Neutrosophic Sets and Systems, {Special Issue: Artificial Intelligence, Neutrosophy, and Latin American Worldviews: Toward a Sustainable Future (Workshop – March 18–21, 2025, Universidad Tecnológica de El Salvador, San Salvador, El Salvador)}, Vol. 84, 2025

University of New Mexico

Evaluation of three projects integrating ancestral knowledge into the circular economy in Peru using Neutrosophic N-Soft Sets

Wilmer Ortega Chávez [1], Edgar Ricardo Yauri Rivera [2], Cheryl Ruiz Bartra [3], Rolando Carlos Canteño Gavino [4], Elizabeth Norma Calixto Arias [5], Ciro Angel Lazo Salcedo [6], Miriam Esther Campos Llana [7], and Roberth Lozano Tacuri Toribio [8].

[1] Universidad Nacional Intercultural de la Amazonia, Pucallpa, Ucayali, Perú. wortegac@unia.edu.pe
[2] Universidad Nacional Intercultural de la Amazonia, Pucallpa, Ucayali, Perú. eyaurir@unia.edu.pe
[3] Universidad Nacional de Ucayali, Pucallpa, Ucayali, Perú. cheryl_ruiz@unu.edu.pe
[4] Universidad Nacional de Ucayali, Pucallpa, Ucayali, Perú. rolando_canteno@unu.edu.pe
[5] Universidad Nacional Intercultural Fabiola Salazar Leguía de Bagua, Perú. ecalixto@unibagua.edu.pe
[6] Universidad Nacional "Hermilio Valdizan", Huánuco, Perú. cirolazo@unheval.edu.pe
[7] Universidad Nacional Daniel Alcides Carrión, Cerro de Pasco, Perú. mcamposl@undac.edu.pe
[8] Universidad Nacional Daniel Alcides Carrión, Cerro de Pasco, Perú. rtacurit@undac.edu.pe

Abstract. The circular economy model, based on the reduction, reuse, and recycling of resources, is gaining increasing importance in today's society, particularly in sustainability. This research examines incorporating ancestral knowledge into this paradigm, addressing the connection between interculturality and sustainable resource management. Ancient communities have cultivated knowledge about natural resource management, recycling, and preservation that can be useful for contemporary circular economy strategies. Through an intercultural study, the multiple ways in which native and traditional cultures contribute to the circular economy are recognized, often with practices that have endured for centuries. However, the incorporation of this knowledge into contemporary legislative and economic contexts encounters multiple obstacles, including cultural, financial, and political barriers. The objective of this article is to evaluate three projects integrating ancestral Peruvian knowledge with the circular economy. Five experts evaluated these projects. The mathematical tool we used is Neutrosophic N-Soft Sets, where each object is associated with a grade on a scale from 0 to N-1, where N is a natural number greater than 1 and also a Single-Valued Neutrosophic Number. This ensures decision-making in multi-attribute problems where uncertainty is explicitly taken into account.

Keywords: Ancestral knowledge, Circular Economy, N-Soft Set, Single-Valued Neutrosophic Number, Single-Valued Neutrosophic Set, Neutrosophic N-Soft Set.

1. Introduction

The circular economy is an economic model that seeks to minimize waste and catch the most of available resources. Unlike more conventional economics, where products are manufactured, used, and then discarded, the circular economy proposes keeping resources in use for as long as possible through strategies such as recycling, reuse, and repair. It also proposes minimizing, eliminating, or reusing, if possible, the byproducts generated during the process, which constitute waste that pollutes the environment.

Among the principles of the circular economy are (1) designing zero-waste products so that they are durable, repairable, and recyclable; (2) keeping products in use where repair, reuse, and sharing are encouraged; (3) regenerating natural systems to ensure that waste is biodegradable or can be reintegrated into nature without causing harm. This model has environmental, social, and economic benefits, such as reducing carbon emissions, creating jobs in green sectors, and saving production costs.

Ancestral knowledge is knowledge passed down from generation to generation, developed by indigenous peoples through observation, practice, and interaction with their environment. This knowledge encompasses areas such as agriculture, medicine, spirituality, farming, and environmental management.

In the specific case of Peru, ancestral knowledge is deeply linked to indigenous cultures such as the

Incas and other pre-Columbian civilizations. Some notable examples include (1) the use of advanced agricultural techniques that optimize the productivity of mountainous terrain and ensure efficient irrigation; (2) the use of medicinal plants to alleviate some of the community's illnesses; (3) the study of astronomy, which ancient Peruvians used to predict agricultural cycles; and (4) the development of textiles to create fabrics with designs that convey stories, cultural symbols, and spiritual practices.

