



Evaluation of the Effectiveness in the National Social Rehabilitation System using Neutrosophy and Compensatory Operators

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Abstract. Deprivation of liberty is a mechanism used by the State to reduce unlawful conduct and preserve a peaceful coexistence among its inhabitants. Having a transparent, equitable, and egalitarian administration of justice is essential when a person violates peace and harmony. The effectiveness of this system lies in need to synergistically achieve efficiency and effectiveness in both the bureaucracy and the actions inherent to it. Failures today affect the remarkable work in the Social Rehabilitation Centers, which violates the inherent rights of adults in conflict. The situation was modeled with compensatory fuzzy logic using the single value neutrosophic numbers to deal with uncertainty, which led to the analysis of the results and strategies to mitigate the situation. The main problems lie at the management level of the system that does not achieve the execution of concrete actions in the Rehabilitation Centers, so it is not effective or efficient. It is suggested as main strategies of action: exhaustive training of the personnel and modifying the legislation that propitiates the imperative mode for this problem.

Keywords: Fuzzy Compensatory Logic, Neutrosophy, National Social Rehabilitation System, Rehabilitation Centers.

1 Prior Knowledge

Deprivation of liberty is a mechanism used by the State to reduce unlawful conduct and preserve a peaceful coexistence among its inhabitants. Similarly, having a transparent, equitable, and egalitarian administration of justice is essential when a person violates peace and harmony. However, this imperatively guarantees the initiation of a criminal process that will culminate in a sanction for committing a typical, unlawful and guilty action classified as a criminal offense [1].

This implies a probability of a custodial sanction towards the convicted person. To serve this sanction, there are Social Rehabilitation Centers under the provisions of Art. 772 numeral 12. It indicates that the Ecuadorian National Social Rehabilitation System in these centers will rule custody. This is why it is considered the initial cell of the rehabilitation process to achieve complete reintegration into society and family, thus embodying the purpose of the mentioned system contained in Art. 2013 of our fundamental regulation [1-12].

Social Rehabilitation Centers have been classified as places with an unsafe future where intimidation and corruption converge under the protection of the law of the strongest. A situation that has changed over the years with the progressive application of the Treatment Axes. Currently, people who have been convicted, while serving their sentence, have the opportunity to be beneficiaries of different treatment axes contemplated in the Integral Organic Penal Code (IOPC) that expressly classifies as the procedures given to the persons deprived of liberty to rehabilitate and reintegrate them socially. The development of each of these treatments is determined in the regulations of the National Social Rehabilitation System, which are shown in Figures 1 and 2.

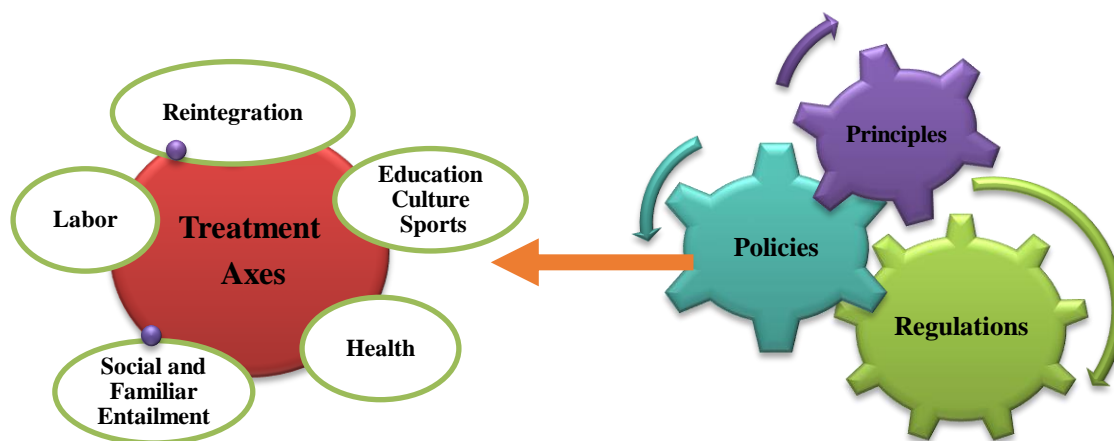


Figure 1: National Social Rehabilitation System. Source: own elaboration

The above stated ideally ensures that the convicted person:

- ✓ Learn or improve activities that will be useful later in his life in freedom.
- ✓ Maybe a beneficiary of the progressivity system contemplated in Article 695 of the Integral Organic Penal Code

The effectiveness of this system lies in the need to achieve synergistically the efficiency and effectiveness in both the bureaucracy and the actions inherent to it as illustrated in figure 2. Failures that exist today affect the remarkable work in the Social Rehabilitation Centers.

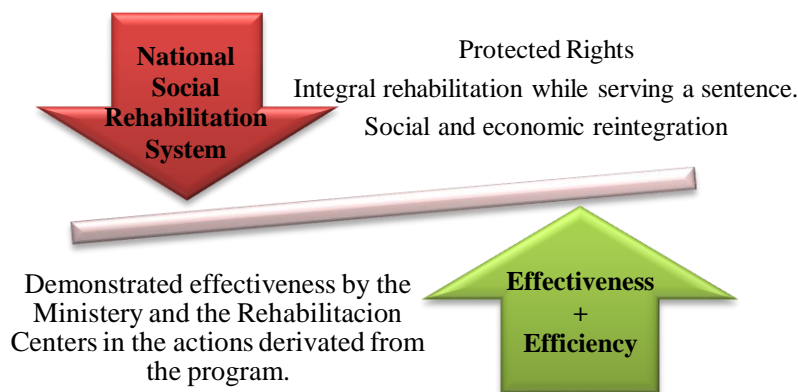


Figure 2: Guarantees for the correct application of the National Social Rehabilitation System. Source: own elaboration

The lack of application of the provisions of Article 701 of the IOPC [4, 13-15] violates the inherent rights of adults in conflict. This is mainly caused because the system is created on the idea that it is optional and not imperative. It is then considered that, to guarantee the effectiveness and efficiency of the system:

- ✓ For the effectiveness of its regulations, principles, policies, and axes, it does not comply with the results for which they were designed.
- ✓ The treatment axes by the Ministry of Justice, Human Rights, and Worship must be effectively complied with. This Ministry is the only State entity having the administrative and political force necessary to exercise imperative control in all the Social Rehabilitation centers of the country, places where the social reintegration of people deprived of liberty is put into practice. Those are the administrative and judicial errors that concur in the processing of penitentiary guarantees cases, but mainly the voluntary nature of the application of treatment axes in an integral rehabilitation system.

Hence the importance of a study of this matter and above all to understand the methods and their impact on the change of the social rehabilitation regime in Ecuador. That is why the previously mentioned is proposed as the objective of this work. To achieve it, we will take advantage of the benefits of mathematical modeling offered by

Compensatory Fuzzy Logic and Neutrosophy [16]. In the following section, we will expose the essential notions for the achievement of the objective.

2. Materials and methods

2.1 Compensatory Fuzzy Logic (CFL)

It is a branch of Fuzzy Logic created by the multidisciplinary scientific group Business Management in Uncertainty: Research and Services (GEMINIS) of the José Antonio Echeverría Higher Polytechnic Institute (ISPJAE), in Havana, Cuba. Dr. Rafael Espín Andrade, professor of the ISPJAE, is one of its most representative researchers. In general, it can be said that it is a new multivalent system that breaks with the traditional axiomatic to achieve semantically better behavior than the classic ones [17-29]. According to the bibliography consulted, we may highlight the precepts listed below:

- ✓ In the processes that require decision making, it involves compound predicates [20]. The truth-values obtained on these compound predicates must have sensitivity to changes in the truth-values of the basic predicates. A predicate is a function of the universe X in the interval $[0,1]$, and the operations of conjunction, disjunction, negation, and implication are defined in such a way that when they are restricted to the domain [30-35] the Boolean Logic is obtained [19].
- ✓ It discards compliance with the classical properties of conjunction and disjunction. This notion makes the FCL a sensible logic [17].
- ✓ It is flexible and tolerant of imprecision, making it possible to model natural language expressions, promoting the use of complete sentences rather than simple linguistic variables to take advantage of the knowledge accumulated by experts following the notion of Knowledge Engineering [21]. It is compatible with the branches of mathematics related to decision-making by taking human language, formed by interrogative, imperative, and declarative phrases, which in many cases present a degree of truthfulness. Vagueness and uncertainty are the objects of its modeling.
- ✓ It uses mathematical operators that guarantee the effective combination of intangible elements assessed by experts, considering categorical scales of veracity, with quantitative information, which provides truth values through conveniently defined predicates based on such information:

| Operators | Predicate logic |
|---------------------------|--------------------|
| Conjunction | (And), c, \wedge |
| Disjunction | (or), d, \vee |
| Fuzzy strict order | (o) |
| Denial | (not) |

Table 1. Presentation of the mathematical operators in FCL predicate logic.

It goes from $[0,1]^n$ to $[0,1]$, or go from $[0,1]^2$ to $[0,1]$ and n to $[0,1]$ [20]. Which satisfies the following axioms:

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

According to [21], the use of sigmoidal membership functions for increasing or decreasing functions is recommended for modeling vagueness. This is also achieved through linguistic variables, which makes it possible to take advantage of the knowledge of the experts. These linguistic variables are based on scales such as the one shown in table 2 [17].

2.2 Neutrosophy

The theory of Neutrosophy proposed by Florentin Smarandache, for the treatment of neutralities, generalizes clear and fuzzy set theories, where indeterminacies have support. It is a useful theory that is increasing the number of its applications in many fields. In this case, the inclusion of this theory enriches the possibilities of the analysis by complementing the values shown in table 2 [31]. This is mainly due to two issues: first, the addition of the notion of indeterminacy and, secondly, the possibility of calculating using linguistic terms [30-36]. For this reason, it was decided to opt for a fusion of both techniques and carry out the study using the neutrosophic CFL. Firstly, let us formally expose neutrosophic logic's original definition as shown in [34, 37-40].

Definition 1. Let $N = \{(T, I, F): T, I, F \in [0,1]\}$ [41] be a neutrosophic set of evaluation. $v: P \rightarrow N$ is a mapping

of a group of propositional formulas into N, ie, each sentence $p \in$ is associated to a value in N, as it is exposed in Equation 1, meaning that p is T true, I indeterminate, and F false.

$$v(p) = (T, I, F) \tag{1}$$

Hence, the neutrosophic logic is a generalization of fuzzy logic, based on the concept of Neutrosophy according to [31, 42].

Definition 2. Be X a universe of discourse. Three membership functions characterize a Neutrosophic Set (NS), $u_A(x), r_A(x), v_A(x) : X \rightarrow]^{-0}, 1^+[$ that satisfy the condition $-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3+$ for all $x \in X$. $u_A(x), r_A(x) \vee v_A(x)$ denote the membership functions of true, indeterminate, and false of x in A, respectively, and their images are standard or non-standard subsets of $]^{-0}, 1^+[$.

Definition 3. Be X a universe of discourse. A Neutrosophic Set of Unique Value (CNVU) A on X is an object of the form: $A = \{(x, u_A(x), r_A(x), v_A(x)) : x \in X\}$ 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 $x \in X$. $u_A(x), r_A(x) \vee v_A(x)$ denote the membership functions of true, indeterminate, and false of x in A, respectively. For convenience, a Neutrosophic Unique Value Number (SVNN) will be expressed as $A = (a, b, c)$, where a, b, c $[0,1]$ and satisfies $0 \leq a + b + c \leq 3$.

