Socioeconomic and Environmental Impact of the Implementation of Renewable Energy: An Analysis from the Neutrosophic PEST-SWOT

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Abstract

The Mantaro Valley in Peru is an inter-Andean River valley, through which the Mantaro River passes. Approximately a population of one million inhabitants live here. Currently, the damage caused by the use of non-renewable energy sources is very evident, both to the environment and to the local economy, which will become unsustainable in the future. That is why we want to critically study the implementation of renewable energy projects that support the generation of electricity and other types of energy in this area. However, this has some positive and negative elements. In this paper, we apply a PEST-SWOT analysis to evaluate the balance of each of these aspects. Furthermore, we use an evaluation in the form of single-valued neutrosophic numbers, which allow us to capture the uncertainty and indeterminacy in this decision-making problem.

Keywords: Renewable Energies; SWOT Analysis; PEST Analysis; Single-Valued Neutrosophic Numbers; Neutrosophic PEST-SWOT Analysis.

1. Introduction

The Mantaro Valley in Peru, which is known for its stunning natural beauty and rich cultural history, faces significant socioeconomic and environmental challenges. Like many regions of the world, it is affected by climate change, environmental degradation, and dependence on unsustainable energy sources. Given this reality, the implementation of renewable energies emerges as a promising alternative to address these challenges comprehensively.

There is a wide variety of renewable energy sources that can be used by nature, and they are not sufficiently used yet. This may be due to the need to have the necessary technology to carry out this exploitation. These technologies are practically in the hands of first-world transnational companies, which is why countries like Peru must import the necessary equipment, which could be expensive. On the other hand, it would be necessary to invest in the maintenance of the equipment and in the training of local workers who work in these plants. However, we consider that in the medium and long term, this investment will be profitable.

On the other hand, traditional financial and purely economic measures are not sufficient to evaluate the impact that a renewable energy project would have on our country, from a political, social, and ecological point of view. Among the most notable renewable energies is hydraulic energy, such that the potential energy accumulated in

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waterfalls can be transformed into electrical energy. Solar thermal energy tries to collect energy from the sun through solar panels and convert it into heat which can be used to satisfy numerous needs. Solar energy can also generate non-polluting electrical energy. Wind energy takes advantage of the force of the winds, or in other words, the kinetic energy obtained from the winds.

In this critical review, we explore the socioeconomic and environmental impact of the adoption of renewable energy in the Mantaro Valley. We immerse ourselves in an exhaustive analysis of the implications that this energy transition may have in the region, considering both its positive aspects and the possible challenges and limitations that could arise.

Through this research, we seek to understand how the introduction of renewable energy sources, such as solar, wind, hydroelectric, and others, can reshape the socioeconomic and environmental landscape of the Mantaro Valley. Furthermore, we examine how these initiatives can influence crucial aspects such as job creation, improving the quality of life of local communities, reducing greenhouse gas emissions, and conserving the natural environment. By approaching this issue from a critical perspective, we aim to provide a balanced assessment of the benefits and potential drawbacks associated with the implementation of renewable energy in the Mantaro Valley. With this review, we hope to contribute to informed debate and strategic decision-making that promotes sustainable development in this emblematic region of Peru.

To achieve our objective, we use a neutrosophic mathematical model based on PEST and SWOT [1-2]. The SWOT analysis allows the study of a project even when it is future, in terms of its internal characteristics (Strengths and Weaknesses) and its external characteristics (Opportunities and Threats) [3-6]. The study of external factors can be carried out through PEST analysis, which identifies the factors (Political, Economic, Social, and Technological) in the general environment that will affect the project [7-9]. Evaluation with the help of neutrosophic tools allows us to capture the indeterminacy of decision-making and the uncertainty that exists in it. So, in this paper, we study the feasibility of carrying out a renewable energy project in the Mantaro Valley in Peru with the help of evaluative tools such as the combination of PEST, SWOT, and single-valued triangular neutrosophic numbers. More literature about neutrosophy combined with SWOT PEST or Neutrosophic decision-making can be read in [10-13].

2 Materials and Methods

2.1 SWOT analysis

SWOT analysis is a methodology for studying the situation of a company or a project, analyzing its internal characteristics (Weaknesses and Strengths) and its external situation (Threats and Opportunities) in a square matrix [3-6].

