Evaluation of Nutritional Education Strategies in Schools in Ecuador Using Neutrosophic TOPSIS

Dr. Miguel Ramos Argilagos, Dr. Alex Valencia Herrera, Dr. Walter Vayas Valdiviezo

[1,2,3]Regional Autonomous University of the Andes (UNIANDES), Ambato, Ecuador

Emails: ua.miguelramos@uniandes.edu.ec; ua.alexvalencia@uniandes.edu.ec; ua.waltervayas@uniandes.edu.ec

Abstract

The need to guarantee a healthy diet and lifestyle in the country's educational centers has become an urgent need if the future of Ecuadorian society is to be improved. In this framework, educational institutions can play a fundamental role in understanding that optimal nutrition is essential for the health, well-being, and cognitive and social development of the younger population and the economic growth of communities and the well-being of future generations. This study proposes a breakdown of various strategies to promote healthy nutritional habits in educational centers throughout the country and evaluates the proposed alternatives to assign an order of priorities based on certain criteria. For this, the TOPSIS method is used in its neutrosophic version so that the vagueness and indeterminacies of the real world can be handled. The results obtained show that, of the five proposed alternatives, it is preferred to implement, firstly, the creation of a school environment for the promotion of healthy diets through the creation of orchards as a pedagogical tool, and secondly, in order of preference, conducting awareness programs on the importance of producing and consuming chemical-free products through educational fairs, communication campaigns, and other school activities.

Keywords: nutritional health; strategies; neutrosophic TOPSIS,;schools

1. Introduction

Promoting healthy and sustainable nutrition, agriculture, education, and healthy habits in conducive environments is not new. Most countries apply these guidelines in their daily work, although not always with the necessary conviction or multidisciplinary and multisectoral articulation[1]. Over the years, many eating habits have been modified or completely changed, resulting in greater consumption of ultra-processed foods high in sugar, fat, and salt; with great repercussions on the environment, people's health, and the well-being of society [2]. This type of diet has generated a significant increase in overweight, obesity, and chronic non-contagious diseases directly related to diet, which largely affects children and adolescents [3].

Promoting initiatives on healthy eating in the youngest age groups requires a call for the responsibility of all States in the fight against malnutrition [4], [5]. One of the fundamental pillars for constructing a healthier society is education due to its ability to generate awareness and develop skills that allow making beneficial decisions about food [6]. In addition, schools can play an integral role in promoting human rights, in particular the right to adequate

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

food and education [7]. Because schools, especially primary schools, are present even in the most rural areas, they offer a unique opportunity to reach a very large number of children.

The promotion of healthy nutritional environments entails the creation of favorable spaces for this, especially in schools. They promote the reorientation of nutrition and the sustainability of diets to guarantee sustainable development and fight against infectious diseases, malnutrition, and unfavorable environmental factors [8]. The Convention on the Rights of the Child, which has achieved almost universal adoption, highlights in its article 24 the importance of providing nutritious food in combating disease and malnutrition [9]

In Ecuador, the prevalence of chronic child malnutrition is approximately 24.6%, but there are provinces where the percentage is higher, such as in the Ecuadorian highlands. It is estimated that 1 out of 4 children under 5 years of age suffers from chronic malnutrition. The situation is more serious for indigenous children since 1 in 2 children suffers from it, and 4 out of 10 have anemia [10]. Research carried out by Georgetown University in collaboration with the government, it revealed that not the absence of food per se but the lack of the correct nutrients in the daily diet is the main factor that triggers child malnutrition in Ecuador. Hence the importance of promoting balanced eating habits in which adequate nutritional values are considered, it is essential to be able to achieve, in the future, a society without chronic child malnutrition in the country [11]

The most affected provinces that register a figure higher than the national average are Bolívar, Santa Elena, and Chimborazo. In these localities, mainly in their rural areas, it is evident that there are at least three factors associated with this condition that prevents its reduction: poverty, poor water quality, and inadequate nutrition [12]. In front of this scenario, this study proposes a breakdown of various strategies to promote healthy nutritional habits in schools throughout the country and evaluates the proposed alternatives to grant an order of priorities based on certain criteria.

The TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) is a decision-making technique developed by t Hwang and Yoon developed in 1981 [13]. This method allows combining several heterogeneous attributes in a single dimensionless index, and this is because the attributes under evaluation are quite possibly expressed in different units or scales. TOPSIS is based on the concept that the selected alternative should have the shortest Euclidean distance to an ideal solution and the greatest Euclidean distance to an anti-ideal solution.

Some authors [14], [15] studied multi-criteria decision-making methods based on fuzzy data. Boran et al. (2006) proposed the TOPSIS method to select the appropriate provider in an intuitive fuzzy environment. So, the TOPSIS method for the Multiple Criteria Decision-Making (MCDM) problem has been extended into intuitionistic fuzzy sets valued at intervals by Ye (2010). The contributions made by neutrosophy and neutrosophic sets will be used for the current study. Neutrosophy is the branch of philosophy that studies the origin, nature, and scope of neutralities [18].

The incorporation of neutrosophic sets in TOPSIS guarantees that decision-making uncertainty is taken into account, including indeterminacies. In this case, the Neutrosophic TOPSIS will be used to determine the stronger alternatives and the weakest measured quantitatively, according to certain evaluation criteria [19].

2. Preliminaries

Definition 1: Let X be a space of points (objects) with generic elements in X denoted by x. An single-valued neutrosophic set (SVNS) A in X is characterized by truth-membership function T_A (x), indeterminacy-membership function I_A (x), and falsity membership function F_A (x). Then, an SVNS A can be denoted by A = {x, $T_A(x)$, $I_A(x)$, $F_A(x)$ x ∈ X}, where T_A (x), I_A (x), F_A (x) ∈ [0,1] for each point x in X. Therefore, the sum of T_A (x), I_A (x) and F_A (x) satisfies the condition $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.[20]. For convenience, a SVN number is denoted by A = (a b c), where a,b,c ∈ [0,1] and a + b + c ≤ 3.

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

Definition 2: Let A_1= (a_1,b_1,c_1) and A_2 = (a_2,b_2,c_2) be two SVN numbers, then sum between A_1 y A_2 is defined as follows:

$$A_1 + A_2 = (a_1 + a_2 - a_1a_2, b_1b_2, c_1c_2) \quad (1)$$

Definition 3: Let A_1= (a_1,b_1,c_1) and A_2 = (a_2,b_2,c_2) be two SVN numbers, then multiplication between A_1 y A_2 is defined as follows:

$$A1 * A2 = (a1a2, b1 + b2 - b1b2, c1 + c2 - c1c2) \quad (2)$$

Definition 4: Let A = (a, b, c) be a SVN number and $\lambda \in \mathbb{R}$ an arbitrary positive real number, then:

$$\lambda A = \left(1 - (1 - a)^{\lambda}, b^{\lambda}, c^{\lambda}\right), \lambda > 0 \quad (3)$$

Definition 5: Let $A = \{A_1, A_2, \dots, A_n\}$ be a set of n SVN numbers, where Aj = (aj, bj, cj) (j = 1,2,…, n). The single value neutrosophic weighted average operator on them is defined by

$$\sum_{j=1}^{n} \lambda_j A_j = \left(1 - \prod_{j=1}^{n} \left(1 - a_j\right)^{\lambda_j}, \prod_{j=1}^{n} b_j^{\lambda_j}, \prod_{j=1}^{n} c_j^{\lambda_j}\right) \quad (4)$$

Where λ_j is the weight of A_j (j= 1,2,…,n), $\lambda_j \in [0,1]$ and $\sum_{j=1}^{n} \lambda_j = 1$

Definition 6. Let $A^* = \{A_1{}^*, A_2{}^*, \dots, A_n{}^*\}$ be a vector of n SVN numbers, such that Aj * = (aj *, bj *, cj *) (j = 1,2,…, n), and $B_i = \{B_{i1}, B_{i2}, \dots, B_{im}\}$ (i= 1,2,…, m), (j= 1,2,…, n). Then the separation measure between B_i and A^* based on Euclidian distance is defined as follows:

$$s_i = \left(\frac{1}{3} \sum_{j=1}^{n} \left(\left|a_{ij} - a_j^*\right|\right)^2 + \left(\left|b_{ij} - b_j^*\right|\right)^2 + \left(\left|c_{ij} - c_j^*\right|\right)^2\right)^{\frac{1}{2}} \quad (5)$$

