Enhancing Decision-Making in Complex Environments: Integrating AHP, Delphi, and Neutrosophic Logic

Marcia Esther E. Heredia[1], Jorge Washigton S. Andachi[2], Nemis García Arias[3], Saziye Yaman[4,*]

[1] Regional Autonomous University of the Andes Babahoyo, Ecuador
[2] Regional Autonomous University of the Andes Puyo, Ecuador
[3] Regional Autonomous University of the Andes Santo Domingo, Ecuador
[4]Liberal Arts Department, American University of the Middle East, Kuwait
Emails: ub.marciaespania@uniandes.edu.ec; up.jorgewsa99@uniandes.edu.ec; us.nemisgarcia@uniandes.edu.ec; saziye.yaman@aum.edu.kw

Abstract

The integration of the Analytic Hierarchy Process (AHP), the Delphi method, and neutrosophic logic provides a powerful framework for complex decision-making, allowing for an enhanced handling of uncertainties and multiple criteria that characterizes many strategic planning and policy formulation scenarios. AHP's structured approach helps decompose decision-making into manageable sub-problems, while the Delphi method facilitates expert consensus through iterative rounds, enriching the decision-making process with diverse expert insights. The inclusion of neutrosophic logic allows for better representation and processing of uncertainty, offering a flexible way to handle indeterminate and contradictory information. This robust methodology not only improves the precision of decisions but also adapts to the nuanced requirements of multifaceted decision environments. Future research could benefit from integrating these methods with technological advancements like artificial intelligence to automate and optimize the decision-making process further. Applying this integrated approach in various sectors such as healthcare, environmental management, and urban planning could also provide valuable insights into its effectiveness and scalability.

Keywords: Decision-making; Neutrosophic Logic; Analytic Hierarchy Process (AHP); Delphi Method

1. Introduction

The Analytic Hierarchy Process (AHP)[1] and the Delphi[2] method are two pivotal techniques often utilized in complex decision-making scenarios that involve multiple criteria. AHP, developed by Thomas Saaty in 1980, is renowned for its ability to decompose decision-making into a hierarchy of sub-problems, each of which can be analyzed independently. This structured method not only simplifies decision-making by dealing with one aspect at a time but also quantifies subjective assessments of intangible criteria, making it highly effective for integrating multiple aspects such as technical, economic, political, social, and cultural factors.

Incorporating neutrosophic logic into AHP (referred to as NAHP) [3] enhances this model by addressing the indeterminacy inherent in decision-making processes. Neutrosophic sets, characterized by their truth, indeterminacy, and falsehood membership functions, allow for a representation that captures uncertainty and vague information more effectively than traditional methods. This integration is particularly useful in complex and uncertain environments where decisions must cater to diverse and sometimes conflicting criteria [4].

The Delphi method complements this approach by employing iterative rounds of surveys to achieve consensus among a panel of experts, thus refining the quality of inputs used in the NAHP framework. This method systematically gathers and aggregates expert judgments on a subject where there may not be a definitive empirical

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answer, ensuring that the decision-making process is both comprehensive and reflective of collective expert insight[5].

Through the integration of AHP with the Delphi method and the incorporation of neutrosophic logic, this innovative approach provides a robust framework for tackling complex decision-making scenarios. It not only enhances the precision of the process but also accommodates the nuanced and often contradictory information that traditional models might overlook, making it exceptionally suited for strategic planning and policy formulation in multifaceted domains.

2. Preliminaries

2.1 Analytic Hierarchy Process Method

The Analytic Hierarchy Process (AHP) is a methodology widely used to tackle complex decision-making problems that involve multiple criteria [6]. The AHP approach involves creating a hierarchy that mirrors the decision-making process, placing the main goal at the highest level and the available options at the lowest level, with relevant criteria and attributes outlined at intermediate levels.

This technique is especially useful for decisions that necessitate the consideration of technical, economic, political, social, and cultural aspects, offering a scientific method to manage elements that are difficult to quantify. Through its structured approach, which includes element prioritization, pairwise comparisons, weight assignment, and synthesis, the AHP aids in identifying the best alternative based on available resources [7].