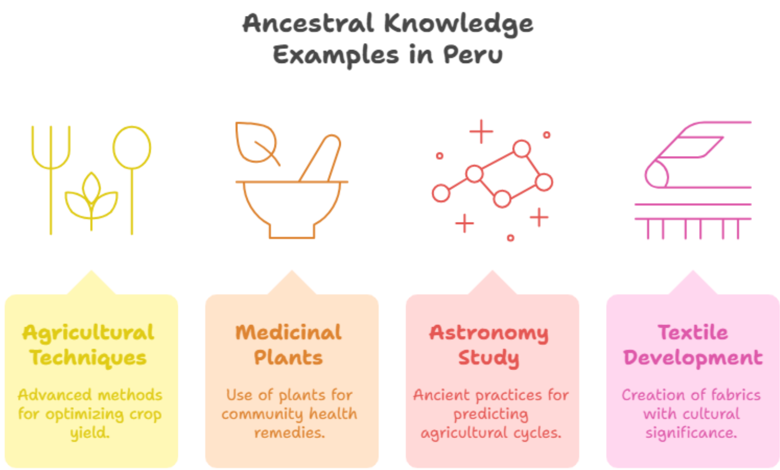

Figure 1. Notable Ancestral Knowledge Examples in Peru

This figure illustrates key areas of ancestral knowledge in Peru: (1) agricultural techniques for optimizing crop yield, (2) the use of medicinal plants for health remedies, (3) astronomy for predicting agricultural cycles, and (4) textile development with cultural significance. These traditional practices reflect sustainable solutions and cultural continuity.

This knowledge is not only a cultural legacy but also offers sustainable solutions to contemporary problems, such as climate change and biodiversity loss. Preserving it is key to maintaining cultural identity and harnessing its wisdom for the benefit of the future.

The study of the integration of ancestral knowledge into the circular economy, from an intercultural perspective, is particularly relevant in the Peruvian context, given the country's rich cultural heritage and biodiversity. In Peru, where diverse Indigenous communities have sustainably man-aged their natural resources for centuries, applying this traditional knowledge to the circular economy model can offer innovative avenues for sustainable development. This intercultural approach not only enriches circular economy practices with proven methods of resource efficiency but also promotes broader socioeconomic inclusion of historically marginalized communities.

By exploring how the principles of the circular economy can be aligned with ancestral knowledge, this analysis offers a framework for public policies that foster economic growth that is both inclusive and environmentally friendly. Consequently, this study contributes significantly to the global conversation on sustainability and presents a replicable model that is respectful of local cultural practices.

Researcher D. Molodtsov introduced the concept of Soft Set, which generalizes the well-known fuzzy sets by L. Zadeh, to deal with uncertainty, where it is not necessary to define a membership function [1-5]. In 2018, Fatimah et al. introduced N-Soft sets where the studied objects are ordered according to grades concerning a parameter or attribute [6-11]. On the other hand, Neutrosophic N-Soft Sets associate with each element of the N-Soft Set a triple of values to represent the degree of truthfulness, indeterminacy, and falsity of each grade for all the attributes [12-15]. This last extension allows taking into account the indeterminacy inherent to each evaluation.

In this paper, we use the opinions of a group of five experts in the circular economy and ancestral knowledge to evaluate how three circular economy integration projects with ancestral knowledge in Peru perform according to six dimensions.

To meet the proposed objective, we divide the article into a Materials and Methods section where we recall the fundamental concepts of Soft Sets, Single-Valued Neutrosophic Sets, N-Soft Sets, and Neutrosophic N-Soft Sets. This is followed by an evaluation section. The final section presents the article's conclusions.

2. Materials and Methods

This section summarizes the main concepts and theories that are part of the theoretical framework of this article. Let us start with the definition of Single-Valued Neutrosophic Sets.

Definition 1 ([16-19]). The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{< x;\ T_A(x), I_A(x), F_A(x) >: x \in U\}$, where $T_A: U \to [0,1]$, $I_A: U \to [0,1]$, and $F_A: U \to [0,1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

It is especially said that a *Single-Valued Neutrosophic Number* (SVNN) is a triple (T, I, F) satisfying $0 \leq T + I + F \leq 3$, so, it is an SVNS for a single value of x.

