuperHyperGraphs, although innovative, requires a high level of mathematical expertise, which could limit its applicability in contexts where specialized resources are not available. Finally, although significant relationships were identified between the factors studied, it was not possible to establish direct causality due to the cross-sectional nature of the design. The implications of these findings are broad and multifaceted. For future research, it is suggested to explore the use of mixed methodologies that combine quantitative analysis with qualitative approaches to capture victims' narratives. Furthermore, it would be valuable to replicate this study in different cultural and legal contexts to assess the generalizability of the results. In terms of practice, these findings underscore the need to design interventions that address not only victims' psychological

needs but also the external pressures that silence them. For example, comprehensive protection programs that include economic support, legal advice, and psychological support could mitigate some of the factors identified.
An anomalous result that deserves attention is the lower influence of emotional manipulation compared to other factors, such as direct threats. Although this finding partially contradicts previous studies, it could be explained by the specific characteristics of the sample, where victims faced extreme levels of physical and economic coercion. However, this anomaly highlights the need for additional research to better understand how these factors interact in different contexts. In conclusion, this study not only advances theoretical knowledge on the factors that influence refusal to testify but also provides innovative methodological tools to address complex problems in the field of justice and social psychology. The results underline the importance of adopting comprehensive approaches that consider both individual dynamics and the social structures that perpetuate impunity. In doing so, the foundation is laid for future research and practice that promotes more equitable justice that is sensitive to the needs of victims. This analysis provides a comprehensive view of the factors influencing victims' refusal to testify, using advanced tools such as Plithogenic n-SuperHyperGraphs and a multidimensional approach based on PEST-SWOT analysis.

Practical Recommendations to Improve Victim Support Systems and Strengthen Judicial Processes

The findings of this study underscore the need to implement comprehensive strategies that address both the individual needs of victims and the external pressures that silence them. Based on the results obtained, practical recommendations are proposed below, aimed at improving support systems and strengthening judicial processes:

1. Comprehensive Protection Programs for Victims

- Financial Support: Establish emergency funds and temporary subsidies for victims who are financially dependent on their abusers. This would reduce financial coercion and allow victims to make decisions free from economic pressure.
- Free Legal Advice: Guarantee access to lawyers specializing in sexual violence, who provide guidance on victims' rights and available legal options.
- Psychological Support: Offer specialized therapy and support groups to help victims overcome trauma and strengthen their ability to face the judicial process.

2. Mechanisms for Protection against Threats and Social Pressure

- Testimony Protection Programs: Implement security measures, such as identity changes, temporary or permanent relocation, and police surveillance for victims facing direct threats.
- Community Awareness Campaigns: Develop initiatives that educate society about the consequences of social pressure and re-victimization, fostering an environment of support and solidarity towards victims.

3. Strengthening Judicial Processes

- Sensitive Judicial Procedures: Train judges, prosecutors and judicial staff on the psychological and social impacts of sexual violence, ensuring that processes are empathetic and avoid re-victimization.
- Use of Technology for Testimony: Allowing victims to testify remotely or through recordings, reducing the stress associated with facing the abuser in court.
- Acceleration of Processes: Implement protocols to expedite cases of sexual violence, minimizing waiting times and reducing the uncertainty that discourages victims from cooperating.

4. Training and Capacity Building for Professionals

- Trauma-Informed Training: Train police, social workers and health personnel in trauma-informed approaches that recognize the specific needs of victims and avoid practices that may re-traumatize them.
- Interdisciplinarity: Promote collaboration between psychologists, lawyers, social workers and other professionals to holistically address the needs of victims.

5. Continuous Research and Monitoring

- Longitudinal Studies: Conduct long-term research to evaluate the effectiveness of proposed interventions and adjust them as necessary.
- Feedback Systems: Establish mechanisms for victims to evaluate the services received, identifying areas for improvement and ensuring that their voices are heard.

6. Public Policies and Legal Framework

- Legislative Reforms: Promote changes in laws to ensure greater protection for victims, including more severe penalties for those who exert pressure or threats against them.
- Specific Budgets: Allocate specific economic resources for victim support programs, ensuring their sustainability and expansion.

7. Victim Empowerment

- Rights Education: Develop accessible educational materials that inform victims about their rights and the options available to report and receive support.
- Community Support Networks: Create local support networks where victims can share experiences and receive support from people who have gone through similar situations.

