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# Application of a Neutrosophic Soft Set Model to Animal Abandonment and its Consideration as Mistreatment

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**Abstract.** The recognition of animal rights is an issue that has boomed in recent years and more and more states are taking them into account in their legal framework. Even though it seeks the recognition of animals as subjects of law, in social life actions of cruelty towards them continue to be appreciated and practices such as abandonment are normalized, without often being interpreted as mistreatment. The present investigation seeks to know the perception of jurists around this problem, using a model to evaluate the relevance of some situations of abandonment, based on the Neutrosophic Soft Set theory. This is a tool where the indeterminacy studied by Neutrosophy is mixed with the classic soft sets. In this way, greater precision is achieved to study the evidence, at the cost of greater uncertainty. As a result, it was obtained that all the situations analyzed were ranked and deemed relevant for consideration as abuse.

**Keywords:** Neutrosophic Soft Set, animal abuse, animal abandonment

## 1 Introduction

Neutrosophy arose as a solution to address many decision-making problems that involve human knowledge, which is often impregnated with uncertainty, indeterminacy, and inconsistency in information. It is a tool to represent those inconsistencies and contradictions that undoubtedly exist in the processing of evidence within administrative law and everyday life [1].

The classical soft set is based on a certain function (whose values are true and unique), but in our world, there are many sources that, due to lack of information or ignorance, provide indeterminate information (uncertain and not unique, but hesitant or alternative). Areas such as artificial intelligence, applied physics, image processing, social sciences, and topology also suffer from the same problems [2].

Classic soft sets [3], [15] started from the studies developed by Professor Molodtsov in 1999 and the neutrosophic soft sets in 2013. The former are deterministic since the set of parameters on which the evaluations are based are deterministic, although they generalize the definition of fuzzy sets. When triads of truth values are assigned to the possible values of the obtained sets, meaning membership, non-membership, and indeterminacy, soft set theory is combined with that of neutrosophic sets to obtain greater precision in the results [4].

These tools are used because there cannot always be one hundred percent clarity in the evidence that is handled, some of them can be interpreted in different and perhaps conflicting ways, and there is some incomplete evidence due to destruction, lack of witnesses, hesitant opinion of one of the factors involved in the process, among other reasons.

This situation can be modeled by operators that have some degree of indeterminacy due to the imprecision that exists in the world. Neutrosophic sets are characterized by a truth membership function ( $t$ ), an indeterminacy membership function ( $i$ ), and a falsehood membership function ( $f$ ) independently, which lie within the standard real unit interval  $[-0, 1+]$  standard or not standard. The Neutrosophic Sets (NS) proposed by Smarandache are a powerful mathematical tool to handle incomplete, indeterminate, and inconsistent information in the real world [5]. They are a generalization of fuzzy set theory, intuitionistic fuzzy sets, and interval-valued intuitionistic fuzzy sets.

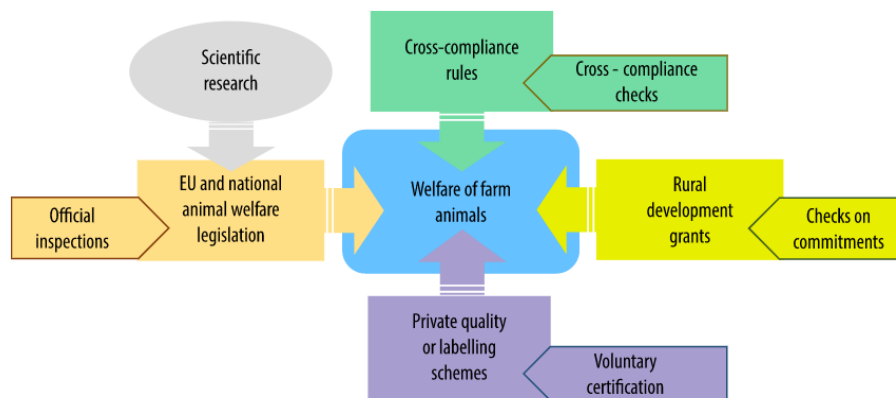
Multiple are the applications of Neutrosophy in real life and within it, the so-called soft sets, among which are the legal and social sciences. In recent years, a social phenomenon has been observed that has been marked by an increase in sensitivity regarding respect for the rights of animals, and, consequently, more mechanisms have been sought for their protection, despite this, manifesting acts of cruelty that threaten the life and integrity

of animals [6].