(i = 1,2,…, m)

Next, we proposed a score function for ranking SVN numbers as follows:

Definition 7: Let A = (a, b, c) be a single-valued neutrosophic number, a score function S of a single-valued neutrosophic value, based on the truth-membership degree, indeterminacy-membership degree, and falsehood membership degree is defined by:

$$S(A) = \frac{1 + a - 2b - c}{2} \quad (6)$$

where $S(A) \in [-1,1]$

The score function S is reduced to the score function proposed by Li (2005) if b = 0 and a + b ≤ 1.

A linguistic variable is a variable whose values are characterized by words or sentences instead of numbers in a natural or artificial language. The value of a linguistic variable is expressed as an element of its term set. The concept of a linguistic variable is very useful for solving decision-making problems with complex content. For

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

example, we can express the performance ratings of alternatives on qualitative attributes by linguistic variables such as very important, important, medium, unimportant, very unimportant, etc. Such linguistic values can be represented using single-valued neutrosophic numbers.

In the method, there are k decision-makers, m alternatives, and n criteria. k-decision-makers evaluate the importance of the m-alternatives under n-criteria and rank the performance of the n-criteria with respect to linguistic statements converted into single-valued neutrosophic numbers. Here, the decision-makers often use a set of weights such that W= {very important, important, medium, unimportant, very unimportant} and the importance weights based on single-valued neutrosophic values of the linguistic terms are given in Table 1.

Table 1: Linguistic variable and SVNSs. Source: [22]

Linguistic term	SVNSs
Not very influential / (NVI)	(0.9; 0.1; 0.1)
Not influetial / (NI)	(0.75; 0.25; 0.20)
Moderately influential / (M)	(0.50; 0.5; 0.50)
Influential / (I)	(0.35; 0.75; 0.80)
Very influential / (VI)	(0.10; 0.90; 0.90)

3. Methodology

The TOPSIS method for SVNS used consists of the following: Assuming 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, the following steps will be carried out:

Step 1: Determine the relative importance 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, let's call $A_t = (a_t, b_t, c_t)$ the SVNS corresponding to the t-th decision-maker (t = 1, 2,…, k). The following formula calculates the weight:

$$\delta_t = \frac{a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)}{\sum_{t=1}^{k} a_t + b_t\left(\frac{a_t}{a_t + c_t}\right)} \tag{7}$$

$$\delta_t \geq 0 \; and \; \sum_{t=1}^{k} \delta_t = 1$$

Step 2: Construction of the neutrosophic decision matrix of aggregated unique values: 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 individual evaluations. d_{ij} 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 4. This way, a matrix $D = (d_{ij})_{ij}$ is obtained, where each d_{ij} is a SVNN (i = 1,2, .., m; j = 1,2,…, n).

Step 3: Determination of Weight of the Criteria: Suppose that the weight of each criterion is given by $W = (w_1, w_2, \dots, w_n)$, where w_j denotes the relative importance of the criterion $\lambda_t w_j^t = (a_j^t, b_j^t, c_j^t)$. If it is the evaluation of the criterion λ_t by the t-th expert. Then Equation 5 is used to aggregate those λ_t with the weights λ_t.

Step 4: Construction of the neutrosophic decision matrix from the weighted average of unique values with respect to the criteria.

$$D^* = D * W, \tag{8}$$

$$where \; d_{ij} = (a_{ij}, b_{ij}, c_{ij})$$

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

Step 5: Calculation of the ideal positive and negative SVNN solutions: The criteria can be classified as cost type or benefit type. Let G_1 be the set of benefit-type criteria and G_2 the cost-type criteria. The ideal alternatives will be defined as follows:

The ideal positive solution corresponding to G_1.

$$\rho^+ = a_{\rho+w}(\beta_j), b_{\rho+w}(\beta_j), ac_{\rho+w}(\beta_j) \tag{9}$$

The ideal negative solution corresponding to G_2.

$$\rho^- = (a_{\rho-w}(\beta_j), b_{\rho-w}(\beta_j), ac_{\rho-w}(\beta_j)) \tag{10}$$