Originally proposed by Thomas Saaty in 1980, this method is distinguished by its ability to structure complexity, quantify preferences on a scale, and synthesize the outcomes to aid decision-making [8]. Moreover, the introduction of neutrosophic sets and their application in this context is noted. These sets are characterized by three membership functions: truth, indeterminacy, and falsehood, applicable to both standard and non-standard subsets [9].

The definition of a Single-Valued Neutrosophic Set (SVNS) and the Single-Valued Neutrosophic Number (SVNN) allows for the representation of these elements in a manner where each can be expressed through values reflecting truth, indeterminacy, and falsehood within a determined range. Additionally, the concept of a single-valued neutrosophic trapezoidal number is mentioned, providing a more detailed structure for these sets [10].

This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme. The formulation of the decision-making problem into a hierarchical structure is the first and main stage. This stage is where the decision maker must break down the problem into its relevant components. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next level. In a typical hierarchy, the highest level locates the problem of decision-making [11]. The elements that affect decision-making are represented at the intermediate level, with the criteria occupying these intermediate levels. At the lowest level, the decision options are placed [12]. The levels of importance or weighting of the criteria are estimated through paired comparisons between them. This comparison is carried out using a scale [13], as expressed in equation (1).

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

In the theory of the AHP technique within a neutrosophic framework, one can model the indeterminacy of decision-making by applying neutrosophic AHP, or NAHP for short. Equation 1 contains a generic neutrosophic pairwise comparison matrix for NAHP.

To convert neutrosophic triangular numbers into crisp numbers, two indexes are defined: the so-called score and accuracy indexes, as seen in Equations 2 and 3, respectively.

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

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (3)$$

A widely recognized method for comparing the relative importance of two alternatives involves the Saaty scale. This comparative model approach, wherein alternatives are evaluated across multiple criteria, enhances precision. Priorities are assigned values from 1 to 9, as detailed in Table 1.

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Table 1: displays Saaty's scale translated into a neutrosophic triangular scale. Source:[14].

Numerical	Scale	Neutrosophic Triangular Scale
1	Equally preferred	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Moderately preferred	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly preferred	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly preferred	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Extremely preferred	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2	Equally to moderately preferred	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
4	Moderately to strongly preferred	$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
6	Strongly to very strongly preferred	$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
8	Very strongly to extremely preferred	$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

To apply the AHP methodology among a set of criteria, the following steps are necessary:

1. Identify the criteria to compare.
2. Determine the Comparison Matrix, for pairs of factors, sub-factors, and strategies, using the linguistic terms shown in Table 1.
3. Normalize the comparison matrix by dividing each number by the sum of its column.
4. Calculate the weight of each criterion from the neutrosophic pairwise comparison matrix, transforming it into a deterministic matrix using Equations 9 and 10.
5. Calculate the consistency index.

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

$$\mathrm{CI} = \frac{\lambda_{\max} - \mathrm{n}}{\mathrm{n} - 1} \quad (4)$$

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

$$CR = \frac{CI}{RI} \quad (5)$$

RI is given in Table 2.

Table 2: RI associated with every order. Source: [14]

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

If CR ≤ 0.1, it is considered that the experts' evaluation is sufficiently consistent, and hence, proceeding to use NAHP is feasible. This procedure is applied to matrix "A" in Equation 12.

