*Research Article*

# Decision Making in Uncertain Rural Scenarios by means of Fuzzy TOPSIS Method

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A great deal of uncertain information which is difficult to quantify is taken into account by farmers and experts in the enterprise when making decisions. We are interested in the problems of the implementation of a rabbit-breeding farm. One of the first decisions to be taken refers to the design or type of structure for housing the animals, which is determined by the level of environmental control sought to be maintained in its interior. A farmer was consulted, and his answers were incorporated into the analysis, by means of the fuzzy TOPSIS methodology. The main purpose of this paper is to study the problem by means of the fuzzy TOPSIS method as multicriteria decision making, when the information was given in linguistic terms.

## 1. Introduction

In rural scenarios, the quantitative information to assess in decision making is usually very poor, or difficult to obtain. The factors to be taking into account present a similar pattern, but the data show clear differences between areas or countries. In this way, many recent works have demonstrated the advantages of the implementation of qualitative information to work in rural farms [1–4].

The rabbit farmer who wishes to start in the production of rabbits must take a series of decisions, including decisions relating to the environmental comfort (temperature, humidity, ventilation, and illumination) of the animals. The climate zone in which the farm is to be

located will condition the environmental control systems that need to be installed in the building to ensure adequate comfort for the animals. In Mediterranean climates, the principal parameter that determines the type of building is the level of temperature control sought, with an excess of heat being much more of a problem than an excess of cold. Thus, we can find open buildings, with open sides, or buildings with the sides closed. The environmental control of the latter is greater. Closed buildings, with more technology, suppose a greater investment cost but generally have higher productions. On the other hand, open buildings present a lower incidence of pathologies since they have greater air renewal although the rabbits may need more looking after as the comfort of the animals cannot be guaranteed. Thus, special care should be taken in choosing the type of building and aspects need to be considered which include not only economic criteria for the implementation, but also aspects related to handling, productivity, and animal welfare.

This type of problem presents the characteristics to be resolved by means of tools to help in decision making, more specifically using the multicriteria method. This type of methods may require consulting experts who can enrich the decision with their judgments regarding the problem. The most common drawback of existing linguistic multi-criteria methods, at least for some classes of problems, is the need to translate the decision makers' knowledge about a decision problem into numbers and functions. There are decision problems in which qualitative judgments prevail over more or less exact quantitative evaluation. For such problems, it is a somewhat natural choice to use models which incorporate qualitative (descriptive, linguistic, and ordinal) variables. Practical problems are often characterized by several no commensurable and conflicting criteria, and there may be no solution which satisfies all the criteria simultaneously [5–10].

The technique for order performance by similarity to ideal solution (TOPSIS), one of the well-known classical multi-criteria decision making (MCDM) methods, was first developed in [11–13]. It is based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS). The final ranking is obtained by means of the closeness index.

Only a limited number of works have been carried out in recent years about decision making using fuzzy numbers in agriculture [14–17] or in farm management [18–21].

The purpose of this paper is to contribute to the rabbit farming sector as a MCDM problem in a fuzzy environment, to model the problem of the choice of the best type of structure for a rabbit farm, by means of the fuzzy TOPSIS method. The TOPSIS method is used since the decision maker includes both linguistic as well as numerical data in his assessment.

This paper is organized as follows: the following section introduces the methodology in detail. The linguistic variables and the fuzzy sets are described as is the TOPSIS method, to be used later. Section 3 presents the application of the method to the most appropriate selection concerning the best type of structure for a rabbit farm. In Section 4, the results and the discussion are presented. Finally, in the Acknowledgments section details the most important conclusions and future works.