As a result, measures have been adopted to control human behavior that can cruelly harm or cause unjustified death to an animal. Animal welfare is multifaceted and involves important scientific, ethical, economic, and political dimensions. An agglutinative approach brings together researchers from different disciplines, such as physiology, veterinary science, ethology, and comparative psychology [7].

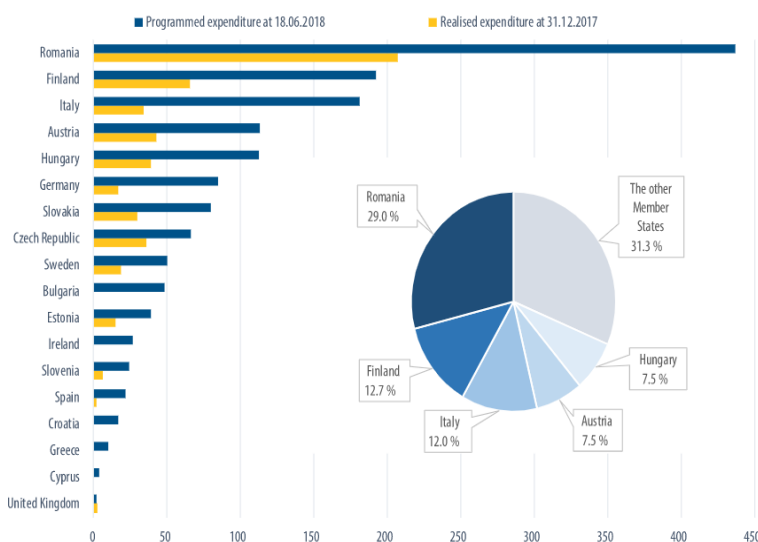
At the global level, actions have been carried out that include some significant achievements of the World Organization for Animal Health (OIE): in 2003, twelve global standards on animal welfare were published, dealing with issues such as transport, slaughter, control of stray dog populations and the welfare of farm animals, including fish; three OIE world conferences on animal welfare were organized, in Paris, 2004, Cairo, 2008 and Kuala Lumpur, 2012; three special issues on animal wellbeing were published, volumes 24, number 2, in 2005 and 33, number 1, in 2014 of the OIE Scientific and Technical Review, and volume 10 of the OIE Technical Series, in 2008 on Evaluation and scientific management of animal pain [8].

The state of the art is limited, especially in relation to interpretation, since there are no clear and established parameters that define the actions of the judges, since the cases in which animal abuse is reported and sanctioned, the punishments do not correspond to the actions committed and the damage caused. Similarly, there is no consensus regarding the actions that are classified as abuse, since, for example, in the case of abandonment, a specific response has not been reached. Although this statistic is included in reports on the treatment of animals [9]. Image 1 shows some of the actions that are taken at the state level and that have an impact on animal welfare.



**Figure 1.** Actions with an impact on animal welfare. Source: <https://op.europa.eu>

Criminal legislation must be an effective tool against the most serious cases of abuse and abandonment of animals. In the first place, an expansion of the animals criminally protected against abuse must be carried out, including wild animals. One of the most advanced regions in the protection of animal welfare is Europe, where large sums are invested for this purpose.



**Figure 2:** EU rural development spending on measure 14 "animal welfare" in the 2014-2020 programming period (million euros). Source: European Court of Auditors, based on information from DG Agriculture and Rural Development.

In the case of Latin America, the situation is different, since being poorer economies, the number of resources destined to guarantee animal welfare is much lower. However, in many of the nations that make up the region, there are protection laws for animals. As shown in Figure 3.