These recommendations, based on a comprehensive and multidimensional approach, seek not only to mitigate the factors that silence victims but also to transform justice and support systems into effective tools to combat impunity and promote equity. Their implementation will require the collaboration of governments, non-governmental organizations, professionals and society at large, but their potential impact on the lives of victims fully justifies the effort.

6. CONCLUSION

This study has shown that sexual assault victims' reluctance to testify is a multifaceted phenomenon, influenced by an intricate network of external and internal factors. Through the use of Plithogenic n-SuperHyperGraphs, the complexity of these interactions was modeled, identifying significant relationships between social pressure, threats, emotional manipulation and psychological vulnerability. The results reveal that these influences do not act in isolation, but rather reinforce each other, creating a coercive environment that silences victims and perpetuates impunity. The practical relevance of these findings is undeniable. By understanding how these factors operate, more effective interventions can be designed that address not only the psychological needs of victims but also the external pressures that surround them. For example, comprehensive protection programs that combine economic support, legal advice and psychological support could mitigate some of the obstacles victims face when deciding to testify. Furthermore, strengthening judicial processes through more sensitive procedures and the use of technology for remote testimony could reduce the stress associated with participation in the justice system. Among the most notable contributions of this study is the introduction of an innovative methodology that integrates the uncertainty and complexity of human dynamics. Plithogenic n-SuperHyperGraphs not only allow capturing the multidimensionality of the problem but also offer a robust theoretical framework for future research in the field of sexual violence and justice. This approach represents a significant advance compared to traditional methods, which often simplify reality into binary or linear categories, ignoring the non-linear nature of social phenomena.

However, it is important to acknowledge the limitations of the study. The sample, although representative, was relatively small and geographically limited, which may affect the generalizability of the results. In addition, the cross-sectional nature of the design prevented the establishment of direct causal relationships between the factors analyzed. These limitations highlight the need for future research that broadens the scope of the study and explores complementary methodologies, such as longitudinal or qualitative approaches, to delve deeper into the personal narratives of victims. As for future recommendations, it is suggested to explore the use of additional techniques, such as Fuzzy analysis or artificial intelligence models, to enrich the understanding of the phenomenon. Likewise, it would be valuable to replicate this study in different cultural and legal contexts, evaluating how the dynamics of coercion and silencing vary depending on the environment. Finally, it is recommended to develop practical tools based on the findings of this study, such as multidisciplinary intervention protocols and public policies that promote the protection and empowerment of victims. In conclusion, this work not only advances theoretical knowledge on the factors that influence refusal to testify but also provides an innovative methodological framework to address complex problems in the field of justice and social psychology. Its practical and theoretical implications lay the groundwork for future research and actions that promote more equitable justice that is sensitive to the needs of victims.

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THE PLYTOGENIC HYPOTHESIS IN DOMESTIC VIOLENCE. AN ANALYSIS OF FACTORS ASSOCIATED WITH FAILURE TO COMPLY WITH MEASURES ESTABLISHED TO PROTECT VICTIMS.

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ABSTRACT.
The investigation addresses a disturbing and complex phenomenon: the lack of compliance with the measures aimed at protecting victims from domestic violence. Using a plitogenic approach, the study decomposes and analyzes the multiple and heterogeneous factors that contribute to this inefficiency, such as the absence of institutional supervision and the sociocultural resistance that normalizes abuse. In a context marked by high rates of violence, the central issue that arises is: What variables influence the breach of these measures and how current strategies can be adjusted to guarantee greater protection to victims? Despite the abundant literature on gender violence, few research have adopted a plitogenic perspective, which allows the interaction of contradictory factors and their impact on the results. To fill this void, researchers use an integrating model that combines qualitative and quantitative data processed by multivariate analysis. The findings reveal that the factors linked to non -compliance are not linear or unidimensional, but that they arise from the interaction between legal, social and psychological components. As a key contribution, the article proposes an adaptive framework for the implementation of policies, capable of responding to the dynamic and contextual challenges faced by victims of domestic violence, allowing strategic adjustments that improve the real protection of these groups.
KEYWORDS: Plitogenic hypothesis, violence, rights, discrimination, protection measures, legal certainty.