## 2. Methodology

### 2.1. The Statement of the Decision Problem

Any multi-criteria decision problem (MCDP) may be expressed by means of the following five elements, $\{C, D, r, I, \prec\}$, where:

(1) $C = \{C_1, C_2, \ldots, C_m\}$. This is the set of criteria that represent the tools which enable alternatives to be compared from a specific point of view;

(2) $D = \{D_1, D_2, \ldots, D_n\}$ This is the set of feasible alternatives for the decision-maker, and from which the decision-maker must choose one. In this case, the sets $C$ and $D$ are finite sets. This allows us to avoid convergence, integrability and measurability problems;

(3) $r : D \times C \rightarrow R$ is a function to every decision $d_i$ and to every criterion $C_j$,

$$(D_i, C_j) \longrightarrow r(D_i, C_j) = r_{ij}. \tag{2.1}$$

Once that set of criteria and alternatives have been selected, then a measure of the effect produced by each alternative with respect to each criterion is needed,

By means of linguistic terms, the decision-maker represents the goodness of an alternative with respect to a criterion; the different values of $r$ can be represented by means of a matrix called the *decision making matrix*;

(4) There is a preference relation $\prec$ by the decision maker. We will suppose a coherent decision maker, therefore he shall try to maximize his profits or otherwise to minimize his losses. In this case, the decision maker needs to obtain the best alternative according to the criteria considered;

(5) Certain information about the criteria in this case is also linguistic. The decision-maker provides us linguistic information about the importance of each criterion.
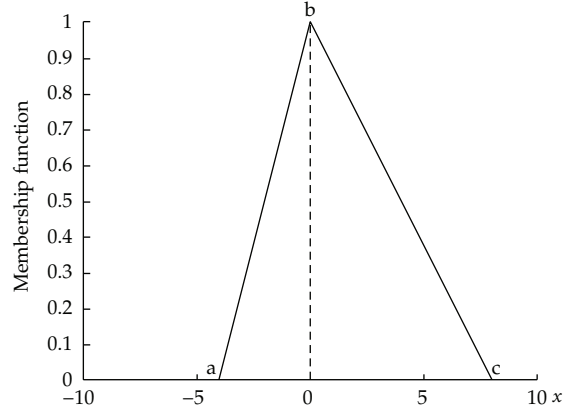
## 2.2. Linguistic Variable and Fuzzy Sets

Since Zadeh [22] introduced the concept of fuzzy sets and subsequently went on to extend the notion via the concept of linguistic variables, the popularity and the use of fuzzy sets have been extraordinary. We are particularly interested in the role of linguistic variables, and their associated terms, in this case fuzzy numbers, which will be used in the MCDM.

By a *linguistic variable* [23–25] we mean a variable whose values are words or sentences in a natural or artificial language. For example, *age* is a linguistic variable if its values are linguistic rather than numerical, that is, *young, not young, very young, quite young, old, not very old and not very young*, and so forth, rather than numbers as $20, 21, 22, 23, \ldots$.

*Definition 2.1.* A linguistic variable is characterized by a quintuple $\{X; T(X); U; G; M\}$ in which

(1) $X$ is the name of the variable,

(2) $T(X)$ is the term set of $X$, that is, the collection of its linguistic values,

(3) $U$ is a universe of discourse,

(4) $G$ is a syntactic rule for generating the elements of $T(X)$,

(5) $M$ is a semantic rule for associating meaning with the linguistic values of $X$.

**Figure 1:** Representation of a triangular fuzzy number.

In the present case, the linguistic variable is identified with a fuzzy set [26–28]. In this paper, reference is only made to the operations on fuzzy sets that will be used in the application.

*Definition 2.2.* A real triangular fuzzy number (TFN) $A$ is described as any fuzzy subset of the real line $\Re$ with membership function $f_A$ which possesses the following properties:

(1) $f_A(x)$ is a continuous mapping from $\Re$ to the closed interval $[0, 1]$,

(2) $f_A(x) = 0$, for all $x \in (-\infty, a]$,

(3) $f_A(x)$ is strictly increasing on $[a, b]$,

(4) $f_A(x) = 1$, for $x = b$,

(5) $f_A(x)$ is strictly decreasing on $[b, c]$,

(6) $f_A(x) = 0$, for all $x \in (c, \infty]$,

where $a, b$, and $c$ are real numbers. See Figure 1.

Unless otherwise specified, it is assumed that $A$ is convex and bounded, (i.e., $-\infty < a, d < \infty$).

*Definition 2.3.* $A_1$ and $A_2$ are two TFNs defined by the triplets $(a_1, b_1, c_1)$ and $(a_2, b_2, c_2)$, respectively. For this case, the necessary arithmetic operations with positive fuzzy numbers are the following.