Among the operations with SVNNs, given (T_1, I_1, F_1) and (T_2, I_2, F_2) the following of them are fulfilled:

1. $(T_1, I_1, F_1) \leq_N (T_2, I_2, F_2)$ if and only if $T_1 \leq T_2$, $I_2 \leq I_1$, and $F_2 \leq F_1$,
2. $(T_1, I_1, F_1) \cap_N (T_2, I_2, F_2) = (min\{T_1, T_2\}, max\{I_1, I_2\}, max\{F_1, F_2\})$,
3. $(T_1, I_1, F_1) \cup_N (T_2, I_2, F_2) = (max\{T_1, T_2\}, min\{I_1, I_2\}, min\{F_1, F_2\})$.

Definition 2 ([1-5]). Given U is the initial universe set and E is the set of parameters. A pair (F, E) is called a *Soft Set* (over U) if and only if F is a mapping of E into the set of all subsets of U.

Therefore, given a set E of parameters and fixing a parameter $\varepsilon \in E$, then $F(\varepsilon) \in \mathcal{P}(U)$, where $\mathcal{P}(U)$ denotes the power set of U and $F(\varepsilon)$ is considered the set of ε-elements of the Soft Set (F, E) or the set of ε-approximate elements of the Soft Set.

In his work, Molodtsov referred to fuzzy sets as a type of soft sets, since the α-levels defined from the membership function μ_A satisfy the following property:

$F(\alpha) = \{x \in U \mid \mu_A(x) \geq \alpha\}$, $\alpha \in [0,1]$. Thus, if we know the family F, then we can reconstruct the function μ_A by using the following formula:

$$\mu_A(x) = \sup_{\substack{\alpha \in [0,1] \\ x \in F(\alpha)}} \alpha$$

Additionally, given a binary operation * for subsets of the set U, where (F, A) and (G, B) are soft sets over U. Then, the operation * for soft sets is defined as follows:

$(F, A) * (G, B) = (J, A \times B)$, where $J(\alpha, \beta) = F(\alpha) * G(\beta)$; $\alpha \in A$, $\beta \in B$, and $A \times B$ is the Cartesian product of the sets A and B.

Definition 3 ([6-11]). Given U is the initial universe set, E is the set of parameters, and $A \subseteq E$. Let $R = \{0, 1, 2, \cdots, N-1\}$ be the set of grades or ratings where $N > 1$. The triple (F, A, N) is called an N-Soft Set (NSS) over U, if $F: A \to \mathcal{P}(U \times R)$ is a function where for each $a_i \in A$, there is a unique $\left(u_j, r_{a_i}(u_j)\right) \in U \times R$ such that $\left(u_j, r_{a_i}(u_j)\right) \in F(a_i), u_j \in U, r_{a_i}(u_j) \in R$. An NSS can be expressed as:

$$(F, A, N) = \{(a_i, F(a_i)): a_i \in A\} = \left\{\left(a_i, \left\{\left(u_j, r_{a_i}(u_j)\right): u_j \in U\right\}\right): a_i \in A\right\}$$

Where $F(a_i) = \left\{\left(u_j, r_{a_i}(u_j)\right): u_j \in U\right\}$. For $\left(u_j, r_{a_i}(u_j)\right) \in F(a_i)$, which could be written as:

$$F(a_i)(u_j) = r_{a_i}(u_j).$$

N-Soft Sets can be represented with the help of a table called the Representation Table of an N-Soft Set, see Table 1.

Table 1: Schematic Representation Table of an N-Soft Set.

(F, A, N)	a_1	a_2	$\cdots$	a_q
u_1	$r_{a_1}(u_1)$	$r_{a_2}(u_1)$	$\cdots$	$r_{a_q}(u_1)$
u_2	$r_{a_1}(u_2)$	$r_{a_2}(u_2)$	$\cdots$	$r_{a_q}(u_2)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
u_p	$r_{a_1}(u_p)$	$r_{a_2}(u_p)$	$\cdots$	$r_{a_q}(u_p)$

Definition 4 ([6-11]). Let (F, A, N_1) and (G, B, N_2) be two N-Soft Sets over U. The operation of conjunction between them is an NSS $\left(H, A \times B, min(N_1, N_2)\right)$ where, for each $c = (a, b) \in A \times B$ and $u \in U$,

$$\left(u, r_{\mathrm{c}}(\mathrm{u})\right) \in H(c) \Leftrightarrow r_{\mathrm{c}}(\mathrm{u}) \coloneqq min\left(r_{\mathrm{a}}(\mathrm{u}), r_{\mathrm{b}}(\mathrm{u})\right) \text{ for } \left(u, r_a(u)\right) \in F(\mathrm{a}) \text{ and } \left(u, r_b(u)\right) \in G(\mathrm{b}).$$