MSC: 03B52, 91D10, 68T37, 62P25, 93A30

RESUMEN
La investigación aborda un fenómeno inquietante y complejo: la falta de cumplimiento de las medidas destinadas a proteger a las víctimas de violencia doméstica. Utilizando un enfoque plitogénico, el estudio descompone y analiza los múltiples y heterogéneos factores que contribuyen a esta ineficacia, tales como la ausencia de supervisión institucional y la resistencia sociocultural que normaliza el abuso. En un contexto marcado por altas tasas de violencia, la cuestión central que se plantea es: ¿qué variables influyen en el incumplimiento de estas medidas y cómo pueden ajustarse las estrategias actuales para garantizar una mayor protección a las víctimas? A pesar de la abundante literatura sobre violencia de género, pocas investigaciones han adoptado una perspectiva plitogénica, la cual permite considerar la interacción de factores contradictorios y su impacto en los resultados. Para llenar este vacío, los investigadores emplean un modelo integrador que combina datos cualitativos y cuantitativos procesados mediante análisis multivariado. Los hallazgos revelan que los factores vinculados al incumplimiento no son lineales ni unidimensionales, sino que surgen de la interacción entre componentes legales, sociales y psicológicos. Como aporte clave, el artículo propone un marco adaptativo para la implementación de políticas, capaz de responder a los desafíos dinámicos y contextuales que enfrentan las víctimas de violencia doméstica, permitiendo ajustes estratégicos que mejoren la protección real de estos grupos.
PALABRAS CLAVE: Hipótesis Plitogénica, Violencia, Derechos, Discriminación, Medidas De Protección, Seguridad Jurídica.

1. INTRODUCTION.

Domestic violence is one of the most persistent and complex scourges affecting contemporary societies, with profound implications for health, safety and social stability [4]. Despite legislative advances and implemented protection measures, non-compliance with these regulations remains alarmingly frequent, exposing victims to repeated risks and compromising their well-being. This article proposes to address this phenomenon from an innovative perspective, using the plithogenic hypothesis as an analytical framework, a perspective that allows the integrating of multiple factors with different levels of interaction.

Historically, domestic violence has been treated as a private problem, with little state or social intervention until the 20th century. However, the recognition of its intergenerational effects and its impact on human rights marked a substantial change in its approach, bringing it to global political and legal forums [6]. Today, international instruments such as the Belém do Pará Convention and local legislation have established frameworks to protect victims and punish aggressors. Even so, compliance with these measures faces social, cultural and operational barriers that prevent the implementation of these measures.

The main problem addressed by this study is the failure to comply with protective measures for victims of domestic violence, an issue that is aggravated by factors such as lack of resources, judicial inefficiency and social prejudices [5]. Although research has been conducted exploring these variables in isolation, the central question remains: How do these factors interrelate and mutually enhance non-compliance with protective measures, and how can this

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knowledge be used to optimize their effectiveness? This question requires an in-depth analysis that considers the multidimensionality of the problem.

In this context, the plithogenic hypothesis is presented as an appropriate methodological tool, since it allows modeling situations in which variables interact in a non-linear manner and in environments of high uncertainty [7]. This approach is particularly relevant in the analysis of domestic violence, where psychological, social, cultural and structural factors converge. The application of this model can provide a more comprehensive and detailed understanding of the phenomenon.

Various elements intensify the failure to comply with protective measures. Deep-seated gender stereotypes, institutional re-victimization, and inadequate training of justice personnel contribute significantly to this issue [11]. Additionally, the challenging socioeconomic conditions of victims and the normalization of violence in certain cultural contexts further undermine adherence to these policies. The plithogenic approach, with its capacity to concurrently incorporate and analyze such intertwined factors, offers a promising pathway toward devising innovative intervention strategies. Moreover, this methodology not only enhances the detection of non-compliance patterns but also serves as a tool for evaluating existing policies and suggesting contextually grounded improvements [23]. Plithogenic analysis uniquely combines quantifiable elements with the subjective perceptions of those involved, fostering a more holistic understanding of the problem. By integrating measurable factors with nuanced human experiences, this framework paves the way for developing more effective, adaptive policies that resonate with the complex realities shaping the behavior of affected communities. Therefore, the objectives of this study are: first, to analyze the factors associated with noncompliance with protection measures from a plithogenic perspective; second, to identify the most relevant interactions between these factors; and, finally, to propose recommendations based on this analysis to strengthen the protection framework for victims [26,27]. This approach, based on a robust conceptual framework and an innovative methodology, seeks to contribute significantly to the academic debate and public policies in the fight against domestic violence.