*(a) Addition:*

$$A_1 \oplus A_2 = [a_1 + a_2, b_1 + b_2, c_1 + c_2].  \tag{2.2}$$

*(b) Multiplication:*

$$A_1 \otimes A_2 = [a_1 \times a_2, b_1 \times b_2, c_1 \times c_2].  \tag{2.3}$$

*(c) Maximum:*

$$\text{Max}(A_1, A_2) = [\text{Max}(a_1, a_2), \text{Max}(b_1, b_2), \text{Max}(c_1, c_2)]. \tag{2.4}$$

*(d) Minimum:*

$$\text{Min}(A_1, A_2) = [\text{Min}(a_1, a_2), \text{Min}(b_1, b_2), \text{Min}(c_1, c_2)]. \tag{2.5}$$

*(b) Division:*

$$A_1 \emptyset A_2 = \left[ [a_1, b_1, c_1] \cdot \left[ \frac{1}{c_2}, \frac{1}{b_2}, \frac{1}{a_2} \right] \right], \quad 0 \neq [a_2, b_2, c_2]. \tag{2.6}$$

*(d) Root:*

$$A_1^{1/2} = \left[ a_1^{1/2}, b_1^{1/2}, c_1^{1/2} \right]. \tag{2.7}$$

*(e) Defuzzification process (see [29]):*

$$I_{1/3,1/2}(A_1) = \frac{1}{3} \left( \frac{a_1 + 4b_1 + c_1}{2} \right). \tag{2.8}$$

### 2.3. TOPSIS Method

The TOPSIS approach is an MCDM for the arrangement of preference to an ideal solution by similarity, which was developed by Hwang and Yoon [12], also by Zeleny [30], Lai et al. [31], and Chen [11].

The fuzzy TOPSIS methods are derived from the generic TOPSIS method with minor differences, with the pertinent adaptation of the operations associated to the linguistic labels.

The fuzzy TOPSIS procedure consists of the following steps

*Step 1* (Establish a Performance Fuzzy Matrix). The construction of the decision matrix is very important when we are interested in obtaining the best alternatives. The outcome of the decision matrix can be one of three types: only deterministic values (numerical values); only linguistic values; or mixed values, as in our case. Conventional MCDM methods require only precise values for a finite set of alternatives. However, true multiple-criteria decision making environments consist of both imprecise and precise values. Therefore, if all or some of the criteria of an alternative are uncertain (or imprecise) or if the given criteria have subjective characteristics, the use of a fuzzy set theory is a reasonable means of resolution. Some examples can be seen in [6, 32, 33].

**Table 1:** Decision matrix.

| | $\underset{\sim}{w}_1$ | $\underset{\sim}{w}_2$ | | $\underset{\sim}{w}_j$ | $\underset{\sim}{w}_n$ |
|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | $\cdots$ | $C_j$ | $C_n$ |
| $A_1$ | $z_{11}$ | $z_{12}$ | $\cdots$ | $z_{1j}$ | $z_{1n}$ |
| $A_2$ | $z_{21}$ | $z_{22}$ | $\cdots$ | $z_{2j}$ | $z_{2n}$ |
| $A_m$ | $z_{m1}$ | $z_{m2}$ | $\cdots$ | $z_{mj}$ | $z_{mn}$ |

The structure of the matrix can be expressed in Table 1,

where $W = [\underset{\sim}{w}_1, \underset{\sim}{w}_2, \dots, \underset{\sim}{w}_n]$ is the vector that indicates the importance that the expert gives the criterion $C_j$; and $A_i$, $i = 1, \dots, m$ denotes the possible alternatives.

Let $z_{ij} = \{x_{ij}, \underset{\sim}{x}_{ij}\}$ be the numerical values $(x_{ij}) = [x_{ij}^a, x_{ij}^b, x_{ij}^c]$ or the linguistic ones $(\underset{\sim}{x}_{ij}) = [\underset{\sim}{x}_{ij}^a, \underset{\sim}{x}_{ij}^b, \underset{\sim}{x}_{ij}^c]$, that represent the opinions expressed by each expert about alternative $A_i$ with respect to criterion $C_j$.