In this article, linguistic terms will be associated with SVNN so that experts can carry out their assessments in linguistic terms, which is more natural. Therefore, the scales shown in table 2 will be taken into account. [42].

| Category | SVNN |
|----------------------|------------------|
| False | (0,1,1) |
| Almost false | (0.10,0.90,0.90) |
| Quite false | (0.20,0.85,0.80) |
| Somewhat false | (0.30,0.75,0.70) |
| More false than true | (0.40,0.65,0.60) |
| As true as false | (0.50,0.50,0.50) |
| More true than false | (0.60,0.35,0.40) |
| Somewhat real | (0.70,0.25,0.30) |
| Pretty true | (0.8,0.15,0.20) |
| Almost true | (0.9, 0.1, 0.1) |
| True | (1,0,0) |

Table 2: Evolution of the magnitude of variables from linguistic fuzzy to neutrosophic ones

To convert neutrosophic numbers into crisp numbers, see Equation 2:

$$s(V) = T - F - I \tag{2}$$

2.3 Calculation of statistical coefficients

The concordance (Cc) coefficient is used to determine the degree of consensus of the experts on the subject. For this, equation 3 will be used.

$$Cc = (1 - \frac{Vn}{Vt}) * 100 \tag{3}$$

Where:

Vn: Number of experts against the prevailing criterion.

Vt: Total number of experts.

It is empirically considered that if $Cc \geq 75\%$ then the agreement is acceptable. The components that obtain Cc values $< 75\%$ are eliminated due to low agreement or little consensus among the experts. [44].

The coefficient of variation (Cv) of the predicates will be calculated using equation 4 applying statistical decision criteria according to the following parameters:

Yes $Cv \geq 0.20$, take the modal value (assessment given by the experts that are repeated the most in the analyzed range)

If $Cv < 0.20$, take the value of the arithmetic mean (average score of the experts)

$$Cv = \frac{S}{X_{med}} \tag{4}$$

S: Standard deviation of the data

Xmed: Average of the data

Summarizing the following is the working algorithm to follow once the experts have been determined.

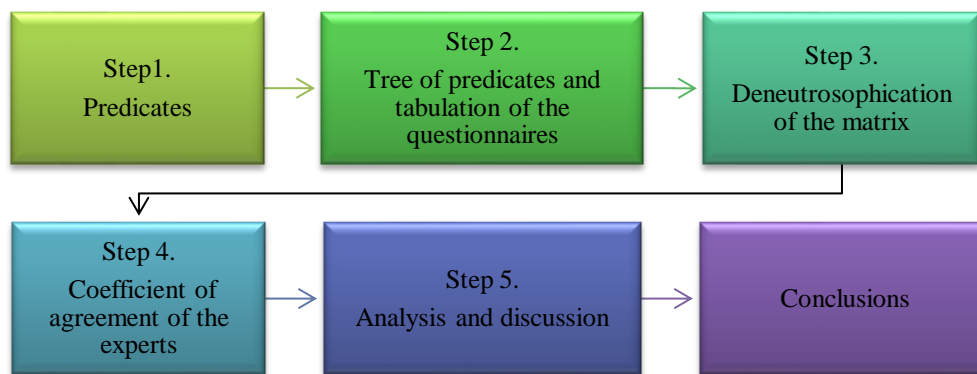


Figure 3: Work algorithm.

For the design and application of the questionnaires, the predicates and their functions were first stated.

3 Results

Experts were selected according to their skills, motivation, and experience required during the exercise of the application of the National Social Rehabilitation System (NSRS) from each of their positions. Then, questionnaires were applied to determine the evaluation of agreement (applying the linguistic scale defined in table 2) to each of the predicates. Finally, seven groups of experts were selected according to the place and profession where the exercise was applied.

Step 1. Predicates

The Prior Knowledge section of this paper was taken into consideration, where we exposed the important notions that characterize the Ecuadorian National Social Rehabilitation System.