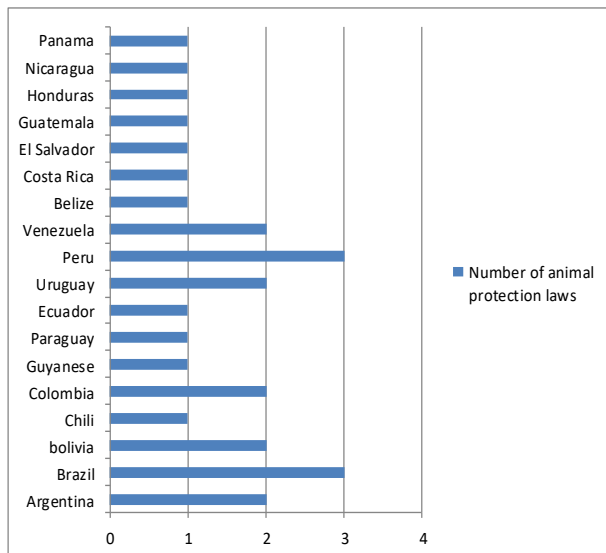


Figure 3. Actions with an impact on animal welfare. Source: [8].

Despite the laws and measures adopted in the region to reduce animal abuse, cases of abuse towards them persist, especially in homes where there is domestic violence. Data suggest that pet abuse is a coercive tactic used to control the victim of domestic violence through intimidation and threats. In other words, this is one of the forms of abuse that animals may suffer in the domestic environment, but it is not the only one. There is talk of physical and sexual abuse, but also neglect of their basic needs such as water, food, medical care, and abandonment [10], [16]. Among the main causes of abandonment are problems related to the behavior of the animal, with changes in the conditions in the environment or by decisions of the owners.

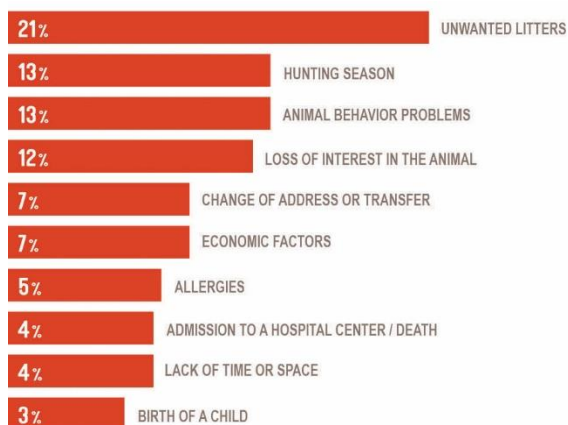


Figure 4. Causes of animal abandonment. Source: <https://www.affinity-foundation.org>.

Due to the aforementioned, the objective of this research is to carry out an analysis, using the Neutrosophic Soft Sets theory, of the act of animal abandonment as mistreatment and therefore as a crime.

## 2 Materials and methods

The neutrosophic soft set is defined as the soft set where  $F$  (maybe) or  $F$  (indeterminate), etc., is roughly equivalent to  $F$  (yes),  $F$  (no),  $F$  (true), or  $F$  (false), associated with a triad of values  $(\alpha, \beta, \gamma)$ , where  $(\alpha, \beta, \gamma) \in [0, 1]^3$  are the degrees of truth, indeterminacy, and falsehood, respectively [11], [17], [19], [21], [22], [23]. Let  $U$ , be a universe of situations,  $H$  a non-empty subset of  $U$ , and  $P(H)$  the power function of  $H$ . Let  $a$  be an attribute and  $A$  a set of these attribute values.

A function  $F: A \rightarrow P(H)$  is called an indeterminate or smooth function if:

- i. The set  $A$  has some indeterminacy;
- ii. or  $P(H)$  has some indeterminacy;
- iii. or there exists at least one attribute value  $v \in A$ , such that  $F(v) = \textit{indeterminate}$  (unclear, uncertain, or not unique);
- iv. or two or the three previous situations.