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: Calculate the distances to the ideal positive and negative SVNN solutions: With the help of Equation 5, the following Equations are calculated:

$$d_i^+ = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^+\right)^2 + \left(b_{ij} - b_j^+\right)^2 + \left(c_{ij} - c_j^+\right)^2\right\}\right)^{\frac{1}{2}} \tag{11}$$

$$d_i^- = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^-\right)^2 + \left(b_{ij} - b_j^-\right)^2 + \left(c_{ij} - c_j^-\right)^2\right\}\right)^{\frac{1}{2}} \tag{12}$$

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

$$\widetilde{\rho_J} = \frac{s^-}{s^+ + s^-} \tag{13}$$

Where $0 \leq .\widetilde{\rho_J} \leq 1$

Step 8: Determine the order of the alternatives: They are ordered according to what was achieved by $\widetilde{\rho_J}$. The alternatives are ordered from highest to lowest, provided that $\widetilde{\rho_J} \rightarrow 1$ is the optimal solution.

4. Results and discussion

The work program for the United Nations Decade of Action on Nutrition 2016-2025 and the 2030 Agenda and the Sustainable Development Goals provide the necessary national and international support to tackle malnutrition

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

and accelerate progress in this area. Its guidelines call for the adoption and implementation, by governments and their partners, of policies and programs for the creation of sustainable food systems and appropriate food environments that promote healthy eating practices [23]

Within the framework of the regional project of the Food Organization of the United Nations (FAO) called: "Institutional articulation for the link of Family Agriculture (FA) to the School Feeding Programs (SFP), the Central American Educational and Cultural Coordination (CECC/CAIS), as part of an agreement with FAO, has presented a regional strategic proposal for the promotion of Healthy Nutritional Environments through the insertion of Nutritional Food Education and Family Agriculture in the curricula of the countries of the Central American Integration System (CAIS) region [24].

Educational centers at all levels of education can create and encourage correct nutritional habits and the promotion of healthy and healthy eating in the different actors over which they have influence. In this sense, although educational actions tend to focus on influencing students, it is also possible to influence parents, educational personnel, and other actors that make up society. Therefore, the alternatives to be evaluated by the experts in this study are based on the strategies proposed in the Institutional Articulation Project for the link of Family Agriculture to School Feeding Programs, as well as other aspects derived from the bibliographic consultations carried out for this purpose, and are focused on:

- **Alternative 1:** Development of intra and extracurricular activity programs related to teaching the basic principles of healthy nutrition that involve both parents and students.
- **Alternative 2:** Carry out awareness programs on the importance of producing and consuming chemical-free products through educational fairs, communication campaigns, and other school activities.
- **Alternative 3:** Creating a school environment to promote healthy diets through the creation of orchards as a pedagogical tool
- **Alternative 4:** Adoption of school feeding programs based on the use of healthy foods and balanced levels of nutrients

To evaluate the potential of the alternatives indicated in the educational centers, the following criteria are selected.

C1. Feasibility: Indicates the degree to which the alternative can be successfully implemented. It is determined by the presence or absence of those requirements or essential resources for its implementation.

C2. Integration: The ability to successfully integrate into an existing infrastructure or any other program or intervention in any sector is evaluated in such a way that both are strengthened without requiring new structures.

C3. Effectiveness: It is an expression of the magnitude in which the results correspond to the objectives. To evaluate the effectiveness, it is necessary, first, to have a clear definition of the objectives. Effectiveness is often related to the quantity and quality of the resources available for the intervention and then the concept of cost-effectiveness is defined, in which an evaluation is made of the "price" that it has cost to achieve the proposed objectives.

C4. Opportunity: It refers to the time between the occurrences of the condition or problem that the intervention is intended to solve and the moment in which the benefits expected from the intervention are available.

C5. Participation: Interventions that promote community participation through their various groups have a much higher probability of success than those whose activities are designed, implemented, and evaluated by external actors.

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

Decision-makers use a set of language weights to determine the performance of each criterion. The weighting information provided to the five criteria by the five decision-makers is presented in tables 2 to 6.