2.2 Delphi Neutrosophic Method

The composition of the group presented in the expert panel must ensure the necessary heterogeneity and significance to address the subject of the study. For the final selection of experts by the coordination group, the neutrosophic expert competence coefficient (KN) is employed, calculated from the following definition [15]:

Let X be a universe of discourse. A Single-Valued Neutrosophic Set (SVNS) A over X is an object in the form described in the following equation:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (6)$$

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In this coefficient, two factors were averaged, the knowledge coefficient (K_{cn}) and the argumentation coefficient (K_{an}).

$$K_N = \frac{1}{2}(K_{aN} + K_{cN}) \qquad (7)$$

Where, by applying equation (7), it is obtained:

$$K_{aN} = \{\langle x, u_{Ka}(x), r_{Ka}(x), v_{Ka}(x)\rangle : x \in X\} \qquad (8)$$

$$K_{cN} = \{\langle x, u_{Kc}(x), r_{Kn}(x), v_{Kn}(x)\rangle : x \in X\} \qquad (9)$$

The so-called neutrosophic knowledge coefficient is determined by the information that the expert provides about the study subject, determined through a self-assessment process on a scale to establish the knowledge of the analyzed topic and subject of study (see Table 3).

Table 3: Linguistic terms used to determine $K_{aN,}K$ and evaluate the proposed criteria. Source: own elaboration.

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 in the subject of study (GK)	(0.70,0.25,0.30)
Moderately good in the subject of study (MGK)	(0.60,0.35,0.40)
Know the topic of study (K)	(0.50,0.50,0.50)
Moderately poorly knows the subject of study (MPK)	(0.40,0.65,0.60)
Poorly knows the topic of study (PK)	(0.30,0.75,0.70)
Know the topic of study very poorly (VPK)	(0.20,0.85,0.80)
Very very poor knowledge of the topic of study (VVPK)	(0.10,0.90,0.90)
No knowledge of the study topic (NK)	(0,1,1)

The Neutrosophic Argumentation Coefficient evaluates criteria through linguistic terms with Single-Valued Neutrosophic Numbers (SVNN) for the consensus of the expert opinion's substantiation (see Table 3). This is based on the weighted sum of values obtained from a series of influence elements determined by the Coordination Group on the experience gained through activity and practice, knowledge of the state of the matter at national and international levels, intuition about the subject addressed, knowledge about technology, and study of works and publications on the study topic.

The evaluation of the experts' responses is established as an objective criterion of the Neutrosophic Expert Competence Coefficient with a critical level required set by the Coordination Group for a value (A) (see Table 4).

Table 4: Linguistic terms used to determine KCN. Source: [8]

Linguistic term	SVNN
Very High (VH)	(0.9, 0.1, 0.1)
High (H)	(0.75,0.25,0.20)
Medium (M)	(0.50;0.5;0.50)
Low (L)	(0.35,0.75,0.80)

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Very Low (VL)	(0.10,0.90,0.90)

To determine the consensus among the participants of the Expert Panel, the agreement coefficient determined through the expression was used:

$$Cc = \left(1 - \frac{V_n}{V_t}\right)100 \quad (10)$$

For binary questions (yes or no), consensus was considered reached with 75% agreement.

In this work, the application of the method was established in four stages:

Design by the Coordination Group based on the variables identified in the undetermined dimensions in the neutrosophic analysis.

Selection of the Expert Panel.

Interpretation of responses and evaluation of actions.

Interpretation of the responses.

3. Case Study

Experts classified nine factors to evaluate the effectiveness of the Analytic Hierarchy Process (AHP) in the context of the codification and treatment of crimes against humanity.

- Need for a Separate Convention: (NCS)
- Adequacy of Codification: (AC)
- Clarity of Definitions and Norms: (CDN)
- Regulatory Coherence: (CR)
- Theoretical and Legal Foundations: (FTJ)
- Role and Evolution of the ILC: (RE)
- International Participation and Cooperation: (PCI)
- Impact on Human Rights Protection: (IPDH)
- Effectiveness of Legal Responsibility: (ERL)

Using the Neutrosophic AHP method, the weights of the factors acting in the codification and treatment of crimes against humanity are determined.

Table 5: Neutrosophic AHP Pairwise Matrix. Source: own elaboration.