**Definition 1** [11]: let  $U$  be a universe of situations,  $H$  is a non-empty subset of  $U$ , with  $P(H)$  the power set of  $H$ , and an attribute, with its set of attribute values, is denoted by  $A$ . Then the pair  $(F, H)$ , where  $f: A \rightarrow P(H)$ , is called classic soft set on  $H$ .

**Definition 2** [11]: If the function  $F: A \rightarrow P(H)$ , where for each  $x \in A$ ,  $f(x) \in P(H)$  and  $f(x)$  is true and unique, it is called a determinate (classical) function.

From the previously discussed, the following neutrosophic triplet can be formed [11, 12, 13, 20]:

- v. (Classical) function, which is a well-defined (inner-defined) function for all elements in its domain of definition, or  $(T, I, F) = (1, 0, 0)$ .
- vi. Neutrofunction (or neutrosophic function), is a function that is partially well defined (degree of truth  $T$ ), partially indeterminate (degree of indeterminacy  $I$ ), and partially externally defined (degree of falsehood  $F$ ) in its domain of definition, where  $(T, I, F) \in \{(1,0,0), (0,0,1)\}$ .

## 2.1 Model based on Neutrosophic Soft Sets

This section presents the design of the proposed model for this case.

Starting from a group of situations or assumptions that will be denoted by  $S = \{s_1, s_2, \dots, s_k\}$ , which must be classified or evaluated by the specialists that belong to the group  $J = \{j_1, j_2, \dots, j_l\}$ . The set of parameters to be measured is given by  $D = \{\text{Yes, No}\}$ , where "yes" means that the expert's opinion on the situation is affirmative, while "no" means the opposite.

The algorithm to follow is:

1. A group of situations or assumptions is compiled whose relevance is to be determined, to classify it and process it as a crime or not. It will be denoted by  $S = \{s_1, s_2, \dots, s_k\}$ .

It is necessary to gather a group of experts or specialists, lawyers in this case, who must issue an opinion on the constitution as a crime of each of the situations expressed. This is understood as a set  $J = \{j_1, j_2, \dots, j_l\}$ .

2. The jurist ( $j_j$ ) is asked to give an opinion on the situation  $s_i$  regarding whether it is considered a crime or not. Jurist ( $J_j$ ) is asked to rate the truth of the situation and its relevance on a scale of 0 to 100. This value is called  $\alpha_{ij}$ 
  - 2.2. Jurist ( $J_j$ ) is asked to give an evaluation of the falsehood and irrelevance of the situation on a scale of 0 to 100. This value is called  $\gamma_{ij}$
  - 2.3. Jurist ( $J_j$ ) is asked to give an assessment of the uncertainty and irrelevance of the situation on a scale of 0 to 100. This value is called  $\beta_{ij}$

As a result, the following triad is obtained:

$$R_{ij} = \langle \alpha_{ij}/100, \beta_{ij}/100, \gamma_{ij}/100 \rangle \quad (1)$$

This is the triad of truth values between 0 and 1, to evaluate the degrees of truth, indeterminacy, and falsehood, respectively, of the relevance of the  $i$ -th test according to the  $j$ -th expert.

3. The Soft Set is formed by  $F: D \rightarrow P(H)$ , where  $D = \{yes, no\}$ , being as follows:

$$F(si) = \{(e_i, s_j, R_{ij}), \text{ where } R_{ij} \neq \langle 0, \tau, 1 \rangle, \tau \geq 0\}, \tag{2}$$

while:

$$F(no) = \{(e_i, s_j, R_{ij}), \text{ where } R_{ij} \neq \langle 1, 0, 0 \rangle\} \tag{3}$$

4. The final results for tests or evidence are obtained from:

$$G(si) = \{(e_i, \Lambda_j R_{ij}): j \in \{1, 2, \dots, l\} \text{ such that } (e_i, s_j, R_{ij}) \in F(yes)\} \tag{4}$$