Table 2: Evaluation of alternatives according to feasibility. Source: Own elaboration

Alternatives	K1	K2	K3	K4	K5
Alt 1	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.35,0.75,0.80)	(0.10,0.90,0.90)	(0.35,0.75,0.80)
Alt 2	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.50,0.5,0.50)
Alt 3	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.9,0.1,0.1)
Alt 4	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	(0.75,0.25,0.20)

Table 3: Evaluation of the alternatives according to the integration. Own elaboration

Alternatives	K1	K2	K3	K4	K5
Alt 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)	(0.9,0.1,0.1)
Alt 2	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.50,0.5,0.50)
Alt 3	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	(0.9,0.1,0.1)
Alt 4	(0.50,0.5,0.50)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	(0.9,0.1,0.1)	(0.75,0.25,0.20)

Table 4: Evaluation of the alternatives according to their effectiveness. Source: Own elaboration

Alternatives	K1	K2	K3	K4	K5
Alt 1	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.50,0.5,0.50)	(0.50,0.5,0.50)	(0.9,0.1,0.1)
Alt 2	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.75,0.25,0.20)
Alt 3	(0.50,0.5,0.50)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.75,0.25,0.20)
Alt 4	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.50,0.5,0.50)	(0.75,0.25,0.20)	(0.9,0.1,0.1)

Table 5: Evaluation of the alternatives according to the opportunity. Source: Own elaboration

Alternatives	K1	K2	K3	K4	K5
Alt 1	(0.9,0.1,0.1)	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.75,0.25,0.20)
Alt 2	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.9,0.1,0.1)
Alt 3	(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)
Alt 4	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)

Table 6: Evaluation of alternatives according to participation. Source: Own elaboration

Alternatives	K1	K2	K3	K4	K5
Alt 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)	(0.9,0.1,0.1)
Alt 2	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.75,0.25,0.20)
Alt 3	(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)
Alt 4	(0.75,0.25,0.20)	(0.75,0.25,0.20)	(0.9,0.1,0.1)	(0.75,0.25,0.20)	(0.9,0.1,0.1)

Considering that all decision-makers have a very important evaluation (VI), according to the linguistic values provided in table 1, for an evaluation of 0.2; we proceed to determine the matrix of unique values, shown in table 7 by using equation 4.

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

Table 7: SVNS Aggregate Decision Matrix. Source: Own elaboration

Alternatives	C1	C2	C3	C4	C5
Alt 1	(0.30629,0.77785,0.81907)	(0.9,0.1,0.1)	(0.80963,0.19037,0.19037)	(0.8557,0.1443,0.132)	(0.9,0.1,0.1)
Alt 2	(0.83428,0.16572,0.15849)	(0.80095,0.19905,0.18206)	(0.85573,0.14427,0.13195)	(0.8267,0.1733,0.1516)	(0.75,0.25,0.2)
Alt 3	(0.85573,0.14427,0.13195)	(0.80095,0.19905,0.18206)	(0.76091,0.23909,0.20913)	(0.9,0.1,0.1)	(0.9,0.1,0.1)
Alt 4	(0.67012,0.32988,0.28854)	(0.68452,0.31548,0.30171)	(0.80095,0.19905,0.18206)	(0.75,0.25,0.2)	(0.8267,0.1733,0.1516)

To obtain the weighted decision matrix (see Table 9), the experts must determine the weights of the criteria according to the values provided in Table 1. The vector of criterion weights obtained according to the evaluations carried out is shown below:

Table 8: Vector of weights of the criteria. Source: Own elaboration

Criterion	Criterion weight
C1	(0.9; 0.1; 0.1)
C2	(0.76091; 0.23909; 0.20913)
C3	(0.87989; 0.12011; 0.11487)
C4	(0.67012; 0.32988; 0.28854)
C5	(0.62107; 0.37893; 0.34657)