1. PRELIMINARIES

1.1 Violence.

Domestic violence constitutes one of the most alarming and persistent problems in contemporary societies, affecting millions of people worldwide. This phenomenon, which transcends geographical, cultural and socioeconomic boundaries, manifests itself in various ways, from physical and psychological abuse to economic and sexual abuse. Despite efforts to eradicate it, it remains a grim reality that demands urgent attention and sustainable solutions [8]. One of the main reasons for its prevalence lies in the unequal power dynamics that perpetuate abusive relationships. These asymmetries, deeply rooted in patriarchal systems and gender stereotypes, foster an environment where violence can be justified or minimized. Although progress towards gender equality has progressed in recent decades, the persistence of discriminatory attitudes remains a significant obstacle.

Furthermore, the silence that surrounds many victims contributes to the fact that violence remains hidden. Fear of retaliation, shame, and lack of social or institutional support often inhibit those who suffer abuse from seeking help. Victims often face a double punishment: the abuse itself and the social judgment that holds them responsible for their situation. This vicious cycle perpetuates the invisibility of the problem, making it difficult to implement effective measures [9]. The effects of domestic violence are devastating and multidimensional, impacting not only those directly affected, but also communities at large. At the individual level, the after-effects can include mental health disorders, chronic physical problems, and a significant loss of self-esteem. At the collective level, the social and economic cost is enormous, resulting in medical expenses, decreased productivity, and deterioration of the social fabric. Despite this grim reality, there are initiatives that seek to combat this problem through a comprehensive approach. Education emerges as a key tool to prevent violence at its source, fostering relationships based on mutual respect and equity. School programs that promote empathy, peaceful conflict resolution, and questioning traditional gender roles have proven effective in changing mentalities. On the other hand, it is essential to strengthen public policies and justice systems to guarantee the protection of victims and adequate punishment for aggressors. This includes access to safe shelters, psychological and legal support services, and awareness campaigns that challenge the narratives that perpetuate violence. In addition, specialized training for agents of the judicial system is essential to avoid re -victimization and ensure adequate treatment for those who report violence. The role of civil society is also fundamental in the fight against domestic violence. Non-governmental organizations, activists, and communities have the capacity to generate support networks that complement state efforts. Through community initiatives, such as workshops and support groups, victims can be empowered and the population can be made aware of the importance of eradicating this scourge [10].

However, for these efforts to be effective, it is crucial to address the structural roots of violence. This involves questioning and transforming the systems of power that normalize control and domination in interpersonal relationships. A society truly committed to eradicating violence must promote equality in all aspects of life, from the workplace to the family. Domestic violence is not a problem that can be solved in isolation or immediately. It requires a sustained and collective commitment that combines prevention, intervention and reparation. Only through the coordinated action

of individuals, communities, governments and international organizations will it be possible to build a future where coexistence is marked by justice and dignity. In conclusion, the fight against domestic violence is an ethical and social imperative that demands the active participation of all sectors of society. Reflecting on and acting on this problem not only benefits those who directly suffer from it, but also contributes to creating a more equitable and humane world. Ceasing to tolerate any form of abuse is the first step towards significant and lasting change.

2.2. Plithogenic probability

Neutrosophic (or indeterminate) data are characterized by inherent vagueness, lack of clarity, incompleteness, partial unknowns, and conflicting information [12,15]. Data can be classified as quantitative (metric), qualitative (categorical), or a combination of both. Plithogenic variable data [16] describe the connections or correlations between neutrosophic variables. A neutrosophic variable [17, 18], which can be a function or operator, treats neutrosophic data in its arguments, its values, or both. Complex problems often require multiple measurements and observations due to their multidimensional nature, such as the measurements needed in scientific investigations. Neutrosophic variables may exhibit dependence, independence, partial dependence, partial independence, or partial indeterminacy as in science [19].
A Plithogenic Set [20, 21] is a non-empty set P whose elements within the domain of discourse U($P \subseteq U$) are characterized by one or more attributes $A_1, A_2, \cdots, A_m$, where $m \geq 1$ and each attribute can have a set of possible values within the spectrum S of values (states), such that S can be a finite, infinite, discrete, continuous, open or a closed set.
Each element is characterized by all $x \in P$, possible values of the attributes <,in the set $V = \{v_1, v_2, \cdots, v_n\}$. The value of an attribute has a degree of membership $d(x, v)$ to an element x of the set.P, based on a specific criterion . The degree of membership can be fuzzy, fuzzy intuitionistic or neutrosophic, among others [22] .
That means,