Where, (5)  $\llbracket \Lambda_j R \rrbracket_{ij} = \langle \min_j \{\alpha_{ij}/100\}, \max_j \{\beta_{ij}/100\}, \max_j \{\gamma_{ij}/100\} \rangle$

$$G(no) = \{(e_i, \Lambda_j NOT(R_{ij})): j \in \{1, 2, \dots, l\} \text{ such that } (e_i, s_j, R_{ij}) \in F(no)\} \tag{6}$$

Where,  $\llbracket NOT(R) \rrbracket_{ij} = \langle \gamma_{ij}/100, \beta_{ij}/100, \alpha_{ij}/100 \rangle$

5. For each proof or evidence  $D = \{yes, no\}$ , select between  $G(yes)$  and  $G(no)$  the triad that meets the following requirements.

5.1 If  $s_i$  is in  $G(yes)$  and it is not in  $G(no)$ , it is determined that this situation is relevant or that it should be considered a crime, with a truth value determined by  $\bar{R}_i = \Lambda_j R_{ij}$ .

5.2 If  $s_i$  is in  $G(no)$  and is not in  $G(yes)$ , this evidence is determined to be relevant to the case with a truth value of  $\tilde{R}_i = \Lambda_j NOT(R_{ij})$ .

5.3 If  $s_i$  is in both sets, the following criteria are followed:

A single value  $V_{-i} = (2 + R_{-i1} - R_{-i2} - R_{-i3})/3$  is calculated, where  $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3} \rangle$ , while  $F_{-i} = (2 + R_{-i1} - R_{-i2} - R_{-i3})/3$ , where  $\tilde{R}_i = \langle \tilde{R}_{i1}, \tilde{R}_{i2}, \tilde{R}_{i3} \rangle$ .

5.3.1 If  $\bar{V}_i > \bar{F}_i$  then the i-th test is relevant with a truth value of  $\bar{R}_i$ .

5.3.2 If  $\bar{V}_i < \bar{F}_i$  then the i-th test is not relevant with a value of truth  $\tilde{R}_i$ .

5.3.4 If  $\bar{V}_i = \bar{F}_i$  then it is determined that the ith test is not relevant enough with a truth value of  $\bar{R}_i = \langle \bar{R}_{i1}, \bar{R}_{i2}, \bar{R}_{i3} \rangle$ .

6. The tests or evidence that were classified as relevant are issued, sorted from highest to lowest, where  $e_m > e_n$  if and only if  $\bar{V}_m > \bar{V}_n$ .

## 2.2 Application

Approaches that can be used for the analysis and interpretation of the case of abandonment as animal abuse or a crime, in the field of so-called soft sets:

### 2.2.1 Classic Soft Set:

The analysis of animal abandonment as mistreatment is based on the consideration of the action as such, and its definition as a crime in 3 situations ( $s_1$ : due to the animal's illness,  $s_2$ : due to not wanting to keep it and  $s_3$ : because the animal has caused damage to the physical integrity of an individual or an affection of the material order) and the criteria of several jurists on the application of the current legality regarding the subject. [14], [18]

The set of alternatives can be represented as  $S = \{s_1, s_2, s_3\} \cup \{\phi\}$ , where  $\{\phi\}$  is empty or null, the attribute  $D = \text{crime}$ , this has 2 possible values for the attribute  $D = \{\text{Yes}, \text{No}\}$

i. It is established as a function  $F_1: C \rightarrow P(S)$ , where  $P(S)$  is determined by S, which represents the information offered by jurist 1,  $J_1$

In this case:

$J_1(\text{Yes}) = s_2$ , this means that according to the criteria of jurist 1, situation 2 is classified as abuse and therefore

should be considered a crime, that is, its value is unique.

### 2.2.2 Indeterminate Operator as an extension of the Soft Set

- ii. Then, the function  $F_2: C \rightarrow P(S)$ , where the value of S is the criterion of jurist 2,  $J_2$ . In this case, the jurist does not have a single opinion, but rather provides some indeterminacy in his response.