Definition 5 ([6-11]). Let (F_1, A, N) and (F_2, B, N) be two N-Soft Sets over U. (F_1, A, N) is a subset of (F_2, B, N) if the following conditions are satisfied:

(1) $A \subseteq B$,

(2) $\forall a_i \in A$, and $u_j \in U$, $r^1_{a_i}(u_j) \leq r^2_{b_i}(u_j)$, where $\left(u_j, r^1_{a_i}(u_j)\right) \in F_1(a_i)$ and $\left(u_j, r^2_{b_i}(u_j)\right) \in F_2(b_i)$.

Thus, $(F_1, A, N) = (F_2, B, N)$ if and only if (F_1, A, N) is a subset of (F_2, B, N) and (F_2, B, N) is a subset of (F_1, A, N).

Definition 6 ([12-15]). Let U be the initial universe set, E be the set of parameters, and $R = \{0, 1, 2, \cdots, N-1\}$ be the set of degrees or ratings where $N > 1$. Also, we consider a non-empty subset $A \subseteq E$. Then, $\lambda_A = \left\{\left(a, \Gamma_A(a)\right): a \in A\right\}$ is a Neutrosophic N-Soft Set (NNSS).

Where $\Gamma_A(a) = \left\{\left(\langle u, T_{A(a)}(u), I_{A(a)}(u), F_{A(a)}(u)\rangle, r_{A(a)}(u)\right): r_A \in R, u \in U;\ T_A, I_A, F_A\ \in [0,1]\right\}$.

To better understand this last definition, let us revisit the example that appears in [15].

Example 1. Let $U = \{u_1, u_2\}$ and $E = \{a_1, a_2, a_3\}$. Consider $A = \{a_1, a_2\} \subseteq E$. Let us define an N8SS as $\lambda_A = \left\{\left(a_i, \Gamma_A(a_i)\right): a_i \in A, i = 1, 2\right\}$, where the N8SS is shown in Table 2 below,

Table 2: Tabular representation of the N8SS of the example. Source: [15].

(F, A, N)	a_1	a_2
u_1	6	3
u_2	4	5

Now let us define the NN8SS as follows:
$\Gamma_A(a_1) = \{(\langle u_1, 0.8,0.5,0.1\rangle, 6), (\langle u_2, 0.6,0.2,0.9\rangle, 4)\}$
$\Gamma_A(a_2) = \{(\langle u_1, 0.5,0.7,0.3\rangle, 3), (\langle u_2, 0.7,0.4,0.8\rangle, 5)\}$
The table form of this NN8SS is the following:

Table 3: Tabular representation of the NN8SS of the example. Source: [15].

(F, A, N)	a_1	a_2
u_1	$(\langle u_1, 0.8,0.5,0.1\rangle, 6)$	$(\langle u_2, 0.6,0.2,0.9\rangle, 4)$
u_2	$(\langle u_1, 0.5,0.7,0.3\rangle, 3)$	$(\langle u_2, 0.7,0.4,0.8\rangle, 5)$

3. The Assessment

This section displays the results of the evaluations performed. Let us begin by determining the dimensions (attributes) we use to evaluate.

The six key dimensions of research on the integration of ancestral knowledge into the circular economy, with an intercultural approach, in the Peruvian context could include:

a_1. Cultural Dimension: This dimension explores how ancestral knowledge and traditional practices can be integrated into contemporary circular economy models. It involves recognizing and valuing indigenous and local wisdom in natural resource management and in recycling and reuse techniques that have been sustainable for generations.

a_2. Ecological Dimension: Focuses on the application of ancient practices for sustainable resource management in the circular economy. This includes the study of traditional agricultural systems, such as crop rotation and agroforestry, which could improve the environmental sustainability of modern industrial practices.

a_3. Economic Dimension: Analyzes the economic impact of integrating ancestral knowledge into the circular economy. This may include the creation of new markets for products derived from sustainable practices, the promotion of ecological and cultural tourism, and the development of industries that use renewable resources and cleaner production processes.

a_4. Political Dimension: Examines the public policies needed to facilitate the integration of ancestral knowledge into the circular economy. This includes an analysis of current legislation, the need for legal reforms to protect and promote the use of traditional knowledge, and incentive policies for companies that implement sustainable practices.

a_5. Social Dimension: Considers the social aspects of the intercultural circular economy, especially in terms of social inclusion and equity. Explores how these practices can improve the quality of life of local communities, strengthen cultural identity, and ensure equitable sharing of the economic benefits generated.

a_6. Technological Dimension: Addresses the adaptation and application of modern technologies to complement and enhance ancestral knowledge without compromising its essence. This may include the development of technologies that allow for better documentation, preservation, and transmission of this knowledge, as well as its integration into larger industrial processes.