Table 9: Weighted decision matrix. Source: Own elaboration

Alternatives	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5
Alt 1	(0.27566; 0.80007; 0.83716)	(0.68482; 0.31518; 0.28822)	(0.71239; 0.28761; 0.28337)	(0.57342; 0.42658; 0.38245)	(0.55896; 0.44104; 0.41191)
Alt 2	(0.75085; 0.24915; 0.24264)	(0.60945; 0.39055; 0.35312)	(0.75295; 0.24705; 0.23166)	(0.55399; 0.44601; 0.3964)	(0.4658; 0.5342; 0.47726)
Alt 3	(0.77016; 0.22984; 0.21876)	(0.60945; 0.39055; 0.35312)	(0.66952; 0.33048; 0.29998)	(0.60311; 0.39689; 0.35969)	(0.55896; 0.44104; 0.41191)
Alt 4	(0.60311; 0.39689; 0.35969)	(0.52086; 0.47914; 0.44774)	(0.70475; 0.29525; 0.27602)	(0.50259; 0.49741; 0.43083)	(0.51344; 0.48656; 0.44563)

Finally, the order of the alternatives is shown in table 10, according to the proximity coefficient calculated.

Table 10: Positive and negative ideal values and distances Note: Source: Own elaboration

Alternatives	Ideal value +	Ideal value -	d +	d-	$\widetilde{\rho_J}$	Order
Alt 1	(0.77016; 0.22984; 0.21876)	(0.27566; 0.80007; 0.83716)	0.6331	0.3147	0.33199	4
Alt 2	(0.68482; 0.31518; 0.28822)	(0.52086; 0.47914; 0.44774)	0.3406	0.6277	0.64825	2
Alt 3	(0.75295; 0.24705; 0.23166)	(0.66952; 0.33048; 0.29998)	0.3035	0.6334	0.67603	1
Alt 4	(0.60311; 0.39689;	(0.50259; 0.49741;	0.3945	0.491	0.55449	3

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

0.35969)	0.43083)	

The analysis shows that the preferred alternative according to the evaluated criteria is the creation of a school environment for the promotion of healthy diets through the creation of orchards as a pedagogical tool. This alternative is preferred, perhaps because it requires the least investment in the short term, and also includes many benefits in the long term. The second alternative in order of preference is to carry out awareness programs on the importance of producing and consuming chemical-free products through educational fairs, communication campaigns, and other school activities. Finally, the last alternative in order of preference is the adoption of school feeding programs based on the use of healthy foods and balanced levels of nutrients.

5. Conclusions

The generation of new practices that actively promote food and nutrition education should be a strong point in all educational institutions in the country. Encouraging a proper and responsible consumption of food and promoting awareness and sensitization about good food practices is a long-term social investment that cannot be rejected at any level of society and government. Therefore, the present study proposed a series of alternatives to foster a rapprochement of educational centers towards food education in the various actors that make up the academic universe.

The analysis carried out shows that, of the five proposed alternatives, it is preferred to implement, firstly, the creation of a school environment for the promotion of healthy diets through the creation of orchards as a pedagogical tool, and secondly, in order of preference, conducting awareness programs on the importance of producing and consuming chemical-free products through educational fairs, communication campaigns, and other school activities.

To obtain the results, the TOPSIS method was used in its neutrosophic version, so that vagueness and indeterminacies typical of the real world could be handled by the method. In addition, the neutrosophic single value sets were used to develop the method and linguistic values for the evaluation of the alternatives and criteria, so the effectiveness of the method used can be verified through the results attained.

Funding: “This research received no external funding”

Conflicts of Interest: “The authors declare no conflict of interest.”

6. References

[1] J. Fanzo et al., "Global Nutrition Report: Shining a light to spur action on nutrition.," 2018.

[2] J. R. M. Álvarez, “La evolución de los hábitos alimentarios en España: las nuevas tendencias, los nuevos alimentos y su relación con la salud.,” Nuevos alimentos para nuevas necesidades, vol. 7, 2003.

[3] M. L. Bergel Sanchís, M. F. Cesani, and E. E. (Oyhenart, “Malnutrición infantil e inseguridad alimentaria como expresión de las condiciones socio-económicas familiares en Villaguay, Argentina (2010-2012). Un enfoque biocultural,” Población y Salud en Mesoamérica, vol. 14, no. 2, pp. 60–85, 2017.

[4] J. F. García-Rodríguez, A. García-Fariñas, G. A. Rodríguez-León, and A. M. Gálvez-González, “Dimensión económica del sobrepeso y la obesidad como problemas de salud pública.,” Salud en Tabasco, vol. 16, no. 1, pp. 891–896, 2010.