This analysis is carried out in four stages:

- External analysis,
- Internal analysis,
- Preparation of the SWOT matrix,
- Determination of the strategy to use.

It is known that the existence of the organization is essentially linked to the environment that surrounds it. This environment contains opportunities and threats that can be presented to the organization. These are the aspects that are measured in the external analysis. On the other hand, there are internal elements of the organization, these are the weaknesses and strengths, which depend directly on the management carried out internally.

These four aspects can be classified as positive or favorable for the development of the organization, or negative and unfavorable that hinder this development. Opportunities are positive factors that exist in the environment and when they are identified we can be taken advantage of, to promote the good development of the organization or the project. Threats are also external factors, but they represent a negative influence on the organization or project. These can threaten the organization or the project and, in this case, it would be necessary to design tactics and strategies to overcome these obstacles. Within the internal aspects, the weaknesses of the organization or the project are negative elements that must be overcome and that are directly manageable by the elements that are the functional basis of the organization or the project. Meanwhile, strengths are positive aspects that mean the opposite of weaknesses and that must be taken advantage of, and they can be enhanced internally.

During the SWOT analysis, strengths and weaknesses can be found in aspects such as the availability of capital resources, personnel, assets, product quality, internal and market structure, and consumer perception, among others. That is why internal analysis allows us to determine the quantity and quality of the resources and processes

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that the organization or project has and that can be managed by the entity. The four elements of the analysis are placed in a matrix and evaluated by experts. These results are aggregated using the percentages of their evaluations.Within the evaluative analysis, combining the positive aspects that are the strengths with the opportunities, the potentialities are obtained, in this way, the most promising strategies and tactics for the organization or the project can be determined.

These promising actions can be limited by combining weaknesses with threats. This combination should never be lost sight of, as it constitutes a brake on the organization.The risks (combination of strengths and threats) and challenges (combination of weaknesses and opportunities), determined by their corresponding combination of factors, will require careful consideration to set the organization's course toward a desirable future.

2.2 PEST analysis

The PEST analysis identifies the external factors that affect the company. PEST refers to the components to be analyzed: Political, Economic, Social, and Technological [7-9].
A more detailed explanation is read below:
Political-legal: Factors related to the legislative regulation of a government. For example, environmental protection laws, antitrust laws, and government stability.
Economic: Economic factors that affect the market.
Socio-cultural: Configuration of market members and their influence on the environment.
Technological: State of technological development and its contributions to business activity.
The PEST-SWOT combination consists of two steps [1-2]. The first of them analyzes the external factors that affect the company, from a political, economic, social, technological, and scientific point of view.
The second step consists of identifying and evaluating the internal aspects of the company, according to the SWOT method. The combination of PEST analysis with SWOT analysis results in a more complete study of the business situation.

2. 3 Basics About Neutrosophy

Unlike traditional PEST-SWOT methods, in this paper evaluations are carried out based on Single-Valued Triangular Neutrosophic Numbers. Below are the fundamental explanations on this topic.
Definition 1 ([14-17]): The Neutrosophic set N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]^{-}0, 1^{+}[$, and $^{-}0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^{+}$.
See that according to the definition, $T_A(x), I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]^{-}0, 1^{+}[$ and hence, $T_A(x), I_A(x)$ and $F_A(x)$ can be subintervals of $[0, 1]$. $^{-}0$ and 1^{+} belong to the set of hyperreal numbers.
Definition 2 ([14-17]): The Single-Valued Neutrosophic Set (SVNN) Aover Uis $A = \{< x, T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$and $F_A: U \to [0, 1]$. $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.
The Single-Valued Neutrosophic Number (SVNN) is symbolized by
$N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$and $0 \leq t + i + f \leq 3$.
Definition 3 ([14-17]): The single-valued triangular neutrosophic number, $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy, and falsity membership functions are defined as follows:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}\left(\frac{x-a_1}{a_2-a_1}\right), a_1 \leq x \leq a_2} \\ \alpha_{\tilde{a}, x=a_2} \\ \alpha_{\tilde{a}\left(\frac{a_3-x}{a_3-a_2}\right), a_2 < x \leq a_3} \\ 0, \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \beta_{\tilde{a}}(x - a_1))}{a_2 - a_1}, a_1 \leq x \leq a_2 \\ \beta_{\tilde{a},}\ x = a_2 \\ \frac{(x - a_2 + \beta_{\tilde{a}}(a_3 - x))}{a_3 - a_2},\ a_2 < x \leq a_3 \\ 1, \text{otherwise} \end{cases} \quad (2)$$

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$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \gamma_{\tilde{a}}(x - a_1))}{a_2 - a_1}, a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, x = a_2 \\ \frac{(x - a_2 + \gamma_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, \ a_2 < x \leq a_3 \\ 1, \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$, $a_1, a_2, a_3 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3$.