These dimensions facilitate a multidimensional analysis that not only assesses economic and environmental aspects, but also incorporates cultural, social, political, and technological considerations for a comprehensive and sustainable approach.

For the evaluation, the scale shown in Table 4 is used, inspired by the scale that appears in [15].

Table 4: Measurement scale inspired by the scale used in [15].

Degree of membership	Degree of non-membership	Grades
$T = 0$	$F = 1$	0
$0 < T \leq 0.2$	$0.8 \leq F < 1$	1
$0.2 < T \leq 0.4$	$0.6 \leq F < 0.8$	2
$0.4 < T \leq 0.6$	$0.4 \leq F < 0.6$	3
$0.6 < T \leq 0.8$	$0.2 \leq F < 0.4$	4
$0.8 < T \leq 1$	$0 \leq F < 0.2$	5

Note that Table 4 only indicates the ranges of values for T and F, the value of I is left to the expert's discretion in a range from 0 to 1.

Three projects or programs will be measured to integrate the knowledge of Peruvian Indigenous peoples with the circular economy, these are:

u_1. **Regenerative agriculture inspired by ancestral technologies**: Implement cultivation systems based on pre-Hispanic techniques such as *Waru Waru* (ridges) or cultivation terraces, which combine sustainable practices with ecological knowledge, promoting soil regeneration and efficient water use.

u_2. **Sustainable handicrafts with a circular approach**: Developing handcrafted products using traditional techniques, but with recycled or biodegradable materials. For example, incorporating natural fibers from agricultural waste to create textiles, promoting local communities, and minimizing environmental impact.

u_3. **Bioeconomy and natural medicine**: Revalue medicinal plants used by indigenous communities, integrating them into a circular production model.

The procedure followed is explained below:

1. Five experts in Circular Economy or Ancestral Knowledge within the group $E = \{e_1, e_2, e_3, e_4, e_5\}$ are asked to evaluate the three projects in terms of the 6 possible dimensions using the scale with the restrictions shown in Table 4. Note that the value of the indeterminacy is free to be established by each expert.
2. Each of them creates an NN6SS, and its tabular representation is similar to the one shown in Table 1.

3. The NN6SS values of the five experts are aggregated using the arithmetic mean of the corresponding values in the same cell. This gives a final grade and SVNN for each project for each aspect.
4. The arithmetic mean is calculated for all the attributes of the NN6SS for each of the projects. In this way, a grade between 0 and 5 is obtained for each of the projects with its corresponding Single-Valued Neutrosophic Number. These grades must be adjusted to an integer value.

Tables 5-10 below summarize the results of the assessments given by the experts in the form of NN6SS.

Table 5: Tabular representation of the NN6SSs corresponding to the expert e_1.

(F,A,N)	u_1	u_2	u_3
a_1	$(\langle u_1, 0.6,0.1,0.4\rangle,3)$	$(\langle u_2, 0.9,0.1,0.1\rangle,5)$	$(\langle u_3, 0.9,0,0.1\rangle,5)$
a_2	$(\langle u_1, 0.8,0,0.2\rangle,4)$	$(\langle u_2, 0.8,0,0.2\rangle,4)$	$(\langle u_3, 0.5,0.3,0.6\rangle,2)$
a_3	$(\langle u_1, 0.9,0.2,0.1\rangle,5)$	$(\langle u_2, 0.9,0.2,0.1\rangle,5)$	$(\langle u_3, 0.9,0.3,0.1\rangle,5)$
a_4	$(\langle u_1, 0.5,0.1,0.4\rangle,3)$	$(\langle u_2, 0.4,0.1,0.7\rangle,2)$	$(\langle u_3, 0.2,0.2,0.8\rangle,1)$
a_5	$(\langle u_1, 0.6,0.2,0.4\rangle,3)$	$(\langle u_2, 0.2,0.2,0.9\rangle,1)$	$(\langle u_3, 0.6,0.4,0.4\rangle,3)$
a_6	$(\langle u_1, 0.5,0.2,0.5\rangle,3)$	$(\langle u_2, 0.2,0,0.9\rangle,1)$	$(\langle u_3, 0.8,0.3,0.2\rangle,4)$

Table 6: Tabular representation of the NN6SSs corresponding to the expert e_2.