[5] R. B. Peláez, “Desnutrición y enfermedad.,” Nutrición Hospitalaria, vol. 6, no. 1, pp. 10–23, 2013.

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022

[6] S. Olivares, J. Snel, M. McGrann, and P. Glasauer, “Educación en nutrición en las escuelas primarias.,” FNA/ANA, vol. 22, pp. 57–62, 1998.
[7] E. M. Trescastro-López and S. Trescastro López, “La educación en alimentación y nutrición en el medio escolar: el ejemplo del Programa EDALNU.,” 2013.
[8] J. Coronel Carbo and N. Marzo Páez, “La promoción de salud para la creación de entornos saludables en América Latina y el Caribe.,” Medisan, vol. 21, no. 12, pp. 3415–3423, 2017.
[9] ONU: Asamblea General, “Convención sobre los Derechos del Niño,” 1989.
[10] W. B. Freire, M. J. Ramírez-Luzuriaga, P. Belmont, M. J. Mendieta, K. Silva-Jaramillo, and N. Romero, Encuesta Nacional de Salud y Nutrición, Tomo 1. 2014.
[11] S. D. R. Chiriboga Calva and D. J. Guamaní Heredia, “Factores determinantes de la desnutrición crónica en los niños menores de 5 años de la Frontera Norte del Ecuador,” UCE, 2020.
[12] elcomercio.com, “La erradicación de la desnutrición infantil, otra deuda de Ecuador,” EL Comercio, 2018.
[13] J. L. Young, Y. L. Ting, and L. H. Ching, TOPSIS for MODM. 1992.
[14] C. T. Chen, "Extensions of the TOPSIS for group decision making under fuzzy environment," Fuzzy Sets and Systems, vol. 14, no. 1, pp. 1 –9, 2000.
[15] G. R. Jahanshahloo, F. H. Lotfi, and M. Izadikhah, "An algorithmic method to extend TOPSIS for decision-making problems with interval data," Applied Mathematics and Computation, vol. 175, no. 2, pp. 1375–1384, 2006.
[16] F. E. Boran, S. Genç, M. Kurt, and D. Akay, "A multi-criteria intuitionistic fuzzy group decision making for supplier selection with TOPSIS method.," Expert Systems with applications, vol. 36, no. 8, pp. 11363–11368, 2006.
[17] F. Ye, "An extended TOPSIS method with interval-valued intuitionistic fuzzy numbers for virtual enterprise partner selection.," Expert Systems with Applications, vol. 37, no. 10, pp. 7050–7055, 2010.
[18] M. Leyva Vázquez and F. Smarandache, “Neutrosofía: Nuevos avances en el tratamiento de la incertidumbre,” Pons, Bruselas., 2018.
[19] I. Del, "Operators on Single Valued Trapezoidal Neutrosophic Numbers and SVTN-Group Decision Making," Neutrosophic Sets and Systems, vol. 22, pp. 131–150, 2018.
[20] D. Xu, X. Wei, H. Ding, and H. Bin, "A new method based on PROMETHEE and TODIM for multi-attribute decision-making with single-valued neutrosophic sets.," Mathematics, vol. 8, no. 10, p. 1816, 2020.
[21] D. F. Li, "Multiattribute decision making models and methods using intuitionistic fuzzy sets.," Journal of computer and System Sciences, vol. 70, no. 1, pp. 73–85, 2005.
[22] P. Biswas, S. Pramanik, and B. C. Giri, "TOPSIS method for multi-attribute group decision-making under single-valued neutrosophic environment.," Neural computing and Applications, vol. 27, no. 3, 2016.
[23] J. Fanzo et al., "Global Nutrition Report: Shining a light to spur action on nutrition.," 2018.
[24] A. M. A. Elizondo, U. C. Murillo, and G. C. Arguedas, “Estrategia Regional para la promoción de Ambientes Nutricionales Saludables a través de la inserción de la Educación Alimentaria Nutricional (EAN) y la Agricultura Familiar (AF) en las mallas curriculares, en los Países de la Región SICA.,” 2020.

Doi : https://doi.org/10.54216/IJNS.1803018
Received: February 18, 2022 Accepted: May 03, 2022