*Step 2* (normalize the fuzzy decision matrix). In the classical TOPSIS, the normalized performance matrix can be obtained using the following transformation formula:

$$\overline{n}_{ij} = \frac{z_{ij}}{\sqrt{\sum_{j=1}^{m} (z_{ij})^2}}, \quad j = 1, \dots, n, \ i = 1, \dots, m. \tag{2.9}$$

In our approach, $\overline{n}_{ij} = (n_{ij}^a, n_{ij}^b, n_{ij}^c)$ is a fuzzy number, and then we need to use the operations defined in (2.2), (2.6), and (2.7). Consequently, with this normalization, each attribute has the same unit scale of vector.

*Step 3* (calculate the weighted normalized decision matrix $V = [\overline{v}_{ij}]_{m \times n}$). The weighted normalized value $\overline{v}_{ij}$ is calculated as

$$\overline{v}_{ij} = \underset{\sim}{w}_j \otimes \overline{n}_{ij}, \quad j = 1, \dots, n, \ i = 1, \dots, m, \tag{2.10}$$

where $\underset{\sim}{w}_j$ such that $1 \in \sum_{j=1}^{n} w_j$ is the degree of importance of the $j$th attribute or criterion and where we will operate using (2.3). It is well known that the weights of criteria in decision making problems do not have the same mean and not all of them have the same importance. These weights can be obtained in different ways: direct assignation, AHP, and so forth.

*Step 4* (determine the positive ideal and negative ideal solutions). The positive ideal value set $\overline{A}^+$ and the negative ideal value set $\overline{A}^+$ are determined using (2.4), (2.5), as follows:

$$\overline{A}^+ = \{\overline{v}_1^+, \dots, \overline{v}_n^+\} = \left\{ \left( \max_i \overline{v}_{ij}, j \in J \right) \right\},$$

$$\overline{A}^+ = \{\overline{v}_1^+, \dots, \overline{v}_n^+\} = \left\{ \left( \min_i \overline{v}_{ij}, j \in J' \right) \right\},$$

$$\overline{A}^+ = \{\overline{v}_1, \ldots, \overline{v}_n\} = \left\{ \left( \min_i \overline{v}_{ij}, j \in J \right) \right\},$$

$$\overline{A}^- = \{\overline{v}_1, \ldots, \overline{v}_n\} = \left\{ \left( \max_i \overline{v}_{ij}, j \in J' \right) \right\},$$

$$(2.11)$$

where $J$ is associated with benefit criteria, and $J'$ is associated with cost criteria and $i = 1, 2, \ldots, m$.

Since the problem is to optimize, in this case, the benefit criteria will be that for which the best option corresponds to the smallest value of labels being the contrary for the cost criteria.

*Step 5* (calculate the separation measures). The separation of each alternative from the PIS $\overline{A}^+$ is given using (2.8), taking into account the defuzzification process given in [29] as follows:

$$\overline{d}_i^+ = \left\{ \frac{1}{3} \sum_{j=1}^{n} \frac{\left(\overline{v}_{ij}^a - \overline{v}_j^{a+}\right)^2 + 4\left(\overline{v}_{ij}^b - \overline{v}_j^{b+}\right)^2 + \left(\overline{v}_{ij}^c - \overline{v}_j^{c+}\right)^2}{2} \right\}^{1/2}, \quad i = 1, \ldots, m, \quad (2.12)$$

and the separation of each alternative from the NIS $\overline{A}^-$ is as follows:

$$\overline{d}_i^- = \left\{ \frac{1}{3} \sum_{j=1}^{n} \frac{\left(\overline{v}_{ij}^a - \overline{v}_j^{a-}\right)^2 + 4\left(\overline{v}_{ij}^b - \overline{v}_j^{b-}\right)^2 + \left(\overline{v}_{ij}^c - \overline{v}_j^{c-}\right)^2}{2} \right\}^{1/2}, \quad i = 1, \ldots, m. \quad (2.13)$$

In this case we use the m-multidimensional Euclidean distance.

