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Neutrosophic Analysis of the Right to Housing

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

Keywords: housing, AHP, TOPSIS, Neutrosophy.

1 Introduction

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

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

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

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

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

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

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

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

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

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

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

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

2 Neutrosophic Methods

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

Definition 2: The Single-Valued Neutrosophic Set (SVNS) N over U is $A = (< x;\ TA(x), IA(x), FA(x) > : x \in U)$, where $TA: U \to [0,1], IA: U \to [0,1]$, and $FA: U \to [0,1]$, $0 \le TA(x) + IA(x) + FA(x) \le 3$. The Single-Valued Neutrosophic Number (SVNN) is represented by $N = (t, I, f), such\ that\ 0 \le t, I, f \le 1\ and\ 0 \le t + I + f \le 3$

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:

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

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

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

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

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

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

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

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

Multiplication by a scalar number:

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

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

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

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

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

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

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

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

Saaty's scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

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

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

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

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

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

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

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

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

- Step 5: Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix:

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

2. Take the total of the row averages.

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

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

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

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

RI is given in Table 2.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Where S(A) ∈ [-1, 1]

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

Linguistic term	**SVNN**
Extremely good (EG)	(1,0,0)
Very Very good (VVG)	(0.9, 0.1, 0.1)
Very good (VG)	(0.8,0,15,0.20)
Good (G)	(0.70,0.25,0.30)
Fairly good (FG)	(0.60,0.35,0.40)
Medium (M)	(0.50,0.50,0.50)
Fairly Bad (FB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very bad (VB)	(0.20,0.85,0.80)
Very Very bad (VVB)	(0.10,0.90,0.90)
Extremely bad (EB)	(0,1,1)

Table 4: Linguistic terms used. Source: own elaboration.

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

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

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

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

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

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

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

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

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

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

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

Denotes the positive ideal solution, corresponding to G1.

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

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

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

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

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

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

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

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

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

$$\tilde{\rho_J} = \frac{s^-}{s^+ + s^-} \quad (28)$$

Where $0 \le \tilde{\rho_J} \le 1$

Step 8: Determination of the order of the alternatives.

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

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

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

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

3 Results

Once the different approaches in the introduction of the document have been analyzed, the aforementioned techniques are applied. For the data in the modeling, surveys were applied to the experts to determine the criteria to be evaluated and the state obligations regarding the right to housing. For them, the resulting table is presented with the weights after having made the binary comparison matrix of the AHP Saaty (see Tables 6 to 9).

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

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

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

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

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

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

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

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

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

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

3.1 TOPSIS

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

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

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

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

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

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

Strategic success evaluation criteria: 3

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

Expert groups: 5 groups of 12 (total 60)

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

4. Group of experts in university assessment and assessment

Determine the weight:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Conclusion