Factors	**AC**	**NCS**	**CDN**	**CR**	**FTJ**	**RE**	**PCI**	**IPDH**	**ERL**
NCS	Equally influential	5	7	5	7	5	7	5	7
AC	1/5	Equally influential	3	5	5	7	5	7	5
CDN	1/7	1/3	Equally influential	3	3	5	5	5	5
CR	1/5	1/5	1/3	Equally influential	1	3	3	3	3
FTJ	1/7	1/5	1/3	1/1	Equally influential	1	3	3	3

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RE	1/5	1/7	1/5	1/3	1/1	Equally influential	1	1	1
PCI	1/7	1/5	1/5	1/3	1/3	1/1	Equally influential	1	1
IPDH	1/5	1/7	1/5	1/3	1/3	1/1	1/1	Equally influential	5
ERL	1/7	1/5	1/5	1/3	1/3	1/1	1/1	1/5	Equally influential

Table 6: Determination of criteria weights using the Neutrosophic AHP method. Source: own elaboration.

Factors	AC	NCS	CDN	CR	FTJ	RE	PCI	IPDH	ERL	WEIGHT
NCS	0,42	0,67	0,56	0,31	0,37	0,20	0,26	0,19	0,23	0,36
AC	0,08	0,13	0,24	0,31	0,26	0,28	0,19	0,27	0,16	0,21
CDN	0,06	0,04	0,08	0,18	0,16	0,20	0,19	0,19	0,16	0,14
CR	0,08	0,03	0,03	0,06	0,05	0,12	0,11	0,11	0,10	0,08
FTJ	0,06	0,03	0,03	0,06	0,05	0,04	0,11	0,11	0,10	0,07
RE	0,08	0,02	0,02	0,02	0,05	0,04	0,04	0,04	0,03	0,04
PCI	0,06	0,03	0,02	0,02	0,02	0,04	0,04	0,04	0,03	0,03
IPDH	0,08	0,02	0,02	0,02	0,02	0,04	0,04	0,04	0,16	0,05
ERL	0,06	0,03	0,02	0,02	0,02	0,04	0,04	0,01	0,03	0,03

Table 7: Analysis of the consistency of the paired matrix. Source: own elaboration.

Factors	|	Approximate eigenvalues
NCS	4.11	11.53051666
AC	2.33	10.89193966
CDN	1.43	10.14890395
CR	0.74	9.650934083
FTJ	0.65	9.889946348
RE	0.37	9.741562706
PCI	0.32	9.799366333
IPDH	0.44	9.105433668
ERL	0.28	9.682770364
Eigenvalue - 10.049042		

From the consistency analysis, it is determined that the modeling meets the parameters, obtaining that its eigenvalue is 6.40, CI=0.13, and CR=0.09. It is considered that the values represent the relative importance (weights) of different factors evaluated through the AHP method developed by Saaty and that the final weights reflect their relative importance in the final decision. Therefore, NCS has the highest weight with 0.36, indicating that it is the most important factor in decision-making. AC follows with a weight of 0.21, suggesting that a separate convention is also significant, but to a lesser extent than AC.

The Clarity of Definitions and Norms weighs 0.14, reflecting moderate importance. CR and FTJ have weights of 0.08 and 0.07 respectively, indicating a relatively low importance. This can be interpreted as though these factors affect decision-making, they are less priority than AC, NCS, and CDN. RE, PCI, IPDH, and ERL have the lowest weights (0.04, 0.03, 0.05, and 0.03 respectively), suggesting that these factors are the least critical in this analysis.

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This indicates that while these aspects are considered, they have a lesser direct influence on strategic decision-making compared to other factors. Therefore, the most relevant criteria are:

1. Need for a Separate Convention: (NCS)
2. Adequacy of Codification: (AC)
3. Clarity of Definitions and Norms: (CDN)
4. Regulatory Coherence: (CR)
5. Theoretical and Legal Foundations: (FTJ)

To model the Delphi method, especially in complex contexts such as the development of international regulations or the drafting of standards in technical and legal fields, the following strategies based on the mentioned criteria are considered:

- Development of a clear framework for the convention: Considering the "Need for a Separate Convention," it is necessary to identify and reach consensus on specific areas that require detailed attention and separate codification. This involves determining the boundaries and scope of such a convention, ensuring that it addresses needs identified and articulated by experts (a).
- Establishment of a Multidisciplinary Expert Panel: Given the criterion of "Adequacy of Codification," selecting a diverse group of experts who possess not only legal knowledge but also experience in areas relevant to the codification at hand is crucial. This ensures a broad and appropriate vision in the drafting of codifications or conventions that are integrally fair and applicable (b).
- Definition and standardization of key terms: In response to "Clarity of Definitions and Standards," the strategy should clarify and reach a consensus on definitions of key terms and regulations. This facilitates a uniform understanding and reduces ambiguities in future interpretations (c).
- Evaluation and harmonization of existing regulations: Given the importance of "Regulatory Coherence," discrepancies between existing regulations and proposals should be identified. The goal would be to harmonize the new codifications with the existing legal and regulatory framework and promote cohesive integration that strengthens the international legal system without generating normative conflicts (d).
- Validation of theoretical and legal foundations: To ensure that new norms or codifications are based on solid "Theoretical and Legal Foundations," the theoretical and legal principles underpinning the proposals can be validated. This involves critically reviewing the legal and theoretical basis and ensuring that the recommendations are well-founded and defensible from an international legal perspective (e).

The selected strategies will be used, and a questionnaire will be sent to the experts, following a structured approach. The Delphi process is characterized by being iterative, anonymous, and controlled, to reach consensus among experts on a specific topic. Below are the steps for implementing this method based on the mentioned strategies:

Step 1: Expert Selection

- A set of 9 specialists with a diversity of knowledge and experiences relevant to the topic of interest is chosen, including jurists, academics specialized in international law, experts with backgrounds in crimes against humanity, specialists in law formulation, and other relevant professionals. To appropriately select these specialists, the Neutrosophic Argumentation Coefficient is used, which is based on the evaluation of the solidity of the experts' opinions through a weighted aggregation of values obtained from various Influence Factors.

- These factors are defined by the Coordination Group and include the professional and practical experience of the expert, their knowledge of the current situation both nationally and internationally, in addition to their intuition capacity related to the topic under discussion, as well as their familiarity with technology, and their contribution to the literature and studies relevant to the matter.

Step 2: Design of the Initial Questionnaire

- The initial questionnaire should be designed to explore the key areas identified in the strategies, with open-ended questions to allow for detailed responses and specific suggestions. This should include:

1. What are the main strategies you identify in the context of the codification and treatment of crimes against humanity?

2. Based on your experience, how would you assess the relative frequency of the current strategies implemented?

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3. Which strategy do you consider the most effective?
4. From your perspective, do you think the strategies are useful for overcoming current challenges?

Step 3: Distribution and Collection of Responses

- Send the questionnaire to the selected experts and ensure anonymity to promote honesty and avoid biases in the responses. Establish a clear deadline for the return of the responses.

Step 4: Analysis of Responses and Preparation for the Second Round

- Analyze the responses to identify areas of consensus and discrepancy. Prepare a summary of the responses and include statistics when possible (for example, level of agreement with each statement) and a second questionnaire based on the results. This second questionnaire should focus on areas where consensus was not reached and ask the experts to reconsider their responses in the context of the group's general responses.

Table 8. Validation of the criteria. Source: own elaboration.