*Step 6* (calculate the relative closeness to the ideal solution). The relative closeness $\overline{R}_i$ to the ideal solution can be expressed as follows:

$$\overline{R}_i = \frac{\overline{d}_i^-}{\overline{d}_i^+ + \overline{d}_i^-}, \quad i = 1, \ldots, m, \quad \text{if } \overline{R}_i = \begin{cases} 1 \longrightarrow A_i = \overline{A}^+, \\ 0 \longrightarrow A_i = \overline{A}^-, \end{cases} \quad (2.14)$$

where the $\overline{R}_i = 1$ value lies between 0 and 1. The closer the $\overline{R}_i = 1$ value is to 1 implies a higher priority of the *i*th alternative.

*Step 7* (rank the preference order). Rank the best alternatives according to $\overline{R}_i$ in descending order.

## 3. Empirical Study: A Real Problem in Farm Management

### 3.1. Structuring the Problem

In the initial stage of obtaining information, the steps taken are as follows.

#### 3.1.1. Identification of the Problem

In Mediterranean climates, the construction design for housing rabbits offers several alternatives according to the environmental comfort sought for the interior. The different types of houses are the alternatives:

(A$_1$) closed buildings with a totally controlled environment

(A$_2$) open buildings with a semicontrolled environment, buildings without closed sides,

(A$_3$) open buildings without a controlled environment: without closed sides and without environmental control mechanisms.

Each type of building has advantages and disadvantages; closed buildings require a greater investment and have higher maintenance costs for the environmental control systems, but production levels are greater.

#### 3.1.2. Identification of the Criteria

(C$_1$) Implementation Costs: They include all the costs derived from the construction of the civil engineering and the installations needed to carry out the activity. They depend on the type of structure of the building (open or closed) and the level of technology of the installations.

(C$_2$) Running Costs: They include all the payments which are included as such in the cash flow (labour, food, electricity, water, repairs to equipment, medicines, etc.)

(C$_3$) Production: It is measured as kilos of meat produced weekly per 100 reproductive females

(C$_4$) Mortality in Lactation: Percentage of kits dead in the breeding period (from birth to 35 days after birth)

(C$_5$) Mortality in Fattening: It is the percentage of dead rabbits from weaning until the moment of slaughtering (approximately 2 kg of live weight and 65 days of age).

The criteria (C$_1$), (C$_2$) are clearly cost criteria. (C$_4$) and (C$_5$) are criteria which when it comes to optimising are considered as cost criteria, since they indicate mortality, and the greater they are then the worse the criterion is. For this reason, in this case, the only criterion which indicates profit is (C$_3$).

The problems arise from the fact that the information will be both quantitative and qualitative; in these conditions, not all decision models are appropriate, for example, the simple average weight, so a good method is the TOPSIS approach, as it is based on normalization and makes the valuations adimensional.

To obtain the data, a questionnaire has been designed at two levels, one in which the questions are asked to obtain the importance the expert gives to each criterion; this is shown

**Table 2:** Linguistic variables for the importance weight of each type 1 criterion and for the ratings of the type 2 alternatives.

| | Type 1 linguistic label | | | Type 2 linguistic label | |
|---|---|---|---|---|---|
| Label | Description | Fuzzy number | Label | Description | Fuzzy number |
| vL | Very low | $[0, 0, 0.1]$ | vG | Very good | $[0, 0, 1]$ |
| L | Low | $[0, 0.1, 0.3]$ | G | Good | $[0, 1, 3]$ |
| mL | Medium low | $[0.1, 0.3, 0.5]$ | mG | Medium good | $[1, 3, 5]$ |
| M | Medium | $[0.3, 0.5, 0.7]$ | m | Medium | $[3, 5, 7]$ |
| mH | Medium high | $[0.5, 0.7, 0.9]$ | mB | Medium bad | $[5, 7, 9]$ |
| H | High | $[0.7, 0.9, 1.0]$ | B | Bad | $[7, 9, 10]$ |
| vH | Very high | $[0.9, 1.0, 1.0]$ | vB | Very bad | $[9, 10, 10]$ |

**Table 3:** Importance weight of criteria.

| | | Fuzzy numbers | Normalization |
|---|---|---|---|
| $C_1$ | High | (0.700,0.900,1.000) | (0.146,0.220,0.323) |
| $C_2$ | Medium high | (0.500,0.700,0.900) | (0.104,0.171,0.290) |
| $C_3$ | Medium high | (0.500,0.700,0.900) | (0.104,0.171,0.290) |
| $C_4$ | High | (0.700,0.900,1.000) | (0.146,0.220,0.323) |
| $C_5$ | High | (0.700,0.900,1.000) | (0.146,0.220,0.323) |
| | SUM | (3.100,4.100,4.800) | 1.000 |

in Table 2, type 1 label. At the other level, the expert is asked to value each alternative for each of the criteria, and that is evaluated with the type 2 labels.