Simple predicates:

1. **CL (x)**: "The Social Rehabilitation Center effectively complies with the activities inherent to the Labor Treatment Axis"
2. **CR (x)**: "The Social Rehabilitation Center effectively fulfills the activities inherent to the Reintegration Treatment Axis"
3. **CECD (x)**: "The Social Rehabilitation Center effectively fulfills the activities inherent to the Education, Culture and Sports Treatment Axis"
4. **CVFS (x)**: "The Social Rehabilitation Center effectively fulfills the activities inherent to the Family Social Bonding Treatment Axis"
5. **CS (x)**: "The Social Rehabilitation Center effectively fulfills the activities inherent to the Health Treatment Axis"
6. **ML (x)**: "The Axis of Labor Treatment is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights, and Religion"
7. **MR (x)**: "The Reintegration Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights, and Cult"
8. **MECD (x)**: "The Education, Culture and Sports Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights and Worship"
9. **MVFS (x)**: "The Family Social Entailment Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights"
10. **MS (x)**: "The Health Treatment Axis is enforced in the Social Rehabilitation Centers effectively by the Ministry of Justice, Human Rights and Cults"
11. **MP (x)**: "The principles of the National System of Social Rehabilitation are effectively enforced by the Ministry of Justice, Human Rights, and Worship, and it effectively comply with it"
12. **MN (x)**: "The regulations of the National Social Rehabilitation System are effectively enforced by the Ministry of Justice, Human Rights, and Worship, and it is effectively enforced"
13. **MPol (x)**: "The policies of the National System of Social Rehabilitation are effectively enforced by the Ministry of Justice, Human Rights, and Worship, and it is effectively enforced"

Compound predicates:

1. **NSRS (x)**: "The National Social Rehabilitation System demonstrates its effectiveness"
2. **Adm (x)**: "The administration of the Ministry of Justice, Human Rights and Worship effectively manages the National System of National Rehabilitation"

3. **ET (x):** "The treatment axes are met effectively"
4. **ETL (x):** "The Axis of Labor Treatment is fulfilled effectively"
5. **ETR (x):** "The Reintegration Treatment Axis is effectively fulfilled"
6. **ETECD (x):** "The Education, Culture and Sports Treatment Axis is effectively fulfilled"
7. **ETVSF (x):** "The Family Social Entailment Treatment Axis is effectively fulfilled"
8. **ETS (x):** "The Health Treatment Axis is effectively fulfilled"

Step 2. Tree of predicates and tabulation of the questionnaires

A logical tree is made where the simple and compound predicates are represented, as well as the linguistic operators and modifiers used. From the tree, we got the calculation expressions that allowed obtaining the result of the evaluation of the activities of the National Social Rehabilitation System.

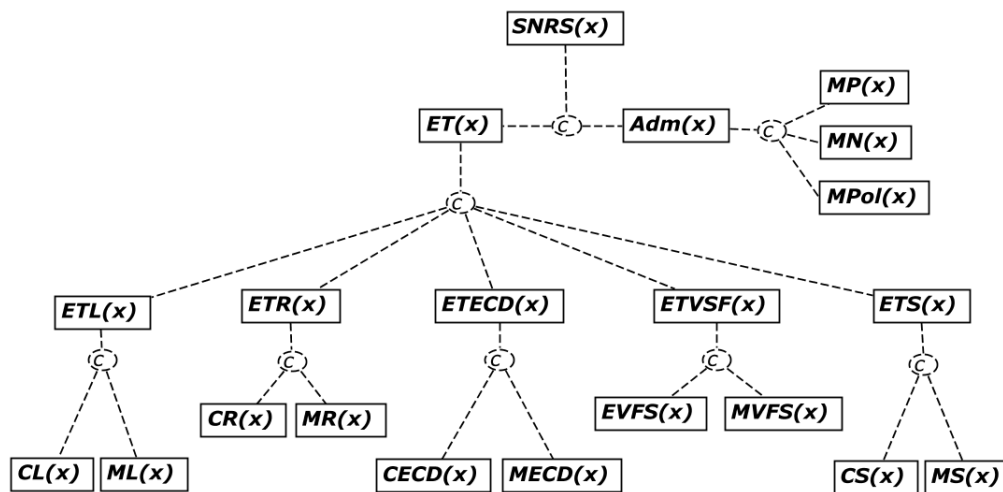


Figure 4: Tree of logical predicates for the effectiveness of the National Social Rehabilitation System.