(F,A,N)	u_1	u_2	u_3
a_1	$(\langle u_1, 0.7,0.2,0.2\rangle,4)$	$(\langle u_2, 1,0,0\rangle,5)$	$(\langle u_3, 1,0.1,0\rangle,5)$
a_2	$(\langle u_1, 0.9,0.1,0\rangle,5)$	$(\langle u_2, 0.9,0.1,0\rangle,5)$	$(\langle u_3, 0.4,0.2,0.6\rangle,2)$
a_3	$(\langle u_1, 0.9,0.1,0\rangle,5)$	$(\langle u_2, 0.9,0.1,0\rangle,5)$	$(\langle u_3, 0.9,0,0.1\rangle,5)$
a_4	$(\langle u_1, 0.6,0.2,0.4\rangle,3)$	$(\langle u_2, 0,0,1\rangle,0)$	$(\langle u_3, 0.2,0.1,0.9\rangle,1)$
a_5	$(\langle u_1, 0.7,0.1,0.2\rangle,4)$	$(\langle u_2, 0.8,0.2,0.2\rangle,4)$	$(\langle u_3, 0.9,0,0.1\rangle,5)$
a_6	$(\langle u_1, 0.7,0.1,0.2\rangle,4)$	$(\langle u_2, 0,0,1\rangle,0)$	$(\langle u_3, 0.8,0.2,0.3\rangle,4)$

Table 7: Tabular representation of the NN6SSs corresponding to the expert e_3.

(F,A,N)	u_1	u_2	u_3
a_1	$(\langle u_1, 0.3,0.2,0.7\rangle,2)$	$(\langle u_2, 0.8,0.1,0.2\rangle,4)$	$(\langle u_3, 1,0,0\rangle,5)$
a_2	$(\langle u_1, 0.9,0.1,0.1\rangle,5)$	$(\langle u_2, 0.8,0.2,0.2\rangle,4)$	$(\langle u_3, 0.6,0.2,0.5\rangle,3)$
a_3	$(\langle u_1, 1,0,0\rangle,5)$	$(\langle u_2, 0.5,0.2,0.5\rangle,3)$	$(\langle u_3, 0.9,0.1,0\rangle,5)$
a_4	$(\langle u_1, 0.6,0.1,0.4\rangle,3)$	$(\langle u_2, 0.2,0.2,0.8\rangle,1)$	$(\langle u_3, 0.3,0.2,0.7\rangle,2)$
a_5	$(\langle u_1, 0.9,0.1,0.1\rangle,5)$	$(\langle u_2, 0.9,0.1,0.1\rangle,5)$	$(\langle u_3, 0.9,0.2,0\rangle,5)$
a_6	$(\langle u_1, 0.7,0.1,0.3\rangle,4)$	$(\langle u_2, 0.1,0.2,0.9\rangle,1)$	$(\langle u_3, 0.6,0.4,0.5\rangle,4)$

Table 8: Tabular representation of the NN6SSs corresponding to the expert e_4.

(F,A,N)	u_1	u_2	u_3
a_1	$(\langle u_1, 0.4,0.2,0.5\rangle,2)$	$(\langle u_2, 0.8,0.1,0.3\rangle,4)$	$(\langle u_3, 0.8,0,0.2\rangle,4)$
a_2	$(\langle u_1, 0.6,0.1,0.4\rangle,3)$	$(\langle u_2, 0.9,0.2,0.1\rangle,5)$	$(\langle u_3, 0.8,0,0.3\rangle,4)$
a_3	$(\langle u_1, 0.7,0.1,0.2\rangle,4)$	$(\langle u_2, 0.2,0,0.8\rangle,1)$	$(\langle u_3, 0.8,0,0.2\rangle,4)$
a_4	$(\langle u_1, 0.4,0.2,0.6\rangle,2)$	$(\langle u_2, 0,0,1\rangle,0)$	$(\langle u_3, 0,0,1\rangle,0)$
a_5	$(\langle u_1, 0.5,0.2,0.5\rangle,3)$	$(\langle u_2, 0.9,0.1,0.1\rangle,5)$	$(\langle u_3, 0.9,0.1,0.1\rangle,5)$
a_6	$(\langle u_1, 0.7,0.1,0.3\rangle,4)$	$(\langle u_2, 0.2,0.2,0.8\rangle,1)$	$(\langle u_3, 0.7,0.4,0.3\rangle,4)$

Table 9: Tabular representation of the NN6SSs corresponding to the expert e_5.