To quantify the importance of the criteria, the labels used were importance labels {VL, L, mL, M, mH, H, vH} whose value ranged from the lowest to the highest importance. However, for the rating of the alternatives, given that we are faced with an optimization problem, the linguistics labels used in the questionnaire were labels to define goodness {vG, G, mG, m, mB, B, VB}, where in these, the numerical values of the labels were assigned in the opposite way, that is, from lowest to highest: vG $= (0, 0, 1), \ldots$, and VB $= (9, 10, 10)$. In this way, the best alternative is that which has the lowest numerical value in the case of the benefit criteria, and the opposite case is true for the cost criteria—the best alternative is that with the highest value.

In this way, for the expert, the criteria $(C_1)$, $(C_4)$, and $(C_5)$ are the most important with a high importance, whilst $(C_2)$ and $(C_3)$ have a valuation of medium good. These normalized values can be seen in Table 3 and will be the weights of the respective criteria for the proposed model. These linguistic data have been reached by direct assignation.

For the evaluation of the alternatives for each criterion, as has been indicated, the type 2 labels have been used (Table 2) for those criteria which do not have a quantitative valuation, and for those whose quantitative value was evaluated with said value plus or minus a margin of error of the numerical values, as can be seen in Table 4.

Note in Table 4 that the criteria $(C_1)$, $(C_2)$, and $(C_3)$ are assessed as qualitative criteria according to Table 2, and $(C_4)$ and $(C_5)$ criteria are quantitative criteria. For these criteria, the expert was able to provide a numerical quantity as a percentage with an approximate error margin, also as a percentage, where $(C_4)$ and $(C_5)$ are cost criteria that represent the mortality of rabbits as a percentage both in lactation as well as in fattening.

**Table 4:** Ratings of the expert under the various criteria by linguistic labels and numerical information (percentage ± SD).

|       | $C_1$ | $C_2$ | $C_3$ | $C_4$     | $C_5$     |
|-------|-------|-------|-------|-----------|-----------|
| $A_1$ | vB    | vB    | vB    | 12%± 1%   | 5%± 1%    |
| $A_2$ | m     | B     | B     | 14%± 1%   | 8%± 1%    |
| $A_3$ | m     | m     | m     | 16%± 1%   | 10%± 1%   |
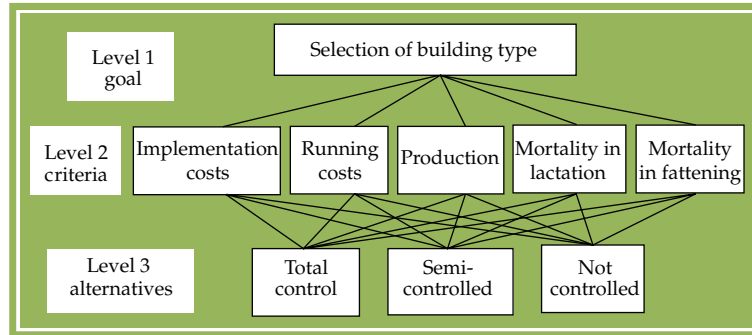


**Figure 2:** Scheme of the decision process for the election of the best type of building for a rabbit-breeding farm.

We have supposed that quantitative and qualitative information is available from the expert.

### 3.2. Results and Discussion

With regard to the choice of criteria, it should be highlighted that with $(C_3)$, $(C_4)$, and $(C_5)$, we have to take into account both the income that a greater or lower rabbit meat production supposes as well as the cost that is generated by the mortality of animals being fattened, in terms of labour and food costs and that later this does not become income. It can be supposed that the mortality criteria $((C_4)$ and $(C_5))$ are negatively correlated with those of production $(C_3)$; however, it is possible to have a low production with low mortality because the number of births is less.