Definition 4 ([14-17]): Given $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued triangular neutrosophic numbers and λ any non-null number in the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
3. Inversion: $\tilde{a}^{-1} = \langle (a_3^{-1}, a_2^{-1}, a_1^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$.
4. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda > 0 \\ \langle (\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, \lambda < 0 \end{cases}$$
5. Division of two triangular neutrosophic numbers:
$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle \left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 > 0 \text{ and } b_3 > 0 \\ \langle \left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle \left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$
6. Multiplication of two triangular neutrosophic numbers:
$$\tilde{a}\tilde{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, \ a_3 > 0 \text{ and } b_3 > 0 \\ \langle (a_1 b_3, a_2 b_2, a_3 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 > 0 \\ \langle (a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \text{ and } b_3 < 0 \end{cases}$$

Where, $\wedge$ is a t-norm and $\vee$ is a t-conorm [18,19].

3 Results of the Study

The study is carried out on the factors that positively or negatively influence the implementation of a renewable energy project in Valle del Mantaro. To do this, experts on the topic and specialized literature were consulted. In this way, the following factors were identified:

To build a comprehensive model that evaluates the socioeconomic and environmental impact of the implementation of renewable energies in the Mantaro Valley, in Peru, it is essential to consider a series of critical indicators that cover various aspects. Here is a list of the key indicators that could be relevant to this analysis:

- Employment generation: Measure the number of direct and indirect jobs created through the development, construction, and operation of renewable energy projects in the region. This includes both temporary and permanent jobs, as well as the quality and stability of these jobs.
- Investment and financing: Evaluate the amount of public and private investment destined for renewable energy projects in the Mantaro Valley, as well as the financing sources and support mechanisms used.
- Impact on the local economy: Analyze how the implementation of renewable energy affects the local economy, including increasing income for local inhabitants, business development, and the revitalization of sectors such as tourism and agriculture.
- Reduction of greenhouse gas emissions: Quantify the amount of CO_2 and other greenhouse gas emissions avoided through renewable energy generation compared to conventional energy sources.
- Energy coverage and electricity access: Evaluate how the implementation of renewable energy improves energy coverage in the region, as well as access to electricity for rural communities and remote areas.
- Impact on air quality and public health: Study how replacing fossil fuels with renewable energy reduces air pollution and improves air quality, which in turn can have significant health benefits for local people.
- Resilience and adaptation to climate change: Investigate how the diversification of the energy matrix towards renewable sources contributes to the resilience of the region against extreme climate events and other impacts of climate change.
- Conservation of natural resources and biodiversity: Evaluate the impact of renewable energy projects on

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the conservation of local natural resources, including the protection of sensitive ecosystems and biodiversity.

- Community participation and empowerment: Analyze the degree of participation of local communities in the development and decision-making on renewable energy projects, as well as their empowerment in terms of ownership and shared benefits.

By integrating these critical indicators into a comprehensive analysis model, a more complete and balanced view of the impact of renewable energy in the Mantaro Valley can be obtained, which in turn can inform the formulation of sustainable development policies and strategies in the region.

The construction of a comprehensive model on the socioeconomic and environmental impact of the implementation of renewable energies in the Mantaro Valley, in Peru, may face several obstacles that require attention and consideration. The main obstacles include:

- Data availability and quality: The lack of accurate and up-to-date data on key variables, such as renewable energy production, employment generated, and environmental and social impacts, can make it difficult to build an accurate and reliable model.
- Complexity and multidimensionality of impacts: Analysis of the socioeconomic and environmental impacts of renewable energy involves multiple interconnected variables and can be difficult to comprehensively capture in a single model.
- Geographic and contextual variability: The geographical, socioeconomic, and environmental characteristics of the Mantaro Valley can vary considerably in different areas, which requires adapting the model to local specificities and considering the heterogeneity of impacts.
- External factors and uncertainty: The influence of external factors, such as changes in energy policies, fluctuations in natural resource prices, and extreme weather events, can introduce uncertainty into the model and make it difficult to accurately predict impacts.
- Community participation and perceptions: Lack of adequate participation and consultation with local communities can lead to a lack of understanding of their needs, concerns, and perceptions about renewable energy projects, which can affect the accuracy and validity of the model.
- Technological and infrastructure limitations: The lack of adequate technologies and energy infrastructure may limit the ability to implement and scale renewable energy projects in the Mantaro Valley, directly affecting the model results.
- Regulatory and political framework: The existence of regulatory, political, and legal barriers can hinder the development of renewable energy projects and affect their economic viability, which must be considered in the model.
- Human resources and training: The lack of trained personnel and experts in the region can hinder the construction and application of robust impact assessment models, as well as the effective implementation of renewable energy projects.

Addressing these obstacles requires a multidisciplinary approach that integrates diverse perspectives, collaboration between different actors, comprehensive data collection, and careful analysis of the complexity and uncertainty inherent in socioeconomic and environmental impact assessment.

According to the PEST analysis, we classify the previous aspects into threats and opportunities, in terms of the four aspects of this analysis.

1. Threats

1.1 Political

$\mathbf{T_1}$: Availability and quality of data,

$\mathbf{T_2}$: Regulatory and political framework,

1.2 Economic

$\mathbf{T_3}$: External factors and uncertainty,

$\mathbf{T_4}$: Impact on air quality and public health,

1.3 Social

$\mathbf{T_5}$: Community participation and perceptions,

1.4 Technological

$\mathbf{T_6}$: Geographic and contextual variability,

$\mathbf{T_7}$: Technological and infrastructure limitations,

2. Opportunities

2.1. Political

$\mathbf{O_1}$**:** Reduction of greenhouse gas emissions,

2.2. Economic

$\mathbf{O_2}$: Investment and financing,

$\mathbf{O_3}$: Impact on the local economy,

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2.3. Social
O_4: Employment generation,
O_5: Energy coverage and access to electricity,
3. Weaknesses
W_1: Human resources and training,
W_2: Complexity and multidimensionality of impacts,
4. Strengths
S_1: Community participation and empowerment,
S_2: Resilience and adaptation to climate change,
S_3: Conservation of natural resources and biodiversity.

There was a group of 11 experts, who evaluated the possible combinations of an external factor with an internal factor. To do this, they were asked to evaluate using the linguistic terms that appear in Table 4.

Table 1: Linguistic terms for evaluations and their associated SVTNNs. See [14-17].

Linguistic Terms	SVTNN
Very low (VL)	$\langle(0,0,1); 0.00, 1.00, 1.00\rangle$
Low (L)	$\langle(0,1,3); 0.17, 0.85, 0.83\rangle$
Medium Low (MDL)	$\langle(1,3,5); 0.33, 0.75, 0.67\rangle$
Medium (M)	$\langle(3,5,7); 0.50, 0.50, 0.50\rangle$
Medium High (MDH)	$\langle(5,7,9); 0.67, 0.25, 0.33\rangle$
High (H)	$\langle(7,9,10); 0.83, 0.15, 0.17\rangle$
Very High (VH)	$\langle(9,10,10); 0.00, 1.00, 1.00\rangle$

Specifically, there are the following sets:
$W = \{W_1, W_2\}$ denotes the set of Weaknesses,
$S = \{S_1, S_2, S_3\}$ denotes the set of Strengths,
$T = \{T_1, T_2, T_3, T_4, T_5, T_6, T_7\}$ denotes the set of Threats,
$O = \{O_1, O_2, O_3, O_4, O_5\}$ denotes the set of Opportunities.

The steps are the following:
1. Each expert was asked to evaluate the possible combinations between the elements of SO, ST, WO, and WT. This evaluation is carried out in terms of how the combination would influence the implementation of a renewable energy project in the Mantaro Valley.
2. Linguistic terms are replaced by the equivalent Single-Valued Triangular Neutrosophic Numbers (SVTNN) in Table 4.
3. A unique SVTNN is obtained by calculating the median of the SVTNNs for all experts for each pair of items.
4. The arithmetic means of the SVTNN for each quadrant SO, ST, WO and WT, is calculated.
5. The final result for each quadrant is converted into a crisp value using Equation 4 of accuracy. This converts them into values on a numerical scale out of 10 that allows the results to be compared.

$$A(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \qquad (4)$$

Tables 5, 6, 7, and 8 summarize the results obtained after applying the previous steps.