(F,A,N)	u_1	u_2	u_3
a_1	$(\langle u_1, 0.8,0.1,0.2\rangle,4)$	$(\langle u_2, 0.8,0.2,0.1\rangle,4)$	$(\langle u_3, 0.6,0.3,0.5\rangle,3)$
a_2	$(\langle u_1, 1,0,0\rangle,5)$	$(\langle u_2, 1,0,0\rangle,5)$	$(\langle u_3, 0.4,0.2,0.7\rangle,3)$
a_3	$(\langle u_1, 0.6,0.1,0.4\rangle,3)$	$(\langle u_2, 0.4,0.2,0.6\rangle,2)$	$(\langle u_3, 0.4,0.3,0.7\rangle,2)$
a_4	$(\langle u_1, 0.8,0.2,0.2\rangle,4)$	$(\langle u_2, 0.2,0.1,0.8\rangle,1)$	$(\langle u_3, 0.1,0,0.9\rangle,1)$

(F,A,N)	u_1	u_2	u_3
a_5	$(\langle u_1, 0.9,0.1,0.1\rangle,5)$	$(\langle u_2, 0.9,0.2,0.1\rangle,5)$	$(\langle u_3, 0.9,0.2,0.1\rangle,5)$
a_6	$(\langle u_1, 0.6,0.1,0.4\rangle,3)$	$(\langle u_2, 0,0.2,1\rangle,0)$	$(\langle u_3, 0.9,0.2,0.1\rangle,5)$

Table 10 contains the aggregation of the experts' assessments using the arithmetic mean.

Table 10: Tabular representation of the average of the NN6SSs corresponding to all experts.

(F,A,N)	u_1	u_2	u_3
a_1	$(\langle u_1, 0.56, 0.16, 0.4\rangle, 3.0)$	$(\langle u_2, 0.86, 0.1, 0.14\rangle, 4.4)$	$(\langle u_3, 0.86, 0.08, 0.16\rangle, 4.4)$
a_2	$(\langle u_1, 0.84, 0.06, 0.14\rangle, 4.4)$	$(\langle u_2, 0.88 , 0.1, 0.1\rangle, 4.6)$	$(\langle u_3, 0.54, 0.18, 0.54\rangle, 2.8)$
a_3	$(\langle u_1, 0.82, 0.1, 0.14\rangle, 4.4)$	$(\langle u_2, 0.58, 0.14, 0.4\rangle, 3.2)$	$(\langle u_3, 0.78, 0.14, 0.22\rangle, 4.2)$
a_4	$(\langle u_1, 0.58, 0.16, 0.4\rangle, 3.0)$	$(\langle u_2, 0.16, 0.08, 0.86\rangle, 0.8)$	$(\langle u_3, 0.16, 0.1, 0.86\rangle, 1.0)$
a_5	$(\langle u_1, 0.72, 0.14, 0.26\rangle, 4.0)$	$(\langle u_2, 0.74, 0.16, 0.28\rangle, 4.0)$	$(\langle u_3, 0.84, 0.18, 0.14\rangle, 4.6)$
a_6	$(\langle u_1, 0.64, 0.12, 0.34\rangle, 3.6)$	$(\langle u_2, 0.1, 0.12, 0.92\rangle, 0.6)$	$(\langle u_3, 0.76, 0.3, 0.28\rangle, 4.2)$

The results for each project are: $(\langle u_1, 0.693333, 0.123333, 0.28 \rangle, 3.73333)$, $(\langle u_2, 0.553333, 0.116667, 0.45 \rangle, 2.93333)$, and $(\langle u_3, 0.656667, 0.163333, 0.366667\rangle, 3.53333)$.

These are not NN6SSs because the grades are not integer. So, adjusting these values we have: $(\langle u_1, 0.693333, 0.123333, 0.28 \rangle, 4)$, $(\langle u_2, 0.553333, 0.116667, 0.45 \rangle, 3)$, and $(\langle u_3, 0.656667, 0.163333, 0.366667\rangle, 4)$.

4. Conclusion

The Circular Economy is a model that has spread throughout the world in the present century as a way to simultaneously solve multiple problems that plague us. However, many practices from ancestral indigenous peoples are part of our cultural arsenal, but they can also be relevant today in their practical application. This paper presented the evaluation carried out by five experts regarding six aspects of three projects currently being developed in Peru, which integrate the knowledge of Peruvian indigenous peoples and the Circular Economy. For the evaluation, we used the theory of Neutrosophic N-Soft Sets. This theory addresses the uncertainty and indeterminacy inherent to Neutrosophy, and N-Soft Sets, which are an extension of Soft Sets. The project with the highest grade was "Regenerative Agriculture Inspired by Ancestral Technologies", followed by "Bioeconomy and Natural Medicine", and "Sustainable Handicrafts with a Circular Approach". The grades and values of neutrosophic triples indicate that any of the three programs can be applied with results of at least Fair.