Once Steps 1, 2, 3, and 4 of the fuzzy TOPSIS algorithm previously detailed have been completed, as can be seen in Table 5, then we need to find the distances $d^+$ and $d^-$ for each alternative to the ideal solutions, which can be seen in Table 6.

In this way, the defuzzified values for each alternative would be calculated, for example

$$d^+(A_1) = \frac{1}{3}\left\{\frac{1}{2}0.098 + \frac{4}{2}0.148 + \frac{1}{2}0.188\right\} = 0.146. \tag{3.1}$$

Similarly, we would do the same for $d^+(A_2)$ and $d^+(A_3)$. The values corresponding to $d^-$ would be determined in a similar fashion. Thus, we reach Table 7 which shows the results of the distances $d^+$ $d^-$ and $R$.

**Table 5:** Calculation of the normalized alternatives, weighted alternatives, and $A^+$ and $A^-$.

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ |
|---|---|---|---|---|---|
| | (0.146,0.220,0.323) | (0.104,0.171,0.290) | (0.104,0.171,0.290) | (0.146,0.220,0.323) | (0.146,0.220,0.323) |
| $A_1$ | (9.000,10.000,10.000) | (9.000,10.000,10.000) | (0.000,0.000,1.000) | (11.000,12.000,13.000) | (4.000,5.000,6.000) |
| $A_2$ | (3.000,5.000, 7.000) | (5.000,7.000,9.000) | (0.000,1.000,3.000) | (13.000,14.000,15.000) | (7.000,8.000,9.000) |
| $A_3$ | (1.000,3.000, 5.000) | (3.000,5.000,7.000) | (3.000,5.000,7.000) | (15.000,16.000,17.000) | (9.000,10.000,11.000) |
| $nA_1$ | (0.682,0.864, 1.048) | (0.593,0.758, 0.933) | (0.000,0.000,0.333) | (0.421,0.492,0.573) | (0.259,0.364,0.497) |
| $nA_2$ | (0.227,0.432, 0.7349) | (0.330,0.531,0.839) | (0.000,0.196,1.000) | (0.497,0.573,0.661) | (0.454,0.582,0.745) |
| $nA_3$ | (0.076,0.259, 0.524) | (0.198,0.379, 0.653) | (0.391,0.981,2.333) | (0.574,0.655,0.749) | (0.583,0.727,0.910) |
| $vA_1$ | (0.100,0.190, 0.338) | (0.062,0.129, 0.271) | (0.000,0.000,0.097) | (0.061,0.108,0.185) | (0.038,0.080,0.160) |
| $vA_2$ | (0.033,0.095, 0.237) | (0.034,0.091,0.244) | (0.000,0.033,0.290) | (0.073,0.126,0.213) | (0.066,0.128,0.240) |
| $vA_3$ | (0.011,0.057, 0.169) | (0.021,0.065, 0.190) | (0.041,0.167,0.677) | (0.084,0.144,0.242) | (0.085,0.160,0.294) |
| $A^+$ | (0.011,0.057, 0.169) | (0.021,0.065,0.190) | (0.000,0.000,0.097) | (0.061,0.108,0.185) | (0.038,0.080, 0.160) |
| $A^-$ | (0.100,0.190, 0.338) | (0.062,0.129, 0.271) | (0.041,0.167,0.677) | (0.084,0.144,0.242) | (0.085,0.160,0.294) |

**Table 6:** Calculation of $d^+$ and $d^-$.

|       |       |                         |
|-------|-------|-------------------------|
|       | A$_1$ | (0.098,0.148,0.188)     |
| $d^+$ | A$_2$ | (0.040,0.076,0.228)     |
|       | A$_3$ | (0.066,0.189,0.598)     |
|       | A$_1$ | (0.066,0.189,0.598)     |
| $d^-$ | A$_2$ | (0.085,0.173,0.406)     |
|       | A$_3$ | (0.098,0.148,0.188)     |

**Table 7:** Results.

|       | $d^+$ | $d^-$ | $R$   |
|-------|-------|-------|-------|
| A$_1$ | 0.146 | 0.237 | 0.619 |
| A$_2$ | 0.096 | 0.197 | 0.673 |
| A$_3$ | 0.237 | 0.146 | 0.381 |

In Table 7 and in Figure 2, it can be seen that the best alternative is (A$_2$) since the value of $R$ confirms this. We should we observe the values corresponding to $d^+$ it is easy to check that the best alternative is (A$_2$) as it has the shortest distance with regard to $A^+$, that is, to say, $0.096 < 0.146 < 0.237$.