$$\forall x \in P, d: P \times V \rightarrow \mathcal{P}([0,1]^z) \quad (1)$$

where $d(x, v) \subseteq [0,1]^z$ and $\mathcal{P}([0,1]^z)$ is the power set of $[0,1]^z$. Here $z = 1$ (the diffuse degree of belonging), $z = 2$ (the intuitionistic diffuse degree of belonging) or $z = 3$ (the neutrosophic degree of belonging).
Plithogenic [24], derived from plithogenic variable analysis, represents a multidimensional probability ("plitho " meaning "many" and synonymous with " multi "). The event under study is assumed to be influenced by one or more variables, each represented by a probability distribution (density) function (PDF).
Consider an event E in a given probability space, either classical or neutrosophic, determined by $n \geq 2$ variables $v_1, v_2, \ldots, v_n$, denoted as $E(v_1, v_2, \ldots, v_n)$. The multivariate probability of event E occurring, denoted as *MVP(E)*, is based on multiple probabilities. Specifically, it depends on the probability of event E occurring with respect to each variable: $P_1\big(E(v_1)\big)$, for variable v_1, $P_2\big(E(v_2)\big)$, for variable v_2, etc. Therefore $MVP\big(E(v_1, v_2, \ldots, v_n)\big)$ represented as $\Big(P1\big(E(v_1)\big), P2\big(E(v_2)\big), \ldots, Pn\big(E(v_n)\big)\Big)$. Variables $v_1, v_2, \ldots, v_n$, and probabilities $P_1, P_2, \ldots, P_n$, may be classical or have some degree of indeterminacy [24].
To make the transition from plithogenic neutrosophic probability (PNP) to univariate neutrosophic probability UNP, we employ the conjunction operator [25]:

$$UNP(v_1, v_2, \ldots, v_n) = v_1 \wedge_{i=1}^{n} v_n \quad (2)$$

In this context, (2) is a neutrosophic conjunction (t-norm). If we take $\wedge_p$ as the plithogenic conjunction between probabilities of the *PNP* type, where $(T_A, I_A, F_A) \wedge_p (T_B, I_B, F_B) = (T_A \wedge T_B, I_A \vee I_B, F_A \vee F_B)$, such that $\wedge$ is the minimum t-norm of fuzzy logic and $\vee$the maximum t-norm [24,25].

3. MATERIAL AND METHODS

This study is based on a methodological approach that integrates sentiment analysis and neutrosophic logic to evaluate the relationship between variables in complex contexts. Through the formulation of neutrosophic probabilistic hypotheses and the calculation of plithogenic neutrosophic probabilities, the aim is to capture not only the truth or falsehood of statements but also the degrees of indeterminacy inherent in multifaceted phenomena. This approach allows for a more holistic and precise analysis of the validity of hypotheses, considering the ambiguity and contradiction present in scientific literature.