References

[1] Maji, P. K., Biswas, R., and Roy, A. R. (2003). Soft set theory. Computers & mathematics with applications, 45, 555-562.
[2] Al Ghour, S. (2021). Some modifications of pairwise soft sets and some of their related concepts. Mathematics, 9, 1781.
[3] Ma, X., Fei, Q., Qin, H., Li, H., and Chen, W. (2021). A new efficient decision making algorithm based on interval-valued fuzzy soft set. Applied Intelligence, 51, 3226-3240.
[4] Kalaiselvan, S., and Vijayabalaji, S. (2022). Soft expert symmetric group and its application in MCDM problem. Symmetry, 14, 2685.
[5] Alcantud, J. C. R., Khameneh, A. Z., Santos-García, G., and Akram, M. (2024). A systematic literature review of soft set theory. Neural Computing and Applications, 36, 8951-8975.
[6] Fatimah, F., and Alcantud, J. C. R. (2021). The multi-fuzzy N-soft set and its applications to decision-making. Neural Computing and Applications, 33, 11437-11446.
[7] Akram, M., Ali, G., Alcantud, J. C., and Fatimah, F. (2021). Parameter reductions in N-soft sets and their applications in decision-making. Expert Systems, 38, e12601.
[8] Ali, S., Kousar, M., Xin, Q., Pamučar, D., Hameed, M. S., and Fayyaz, R. (2021). Belief and possibility belief

interval-valued N-soft set and their applications in multi-attribute decision-making problems. Entropy, 23, 1498.
[9] Liu, J., Chen, Z., Chen, Y., Zhang, Y., and Li, C. (2021). Multiattribute group decision making based on interval-valued neutrosophic N-soft sets. Granular Computing, 6, 1009-1023.
[10] Alcantud, J. C. R. (2022). The semantics of N-soft sets, their applications, and a coda about three-way decision. Information Sciences, 606, 837-852.
[11] Alcantud, J. C. R., Santos-García, G., and Akram, M. (2022). OWA aggregation operators and multi-agent decisions with N-soft sets. Expert Systems with Applications, 203, 117430.
[12] Liu, J., Chen, Z., Chen, Y., Zhang, Y., and Li, C. (2021). Multiattribute group decision making based on interval-valued neutrosophic N-soft sets. Granular Computing, 6, 1009-1023.
[13] Ashraf, A., and Butt, M. A. (2021). Extension of TOPSIS Method under Single-Valued Neutrosophic N-Soft Environment. Neutrosophic Sets and Systems, 41, 286-303.
[14] Demirtaş, N., and Dalkılıç, O. (2021). Neutrosophic extension of N-soft set and similarity-based decision-making. Turkish Journal of Mathematics and Computer Science, 13, 294-309.
[15] Riaz, M., Naeem, K., Zareef, I., and Afzal, D. (2020). Neutrosophic N-soft sets with TOPSIS method for multiple attribute decision making. Neutrosophic sets and systems, 32, 146-170.
[16] Deli, I., and Subas, Y. (2014). Single valued neutrosophic numbers and their applications to multicriteria decision making problem. Neutrosophic Sets Syst, 2, 1-13.
[17] Ricardo, J. E., Fernández, A. J., & Vázquez, M. Y. (2022). Compensatory Fuzzy Logic with Single Valued Neutrosophic Numbers in the Analysis of University Strategic Management. International Journal of Neutrosophic Science (IJNS), 18(4).
[18] Ye, J., Yong, R., & Du, W. (2024). MAGDM Model Using Single-Valued Neutrosophic Credibility Matrix Energy and Its Decision-Making Application. Neutrosophic Systems With Applications, 17, 1-20. https://doi.org/10.61356/j.nswa.2024.17243.
[19] Álvarez Gómez, G., Viteri Moya, J., & Estupiñán Ricardo, J. (2020). Método para medir la formación de competencias pedagógicas mediante números neutrosóficos de valor único. Neutrosophic Computing and Machine Learning, 11, 38–44. https://doi.org/10.5281/zenodo.3558988

Received: December 22, 2024. Accepted: April 3, 2025.