Expert	a	b	c	d	e
E1	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.10;0.90;0.90)	I
E2	(0.75;0.25;0.20)	(0.9;0.1;0.1)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.9;0.1;0.1)
E3	(0.9;0.1;0.1)	I	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.75;0.25;0.20)
E4	(0.75;0.25;0.20)	(0.9;0.1;0.1)	(0.75;0.25;0.20)	(0.75;0.25;0.20)	(0.75;0.25;0.20)
E5	(0.35;0.75;0.80)	(0.75;0.25;0.20)	(0.10;0.90;0.90)	(0.75;0.25;0.20)	(0.35;0.75;0.80)
E6	(0.35;0.75;0.80)	(0.9;0.1;0.1)	I	(0.9;0.1;0.1)	(0.75;0.25;0.20)
E7	(0.10;0.90;0.90)	(0.10;0.90;0.90)	(0.35;0.75;0.80)	(0.35;0.75;0.80)	(0.10;0.90;0.90)
E8	(0.10;0.90;0.90)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.9;0.1;0.1)	(0.35;0.75;0.80)
E9	(0.9;0.1;0.1)	(0.75;0.25;0.20)	(0.75;0.25;0.20)	(0.75;0.25;0.20)	I

According to the evaluation given by the experts, strategies b, c, and e each show a level of indeterminacy.

Table 9: Relative frequency. Source: own elaboration.

Indicators	Very high	High	Medium	Low	Very Low
a	0.2222	0.4444	0.4444	0.7778	1,0000
b	0.4444	0.6667	0.7778	0.8889	1,0000
c	0.1111	0.3333	0.4444	0.6667	1,0000
d	0.2222	0.5556	0.5556	0.8889	1,0000
e	0.1111	0.4444	0.6667	0.8889	1,0000

Table 10: Calculation of cut points. Source: own elaboration.

Indicators	Very high	High	Medium	Low	Very Low
a	-0.76	-0.14	-0.14	0.76	3.50
b	-0.14	0.43	0.76	1.22	3.50
c	-1.22	-0.43	-0.14	0.43	3.50
d	-0.76	0.14	0.14	1.22	3.50
e	-1.22	-0.14	0.43	1.22	3.50

Table 11: Scale of neutrosophic indicators. Source: own elaboration.

Indicators	Average	N - Avg.	SVNN
a	0.64	**-0.95**	(0.35;0.75;0.80)
b	1.15	**-1.46**	(0.75;0.25;0.20)
c	0.43	**-0.74**	(0.35;0.75;0.80)
d	0.85	**-1.16**	(0.35;0.75;0.80)

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e	0.76	**-1.07**	(0.35;0.75;0.80)
	-0.31	**=N**	
	N =	**-0.31**	

Table 12: Expert validation. Source: own elaboration.

Expert	**C1**	**C2**	**C3**	**C4**	**C5**
E1	YES	YES	YES	YES	YES
E2	YES	YES	YES	YES	YES
E3	YES	YES	YES	NO	YES
E4	YES	NO	YES	YES	YES
E5	YES	YES	YES	YES	YES
E6	YES	YES	YES	YES	YES
E7	NO	YES	YES	YES	YES
E8	YES	YES	YES	YES	YES
E9	YES	YES	YES	YES	YES
YES	8	8	9	8	9
NO	1	1	0	1	0
Coefficient	88.89	88.89	100	88.89	100

From the results it is clear that in all cases a consensus was reached; therefore, a second round was not necessary.

5. Conclusion

The integration of the Analytic Hierarchy Process (AHP) with the Delphi method and neutrosophic logic has proven to be a robust framework for complex decision-making scenarios, enhancing both the precision and adaptability of traditional decision-making models. Through this integration, decision-makers can better handle the indeterminacies and uncertainties prevalent in multi-criteria decision environments, such as those involving socio-economic and technical assessments. The structured approach of AHP, combined with the iterative consensus-building process of the Delphi method and the flexibility of neutrosophic logic, allows for a comprehensive evaluation and synthesis of expert opinions, leading to more informed and nuanced decisions.

Looking to the future, further research could explore the integration of these methodologies with advanced computational tools like artificial intelligence and machine learning. These technologies could automate and refine the processes of data collection, analysis, and synthesis, thus speeding up decision cycles and enhancing the accuracy of predictions. Additionally, extending this integrated approach to other fields such as environmental management, healthcare, and urban planning could prove beneficial. Testing and adapting the framework in these diverse contexts could provide deeper insights into its applicability and limitations, paving the way for more resilient and adaptive decision-making structures across various domains.

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