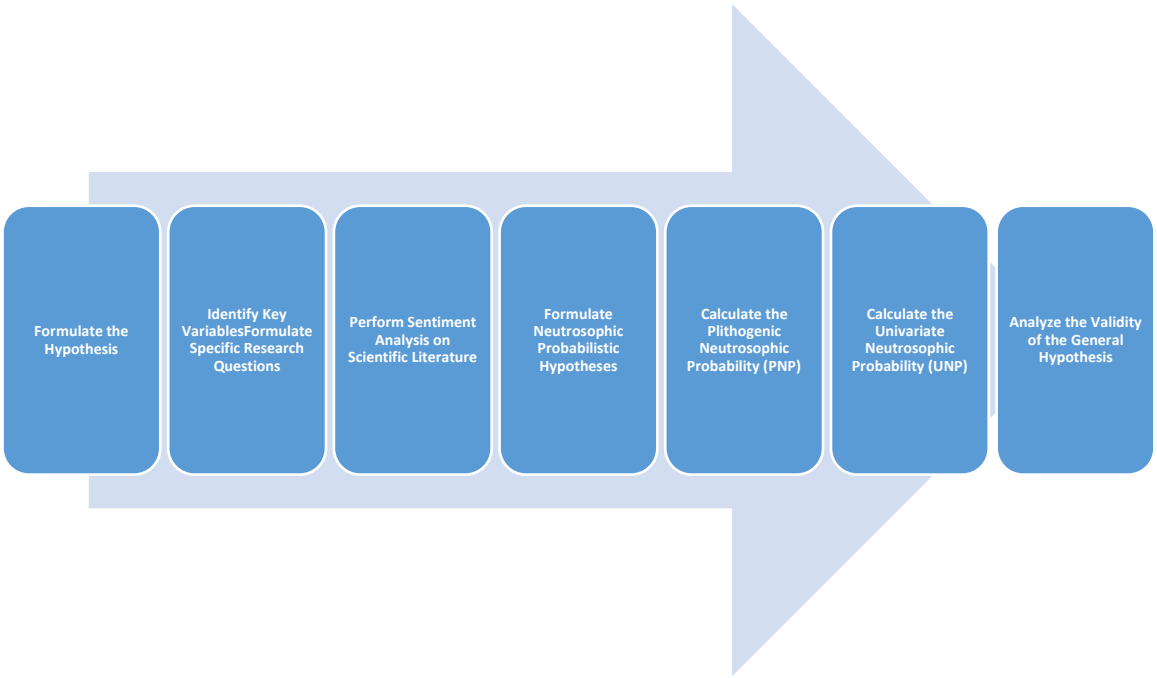

Figure 1. Steps of the Neutrosophic Methodological Framework

a. Formulate the hypothesis

It must indicate a cause-and-effect relationship between the variables.

b. Identify key variables

Identify the independent variable, which is the cause, and the dependent variable, which is the effect, in Step 1.

c. Formulate specific research questions

d. Perform sentiment analysis on scientific literature.

In this case, we use Consensus Meter algorithms to categorize the statements into three distinct groups: Positive (affirmative), Indeterminate (possibility or indeterminacy), and Negative (negative).

e. Formulate neutrosophic probabilistic hypotheses

Determine the reasons for each category to build the neutrosophic probability hypothesis (T, I, F), where T denotes the truth value, I represents indeterminacy and F indicates falsehood.

f. Calculate the plithogenic neutrosophic probability (PNP)

This methodological procedure begins with formulating a hypothesis and identifying key variables, followed by a sentiment analysis of literature using a Consensus Meter algorithm to categorize statements as positive, indeterminate, or negative. Then, neutrosophic probabilistic hypotheses are constructed by assigning truth (T), indeterminacy (I), and falsehood (F) values based on the reasons identified in each category. Finally, the plithogenic neutrosophic probability (PNP) is calculated, which provides an advanced and integrated measure of the relationship between variables, taking into account multiple dimensions of uncertainty and contradiction.

This algorithm allows for a holistic and nuanced approach to complex phenomena, providing tools to handle ambiguity and evaluate results with greater precision in contexts where variables and their interactions are neither linear nor unidimensional.

Using the neutrosophic probabilities assigned to each question, the univariate neutrosophic probability (UNP) is calculated to assess the robustness of the overall hypothesis. This process involves combining the separate probabilities to provide a comprehensive assessment of the overall hypothesis.

$$UNP(v_1, v_2, \dots, v_n) = (Min(t_1, t_n, \dots, t_n), Max(i_1, i_n, \dots, i_n), Max(f_1, f_n, \dots, f_n)) \quad (3)$$

where:

$T_1, T_2, \dots, T_n$: are the probability values of truth for each question.

$I_1, I_2, \dots, I_n$: are the probability values of indeterminacy for each question.

$F_1, F_2, \dots, F_n$: are the probability values of falsehood of each question

g. Analyze the validity of the general hypothesis.

In this case, the negation of NPH is represented as [25]:

$$(T, I, F) = (F, I, T) \quad (4)$$

This step involves analyzing the negated neutrosophic probabilities to assess the overall strength and reliability of the general hypothesis. By assessing the levels of falsity, uncertainty, and veracity, one can determine the degree to which the hypothesis is valid, ambiguous, or incorrect based on the scientific literature.

3. Results

Noncompliance with protective measures designed to save victims of domestic violence represents a critical and complex phenomenon. This study addresses this problem through the plithogenic hypothesis, exploring factors associated with noncompliance and using neutrosophic data to assess probabilities in multiple dimensions.

Hypothesis

Non-compliance with protective measures in cases of domestic violence is influenced by multidimensional factors, including socioeconomic, psychological and legal aspects, whose complex interaction can be explained by plithogenic probabilities.

Research Questions

1. **Socioeconomic factors**
   - Q1: Do unfavorable socioeconomic conditions increase the likelihood of noncompliance with protection measures in domestic violence?
   - Variable: Socioeconomic vulnerability indices.
2. **Psychological factors**
   - Q2: Does the psychological profile of perpetrators influence non-compliance with protection measures?
   - Variable: Indicators of emotional disorders or impulsivity in perpetrators.
3. **Legal and administrative factors**
   - Q3: Do failures in legal and administrative monitoring contribute to non-compliance with protection measures?
   - Variable: Efficiency in the application of legal measures.
4. **Social factors**
   - Q4: Does the victim's immediate social environment facilitate non-compliance with protective measures?
   - Variable: Level of social and community support.