The difference between Table 7 and Figure 3 lies in the fact that in Figure 3 the values for $d^+$ have been changed for those of $(1 - d^+)$, since if the values of $A^+$, $d^+$, $d^-$, $R$, and $A^-$ are represented on a line, the graphic should maintain the sequence expressed in Figure 4, as $d^+$ measures the distance to $A^+$.

The fact of using the TOPSIS methodology rather than other methods means that the data analysed correspond both to numerical values and linguistic labels, and it therefore becomes necessary to use different measurement scales. This is the case, and therefore, the methodology is very suitable because it allows to analyse the values presented in a clear and concise manner.

Other methodologies [12, 13], such as weighted sum, may not be applied in this problem since different types of data are employed. Moreover, in the case of using other methods such as AHP or PROMETHEE, the surveys for the experts are much longer and developed. This was deemed to be potentially difficult for the experts to interpret, since they are not highly qualified experts but farmers. Thus, deciding on the TOPSIS method was clear since this survey was simple and intuitive for the experts to answer.

## 4. Conclusions

Today many enterprises use decision making tools to help with their decisions. In rural scenarios, where many important decisions must be taken, these tools may be easily implemented and used by governments and/or farmers. A fuzzy model has great potential as a valuable tool in evaluating such decisions owing to the uncertainty and difficulty in finding quantitative information in some aspects involving this sector. In the illustrative example presented, the problem is affected by many factors which may offer only imprecise and uncertain data. Therefore, a methodology based on fuzzy TOPSIS was developed to resolve a problem of rabbit farm management. The example demonstrates the power of this method to identify preferred options from a given combination of quantitative and qualitative information.
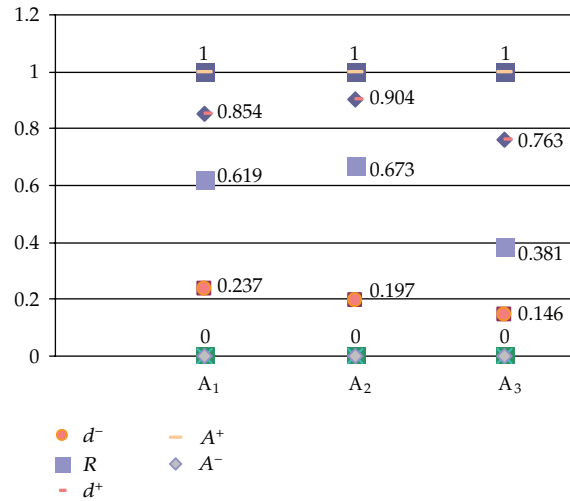
**Figure 3:** Representation of the values corresponding to $(1 - d^+)$, $d^-$ and $R$ for alternatives $(A_1)$, $(A_2)$, and $(A_3)$.
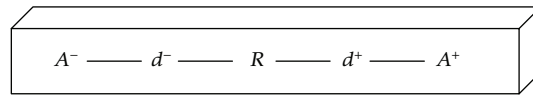


**Figure 4:** Representation of the values corresponding to $A^+, d^+, d^-, A^-$ and $R$ throughout the real line.

So, the expert's preferred option for the construction design for housing the rabbits in the southeast of Spain is $(A_2)$, the open buildings with a semicontrolled environment. Option $(A_3)$, open buildings without a controlled environment, comes out as the least preferred by the expert and is therefore a priori to be rejected. Option $(A_1)$, closed buildings with a totally controlled environment, would be rather near to the preferred option, and this option could become an interesting choice in the event that the investment and maintenance costs decreased sufficiently to make this alternative preferable over alternative $(A_2)$.

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