Expressions:

- ✓ $SNRS(x) = ET(x) \wedge Adm(x)$
- ✓ $ET(x) = ETL(x) \wedge ETR(x) \wedge ETECD(x) \wedge ETVSF(x) \wedge ETS(x)$
- ✓ $ETL(x) = CL(x) \wedge ML(x)$
- ✓ $ETR(x) = CR(x) \wedge MR(x)$
- ✓ $ETECD(x) = CECD(x) \wedge MECD(x)$
- ✓ $ETVSF(x) = CVSF(x) \wedge MVSF(x)$
- ✓ $ETS(x) = CS(x) \wedge MS(x)$
- ✓ $Adm(x) = MP(x) \wedge MN(x) \wedge MPol$

The questionnaires were applied by groups of experts using the neutrosophic scales in Table 2.

| Predicate | Expert Group 1 | Expert Group 2 | Expert Group 3 | Expert Group 4 | Expert group 5 | Expert Group 6 | Expert Group 7 |
|-----------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| CL (x) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.5;0.5;0.5) |
| CR (x) | (0.6;0.35;0.4) | (0.6;0.35;0.4) | (0.4;0.65;0.6) | (0.4;0.65;0.6) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.4;0.65;0.6) |
| CECD (x) | (0.4;0.65;0.6) | (0.4;0.65;0.6) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.6;0.35;0.4) | (0.4;0.65;0.6) | (0.5;0.5;0.5) |
| CVFS (x) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.4;0.65;0.6) | (0.6;0.35;0.4) | (0.5;0.5;0.5) |
| CS (x) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.6;0.35;0.4) | (0.6;0.35;0.4) | (0.5;0.5;0.5) | (0.6;0.35;0.4) | (0.6;0.35;0.4) |
| ML (x) | (0.8;0.15;0.2) | (0.7;0.25;0.3) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) |
| MR (x) | (0.7;0.25;0.3) | (0.7;0.25;0.3) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) |
| MECD (x) | (0.8;0.15;0.2) | (0.7;0.25;0.3) | (0.9;0.1;0.1) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) |
| MVFS (x) | (0.8;0.15;0.2) | (0.7;0.25;0.3) | (0.9;0.1;0.1) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) |
| MS (x) | (0.8;0.15;0.2) | (0.7;0.25;0.3) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) | (0.8;0.15;0.2) |
| MP (x) | (1;0;0) | (1;0;0) | (1;0;0) | (1;0;0) | (0.9;0.1;0.1) | (1;0;0) | (1;0;0) |
| MN (x) | (0.9;0.1;0.1) | (0.9;0.1;0.1) | (0.9;0.1;0.1) | (0.9;0.1;0.1) | (0.9;0.1;0.1) | (1;0;0) | (0.9;0.1;0.1) |
| MPol (x) | (1;0;0) | (1;0;0) | (0.9;0.1;0.1) | (0.9;0.1;0.1) | (0.9;0.1;0.1) | (0.9;0.1;0.1) | (0.9;0.1;0.1) |

Table 1: Tabulation of the results.