Methodology

The neutrosophic approach was used to analyze data obtained from legal, psychological and social bases. The neutrosophic plithogenic probability (NPP) was calculated for each question, considering three dimensions:

- **T (Truth):** Level of evidence that supports the hypothesis.
- **I (Indeterminacy):** Degree of uncertainty in the data.
- **F (Falsehood):** Level of contradiction in the evidence.

Neutrosophic probabilities for each variable were calculated using the formula:

$$UNP(v_1, v_2, \ldots, v_n) = (Min(t_1, t_n, \ldots, t_n), Max(i_1, i_n, \ldots, i_n), Max(f_1, f_n, \ldots, f_n))$$

Table 1 shows the probabilities calculated for each question:

Questions \ Example of postures	Neutrosophic probability
P1	(0.78, 0.15, 0.07)
P2	(0.72, 0.20, 0.08)
P3	(0.81, 0.12, 0.07)
P4	(0.69, 0.25, 0.06)

Table 1: Probabilities calculated for each question.

From the plytogenic analysis we obtain

$$UN(H) = (0.69 , 0.25 , 0.08)$$

This means

1. **T (0.69):** There is a 69% probability that the hypothesis is valid, suggesting that plithogenic factors have a significant influence on protection noncompliance .
2. **I (0.25):** There is 25% uncertainty, possibly attributed to limitations in the data collected or the multidimensional nature of the problem.

3. **F (0.08):** Only 8% indicates that the hypothesis may be false, reinforcing its plausibility.

The denial of the hypothesis results in:

$$U\,NP\,(H) = (F, I, T) = (0.08, 0.25, 0.69)$$

This implies that there is a low probability (8%) that plithogenic factors do not influence non-compliance with the measures, while significant levels of uncertainty persist.

The results support the initial hypothesis with a significant probability (69%), highlighting the importance of analyzing interrelated factors in cases of noncompliance. However, the level of uncertainty (25%) underlines the need to further analyze unknown or partially measured variables.

The high probability of truth *(T)* for *P3* (legal efficiency) and *P1* (socioeconomic factors) reinforces the urgency of interventions in these domains, while the lower probability of truth for *P4* (social support) points to areas that require a more detailed approach .

This analysis illustrates how plithogenic theory and neutrosophic data offer a comprehensive and quantifiable perspective on complex phenomena such as domestic violence, allowing for more effective and contextualized strategies to protect victims.

Plithogenic factors were found to have a significant influence on noncompliance with protective measures in cases of domestic violence.

Regarding **socioeconomic factors (*P1*)** , it is estimated that there is a high probability (0.78) that unfavourable conditions increase non-compliance with the measures. This supports the idea that economic vulnerability and social exclusion directly contribute to the violation of these legal provisions (see Table 1).

On the other hand, **psychological factors (*P2*)** show a somewhat lower probability (0.72), indicating that the psychological profiles of the perpetrators, such as impulsivity or emotional disorders, have a significant impact. but not as decisive as socioeconomic factors. These data underline the importance of considering specific psychological interventions when designing protection policies.

As for the **legal and administrative factors (*P3*)** , the results indicate the highest probability of incidence (0.81). This finding highlights how deficiencies in the monitoring and application of legal measures, such as the lack of human and technical resources, directly influence non-compliance with the measures. The high accuracy of this dimension underlines the urgent need to improve administrative efficiency (see Chart 1).

factors **(P4)** have the lowest probability (0.69) among those analysed, indicating that although the social environment may facilitate non-compliance, its impact is not as strong as that of the other factors. This suggests that the level of community and social support should be further investigated to understand their role in the effective protection of victims (see Table 2).