$J_2(Yes) = NO (s_3)$  and  $J_2(No) = s_1$  or  $s_2$ . This means that jurist 2 provides information that is not clear or unique, which means that for him the situation  $s_3$  is not considered abuse, consequently: the situations  $s_1$  and  $s_2$  can be considered as such, or  $\{\phi\}$  would mean that neither is considered abuse, consequently:

$C_2^1 + C_2^2 + 1 = 2^2 = 4$  possibilities (alternatives or outputs), resulting from 1 single input to choose from, where  $C_n^m$ , which means the combination of n elements taken from the groups of m elements, for intervals  $0 \leq m \leq n$ .

The following indeterminate information is given by  $s_1$  or  $s_2$ , this can mean that:  $\{s_1 Yes and s_2 No\}$ , or that  $\{s_1 No and s_2 Yes\}$ , or that  $\{s_1 Yes and s_2 Yes\}$ , then there are 3 alternatives or outputs to choose from.

Consequently

$F_2: C \rightarrow P(S)$  is an indeterminate soft function

### 2.2.3 Indeterminate values

In the case of jurist 3, he has a less tacit criterion, that is, he thinks that in the case of situation  $s_1$ , "perhaps" can be considered as mistreatment, this can be translated using Neutrosophy, through the theory of opposites:  $\langle A \rangle = yes, \langle antiA \rangle = no$  and the indeterminate or neutral function. Therefore  $F_3: C \rightarrow P(S)$ , would be given by  $J_3(perhaps) = s_1$ , this can be translated as follows:

$J_3(perhaps) = s_1$  that is  $J_3(Yes) = s_1$  (to a certain degree);  $J_3(No) = s_1$  (to a certain degree), which is the same as,  $J_3(Yes) = s_1(0,6)$  which is interpreted as a 60% probability that it will be considered abuse and therefore a crime.

$J_3(perhaps) = s_1$  that is  $J_3(Yes) = s_1(0,6; 0,3)$  which means that there is a 60% probability that it will be considered abuse and therefore a crime and a 30% that it will not be.

$J_3(perhaps) = s_1$  that is  $J_3(Yes) = s_1(0,6; 0,3; 0,2)$  which means that there is a 60% probability that it will be considered an abuse and therefore a crime, a 30% probability that it will not be, and a 20% probability that it will not be considered as either of the two.

## 2.3 Application of the Model based on Neutrosophic Soft Sets

The 3 jurists consulted ( $j_1, j_2, j_3$ ) issue their criteria regarding the situations ( $s_1, s_2, s_3$ ), in triads of values from 0 to 100, to standardize the veracity, the negative and indeterminate responses, where the first score represents the seriousness or relevance of the situation raised to be considered as a crime of abuse, the second value indicates the doubt or indeterminacy regarding the relevance of the situation described in its consideration as a crime of abuse and the third value indicates the irrelevance of that situation to be considered as a crime of mistreatment of animals.

Results are shown in Table 1.

| Situation/Jurist | $j_1$                      | $j_2$                      | $j_3$                      |
|------------------|----------------------------|----------------------------|----------------------------|
| $s_1$            | $\langle 76,0,20 \rangle$  | $\langle 80,0,10 \rangle$  | $\langle 75,10,22 \rangle$ |
| $s_2$            | $\langle 95,0,15 \rangle$  | $\langle 85,0,30 \rangle$  | $\langle 70,20,40 \rangle$ |
| $s_3$            | $\langle 50,30,18 \rangle$ | $\langle 45,50,20 \rangle$ | $\langle 65,25,15 \rangle$ |

**Table 1:** Result of the evaluation of the relevance of the situation according to the jurists.

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

| Situation/Jurist | $j_1$                              | $j_2$                              | $j_3$                              |
|------------------|------------------------------------|------------------------------------|------------------------------------|
| $s_1$            | $\langle 0.76, 0, 0.20 \rangle$    | $\langle 0.80, 0, 0.10 \rangle$    | $\langle 0.75, 0.10, 0.22 \rangle$ |
| $s_2$            | $\langle 0.95, 0, 0.15 \rangle$    | $\langle 0.85, 0, 0.30 \rangle$    | $\langle 0.70, 0.20, 0.40 \rangle$ |
| $s_3$            | $\langle 0.50, 0.30, 0.18 \rangle$ | $\langle 0.45, 0.50, 0.20 \rangle$ | $\langle 0.65, 0.25, 0.15 \rangle$ |

**Table 2:** Result of the evaluation of the relevance of the situation according to the jurists expressed in the form of neutrosophic numbers.