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

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

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

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

References

[1] I. Turok and A. Scheba. (2019) ‘Right to the city’ and the New Urban Agenda: learning from the right to housing. Territory, Politics, Governance. 494-510.
[2] R. Baušys, B. Juodagalvienė, R. Žiūrienė, I. Pankrašovaitė, J. Kamarauskas, A. Usovaitė, et al., "The residence plot selection model for family house in Vilnius by neutrosophic WASPAS method," International Journal of Strategic Property Management, vol. 24, pp. 182-196, 2020.
[3] R. Disney and G. Luo, "The Right to Buy public housing in Britain: A welfare analysis," Journal of Housing Economics, vol. 35, pp. 51-68, 2017/03/01/ 2017.
[4] E. K. Zavadskas, R. Bausys, B. Juodagalviene, and I. Garnyte-Sapranaviciene, "Model for residential house element and material selection by neutrosophic MULTIMOORA method," Engineering Applications of Artificial Intelligence, vol. 64, pp. 315-324, 2017.
[5] R. Baušys, B. Juodagalvienė, R. Žiūrienė, I. Pankrašovaitė, J. Kamarauskas, A. Usovaitė, et al., The residence plot selection model for family house in Vilnius by neutrosophic WASPAS method: Infinite Study, 2020.
[6] E. K. Zavadskas, R. Bausys, A. Kaklauskas, I. Ubarte, Kuzmin-, A. ske, &, et al., "Sustainable market valuation of buildings by the single-valued neutrosophic MAMVA method. ," Applied Soft Computing, vol. 57, pp. 74-87, 2017b.
[7] A. Karaşan, E. Bolturk, and C. Kahraman, "An integrated interval-valued neutrosophic AHP and TOPSIS methodology for sustainable cities’ challenges," in International Conference on Intelligent and Fuzzy Systems, 2019, pp. 653-661.
[8] J. E. Ricardo, Z. M. M. Rosado, E. K. C. Pataron, and V. Y. V. Vargas. (2021) Measuring Legal and Socioeconomic Effect of the Declared Debtors Using The AHP Technique in a Neutrosophic Framework Neutrosophic Sets and Systems, . 357-366. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85116161925&partnerID=40&md5=948dae6f450340530ee8e2095525636b
[9] M. Abdel-Basset, M. Mohamed, and F. Smarandache, "An Extension of Neutrosophic AHP-SWOT Analysis for Strategic Planning and Decision-Making," Symmetry, vol. 10, p. 116, 2018.
[10] R. G. Ortega, M. L. Vázquez, J. A. S. Figueredo, &, and A. Guijarro-Rodriguez. (2018) Sinos river basin social-environmental prospective assessment of water quality management using fuzzy cognitive maps and neutrosophic AHP-TOPSIS. Neutrosophic Sets and Systems. 160–171. Available: http://fs.unm.edu/NSS2/index.php/111/article/view/408
[11] F. X. Poveda Paredes, K. J. Toctaquiza Cumbicos, & M. J. Goyes Baca. “Efectos adversos de la ivermectina en pacientes con Sars-Cov-2”. Universidad y Sociedad, Vol. 14 Num. S2, pp- 479-487, 2022.
[12] S. A. Montecé Giler, & L. A. Montecé Giler. “Tipos de normas que regulan la sociedad”. Universidad y Sociedad, Vol. 14 Num.S2, pp- 471-478, 2022.
[13] J. E. Jami Carrera, & A. A. Monsalve Guamán. “Efluvio telógeno como secuela de Covid-19”. Universidad y Sociedad, Vol. 14 Num. S2, pp- 465-470, 2022.
[14] P. E. Salas Medina, & M. E. Orozco Manobanda. “Análisis de las dificultades en el proceso de implementación de protocolos de bioseguridad para reapertura de establecimientos turísticos en Tungurahua post Covid-19”. Universidad y Sociedad, Vol. 14 Num.S2, pp- 456-464, 2022
[15] M. R. Aguilar Martínez, D. P. Gordillo Cevallos, J. A. Paredes López & G.P. León Burgos. “La aplicación de los principios procesales en la justicia electoral”. Universidad y Sociedad, Vol. 14 Num. S2, pp- 450-455, 2022.
[16] A R. Soria Acosta, & Y. C. Hernández Zambrano. “Claves de emergencia obstétrica en la hemorragia post parto”. Universidad y Sociedad, Vol. 14 Num. S2, pp- 445-449, 2022.
[17] M. M Vidal del Río, & A. A. Monsalve Guamán. “La equinococosis canina, una zoonosis de importancia”. Universidad y Sociedad, Vol. 14 Num. S2, pp- 440-444, 2022.
[18] Álvarez Gómez, G. A., Viteri Moya, J. R., Viteri Intriago, D. A., & Estupiñán Ricardo, J. “Integración de los procesos sustantivos para la mejora de la calidad del aprendizaje”. Conrado, vol. 17 no. 80, pp 21-27, 2021.
[19] Vega Falcón, V., Alarcón Quinapanta, M., Yancha Villacís, M., & Estupiñán Ricardo, J. Medición del capital intelectual: Caso hotelero. Dilemas Contemporáneos: Educación, Política y Valores, no. 96, pp 1-19, 2019.
[20] von Feigenblatt, O. F., & Linstroth, J. P. “Applied history and the teaching of leadership: a case for the use of historical case studies in leadership programs”. Universidad y Sociedad, vol. 14 no. S3, pp 433-438, 2022

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