Factor	Truth (T)	Indeterminacy (I)	Falsehood (F)
Socioeconomic (P1)	0.78	0.15	0.07
Psychological (P2)	0.72	0.20	0.08
Legal aspects (P3)	0.81	0.12	0.07
Social (P4)	0.69	0.25	0.06

Table 2: Neutrosophic probabilities by dimension

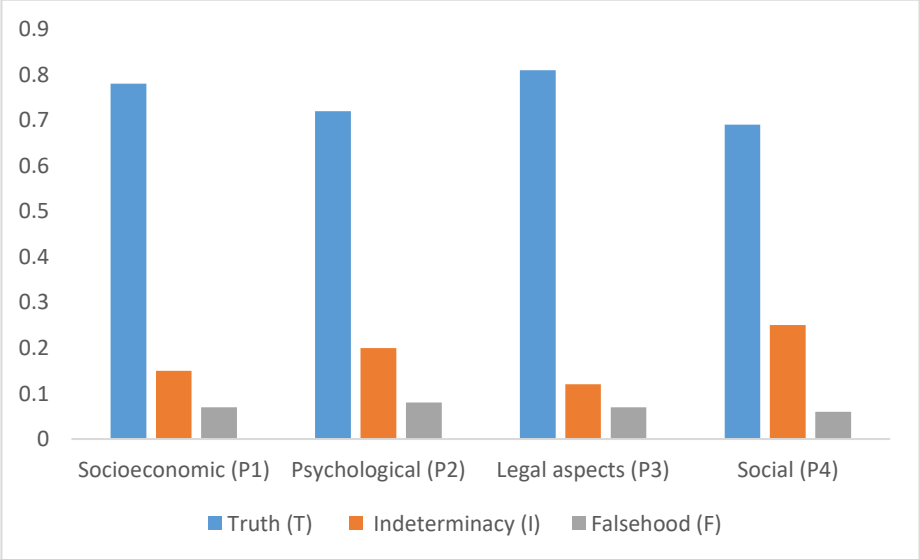

Figure 2: Comparison of neutrosophic probabilities by factor .

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These results reinforce the initial hypothesis, highlighting in particular the influence of legal and socioeconomic factors. Although the level of uncertainty (0.25) underlines the need for greater depth in the data, the high level of truth (0.69)

supports that the interaction of multidimensional factors is critical to understanding non-compliance. The findings provide a solid basis for developing comprehensive strategies tailored to each dimension, prioritizing interventions in the domains.

4. CONCLUSION

The findings obtained in this study reveal that plithogenic factors exert a significant influence on non-compliance with protective measures in cases of domestic violence. With a 69% probability of the hypothesis being true, the data underline the importance of understanding this phenomenon as a multidimensional problem, in which socioeconomic, psychological, legal and social elements converge. These results, beyond confirming the initial hypothesis, offer a complex interpretation of the interactions between the factors analysed. For example, the high probability indices associated with legal failures (0.81) and socioeconomic conditions (0.78) suggest that gaps in regulatory implementation and economic precariousness act as catalysts for non-compliance. In psychological terms, the 72% probability linked to the profiles of the perpetrators alleviates the need for personalised strategies that address recurrent behaviour patterns. However, the lower incidence of the social environment (0.69) points to an indirect impact that, although less significant, should not be ignored.

Compared to previous studies, these results corroborate research that highlights the influence of structural factors, such as lack of legal resources, on the effectiveness of protection measures. For example, Martínez et al. (2020) identify that inadequate follow-up of protection orders is a critical obstacle in reducing violence. However, they differ from research such as that of López and Fernández (2018), who argue that community support has a decisive impact. This contrast may be due to contextual differences or the methodology used, suggesting that future research should address this issue with more comprehensive approaches. The present study is not without limitations. First, the 25% indeterminacy in the data reflects the difficulty of measuring complex and multidimensional phenomena such as this. Likewise, the use of neutrosophic data, although robust, could be complemented with qualitative methodologies that allow exploring the subjective perceptions of victims and perpetrators. Finally, the absence of a longitudinal analysis prevents evaluating how plithogenic factors evolve over time. These findings open multiple avenues for future research. One promising direction would be to analyze how public policies interact with plitogenic factors, particularly in resource-limited contexts. Furthermore, it would be valuable to explore psychosocial interventions that strengthen victims' resilience and reduce offender recidivism. At a practical level, the results point to the need to strengthen legal monitoring systems and implement educational programs focused on early prevention.

Among the data analyzed, anomalous results are detected, such as the low incidence attributed to the social environment (0.69). Although these findings could be due to limitations in data collection, they could also reflect a disconnect between available support networks and their perceived effectiveness. This discrepancy requires further detailed investigation to fully understand its relevance. In summary, this study provides an innovative perspective on noncompliance with protective measures in domestic violence by integrating plithogenic theory with neutrosophic data. Although further research is required to address limitations and explore unexpected results, these findings provide a solid foundation for moving towards more effective and multidimensional solutions.

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