Step 3. Deneutrosophication of the matrix

Then equation 2 was applied for the des-neutrosophication of the results, obtaining tables 2 and 3.

| Simple predicates | fashion | Half | S | Cv | Truth value | Category |
|-------------------|---------|--------|-------|--------|-------------|------------------|
| CL (x) | -0.5 | -0.350 | 0.187 | -0.535 | -0.350 | As true as false |
| CR (x) | -0.15 | -0.500 | 0.350 | -0.700 | -0.500 | As true as false |
| CECD (x) | -0.85 | -0.550 | 0.315 | -0.573 | -0.550 | As true as false |
| CVFS (x) | -0.5 | -0.400 | 0.265 | -0.661 | -0.400 | As true as false |
| CS (x) | -0.15 | -0.250 | 0.171 | -0.683 | -0.250 | As true as false |
| ML (x) | 0.45 | 0.407 | 0.113 | 0.279 | 0.450 | Pretty True |
| MR (x) | 0.45 | 0.364 | 0.146 | 0.402 | 0.450 | Pretty True |
| MECD (x) | 0.45 | 0.443 | 0.159 | 0.360 | 0.450 | Pretty True |
| MVFS (x) | 0.45 | 0.443 | 0.159 | 0.360 | 0.450 | Pretty True |
| MS (x) | 0.45 | 0.407 | 0.113 | 0.279 | 0.450 | Pretty True |
| MP (x) | 1 | 0.957 | 0.113 | 0.118 | 0.957 | True |
| MN (x) | 0.7 | 0.743 | 0.113 | 0.153 | 0.743 | Almost true |
| MPol (x) | 0.7 | 0.786 | 0.146 | 0.186 | 0.786 | Almost true |

Table 2: Calculation of the truth-values of simple predicates

| Compound predicate | Truth value | Category |
|--------------------|-------------|----------------------|
| ETL (x) | 0.050 | Somewhat real |
| ETR (x) | -0.025 | More true than false |
| ETECD (x) | -0.050 | More true than false |
| ETVSF (x) | 0.025 | Somewhat real |
| ETS (x) | 0.100 | Somewhat real |
| ET (x) | 0.020 | Somewhat real |
| Adm (x) | 0.829 | Almost true |
| SNRS (x) | 0.424 | Pretty true |

Table 3: Calculation of compound predicates

Step 4. Coefficient of agreement of the experts

Equation 3, the tabulated outputs of the questionnaires were applied. As a result, we obtained that in all cases the coefficient of agreement among experts is $0.785 > 0.75$; so it is considered acceptable.

Step 5. Analysis and discussion

Experts agree that the greatest weakness within the National Social Rehabilitation System is found in the Social Rehabilitation Centers. The results show that the system's effectiveness is affected by the low importance of what was agreed by the Ministry for them. We may observe that the fulfillment of the simple predicates related to the Treatment Axes in the Social Rehabilitation Centers are those rated with the lowest score. This means that the Ministry does not enforce the provisions.

The previously mentioned may translate into a system management level qualifying each of the parameters as fulfilled, but it occurs at the operational level. This means that its translation into concrete actions in the Rehabilitation Centers is not effective or efficient. Therefore, it is necessary to draw up concrete action strategies and give it the appropriate follow-up. First, it is suggested, to begin with, an exhaustive training of the personnel who work in them, by the Ministry itself, and then draft a document that eliminates the optional character by making it mandatory.

Conclusions

- ✓ Deprivation of liberty is a mechanism used by the State to reduce unlawful conduct and preserve a peaceful coexistence among its inhabitants.
- ✓ Having a transparent, equitable, and egalitarian administration of justice is essential when a person violates the peace and harmony of a state.
- ✓ The effectiveness of this system lies in the need to synergistically achieve efficiency and effectiveness in both the bureaucracy and the actions inherent to it.
- ✓ Current existing failures affect the remarkable work in the Social Rehabilitation Centers, which violates the inherent rights of adult people in conflict.
- ✓ The situation was modeled using compensatory fuzzy logic with a neutrosophic fusion. Which led to the analysis of the results and strategies to mitigate the situation.

- ✓ The main problems lie at the management level of the system that does not achieve the execution of concrete actions in the Rehabilitation Centers, so it is not effective or efficient.
- ✓ Suggested main strategies of action: exhaustive training of the personnel and the modification of the legislation so that it propitiates the imperative mode for this problem.

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