Soft sets are defined as

$$F(Yes) = \left\{ \begin{array}{l} (j_1, s_1, \langle 0.76, 0, 0.20 \rangle), (j_1, s_2, \langle 0.95, 0, 0.15 \rangle), (j_1, s_3, \langle 0.50, 0.30, 0.18 \rangle), (j_2, s_1, \langle 0.80, 0, 0.10 \rangle), \\ (j_2, s_2, \langle 0.85, 0, 0.30 \rangle), (j_2, s_3, \langle 0.45, 0.50, 0.20 \rangle), (j_3, s_1, \langle 0.75, 0.10, 0.22 \rangle), (j_3, s_2, \langle 0.70, 0.20, 0.40 \rangle), \\ (j_3, s_3, \langle 0.65, 0.25, 0.15 \rangle) \end{array} \right\}$$

$F(no)$  is exactly the same as above.

$$G(Yes) = \{(j_1, \langle 0.75, 0.10, 0.22 \rangle), (j_2, \langle 0.70, 0.20, 0.40 \rangle), (j_3, \langle 0.45, 0.50, 0.20 \rangle)\}$$

$$G(no) = \{(j_1, \langle 0.22, 0.10, 0.75 \rangle), (j_2, \langle 0.40, 0.20, 0.70 \rangle), (j_3, \langle 0.20, 0.50, 0.45 \rangle)\}$$

From  $G(Yes)$  and  $G(no)$  it is concluded that  $s_1$  is relevant with a truth value of  $\langle 0.75, 0.10, 0.22 \rangle$ ,  $j_2$  relevant with a truth value of  $\langle 0.70, 0.20, 0.40 \rangle$ , and finally  $j_3$  is also relevant with a truth value of  $\langle 0.45, 0.50, 0.20 \rangle$ .

This decision is made since,  $\bar{V}_1 = 0.9122 > \bar{F}_1 = 0.4589$ ;  $\bar{V}_2 = 0.922 > \bar{F}_2 = 0.4611$ ;  $\bar{V}_3 = 0.727 > \bar{F}_3 = 0.4333$ . Following step 5.3 of the chosen algorithm.

The order of severity or relevance of abandonment situations to be considered a crime is as follows:  $e_2 > e_1 > e_3$ , where all are relevant or important according to the results obtained.

Finally, the order of severity of the situations is as follows:

- 1-  $s_2$ : for not wanting to keep it
- 2-  $s_1$ : due to animal disease
- 3-  $s_3$ : because the animal has caused damage to the physical integrity of an individual or an affectation of the material order

### Conclusions

With the completion of this investigation, the following conclusions were reached: the different approaches that can be given in the processing of responses to real-life situations and in particular the legal framework were analyzed. The application of the chosen neutrosophic model allows us to focus more clearly on the relevant tests or situations, eliminating those that do not contribute to what is being analyzed. The consideration of indeterminacy in the answers is introduced, which makes the result closer to reality. The hierarchization of the answers provides a useful edge for decision-making in relation to the situations raised, in this case, it was found as the most serious or relevant for the consideration of abandonment as abuse, according to the jurists consulted that it should be to the decision or personal desire not to keep the animal, in a second moment that is due to illness of the animal and finally that it has caused damage to the physical integrity of an individual or a material affectation. It should be noted that according to the results obtained, although the situations are ranked, all are relevant for the consideration of abandonment as animal abuse.

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