Table 2: Calculation results for the SO quadrant. Medians are shown for all experts.

		Opportunities				
		$\boldsymbol{O_1}$	$\boldsymbol{O_2}$	$\boldsymbol{O_3}$	$\boldsymbol{O_4}$	$\boldsymbol{O_5}$
Strengths	$\boldsymbol{S_1}$	MDH	H	H	VH	VH
	$\boldsymbol{S_2}$	H	VH	H	H	H
	$\boldsymbol{S_3}$	VH	VH	VH	H	H

Table 3: Calculation results for the ST quadrant. Medians are shown for all experts.

	Threats

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		T_1	T_2	T_3	T_4	T_5	T_6	T_7
Strengths	S_1	MDH	H	MDH	MDH	VH	H	H
	S_2	H	H	H	H	H	H	H
	S_3	H	MDH	H	H	H	MDH	H

Table 4: Calculation results for the WO quadrant. Medians are shown for all experts.

		Opportunities				
		O_1	O_2	O_3	O_4	O_5
Weaknes-ses	w_1	MDH	MDH	MDH	MDH	MDH
	w_2	MDH	MDH	MDH	MDH	MDH

Table 5: Calculation results for the WT quadrant. Medians are shown for all experts.

		Threats						
		T_1	T_2	T_3	T_4	T_5	T_6	T_7
Weaknes-ses	w_1	H	H	H	H	H	H	H
	w_2	M	M	M	M	M	M	M

From Tables 5-8, we have the following results:

- Potentials (Opportunities+Strengths): $\langle(7.6667, 9.2667, 9.9333); 0.67, 0.25, 0.33\rangle$,
- Risks (Strengths+Threats): $\langle(6.6190, 8.5714, 9.7619); 0.67, 0.25, 0.33\rangle$,
- Challenges (Weaknesses+Opportunities): $\langle(5, 7, 9); 0.67, 0.25, 0.33\rangle$,
- Limitations (Weaknesses+Threats): $\langle(5.0, 7.0, 8.5); 0.50, 0.50, 0.50\rangle$.

As a last step, these values are converted into a crisp scale with a maximum of 10 using Equation 4. From here we have the following results:

- Potentials (Opportunities+Strengths): 9.2354,
- Risks (Strengths+Threats): 8.5774,
- Challenges (Weaknesses+Opportunities): 7.2188,
- Limitations (Weaknesses+Threats): 6.4062.

3. Conclusion

The implementation of projects for the generation of renewable energy in the Mantaro Valley in Peru is a very welcome idea by the local inhabitants and the authorities. However, to develop the project it is necessary to carry out a preliminary study about the factors that would enhance or hinder the creation of such projects. This article addresses this problem, first identifying a total of both positive and negative factors that could influence a project of such magnitude. The tool selected to model this assessment was a Neutrosophic PEST-SWOT. The PEST analysis allowed the identification of external factors that could affect the project as a preliminary process. These results are incorporated into the SWOT analysis to determine the internal factors that would affect the project. Single-valued triangular Neutrosophic Numbers were used for the measurement. The inclusion of neutrosophic tools allowed us to take into account uncertainty, indeterminacy, and the use of a linguistic scale. 11 experts determined that the potential is very high, although the risks are also high, the challenges are high, but to a lesser degree than the risks and potential. Finally, the limitations are not negligible, but they are of a lesser degree than the other aspects measured.

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References

[1] Yasir, M. Zafar, A. Anas, M. (2023). NEP-2020's Implementation & Execution: A Study Conducted Using Neutrosophic PESTEL Analysis. International Journal of Neutrosophic Science, 20(2), 86-106.

[2] Xu, K., Xu, W., Liu, C., Liu, Y., Yang, F., Sheng, M., and Cao, M. (2022, October). Research on the development path of a new power system based on SWOT-PEST analysis. In 2022 Asian Conference on Frontiers of

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Power and Energy (ACFPE) (pp. 387-393). IEEE.

[3] Benzaghta, M. A., Elwalda, A., Mousa, M. M., Erkan, I., and Rahman, M. (2021). SWOT analysis applications: An integrative literature review. Journal of Global Business Insights, 6(1), 54-72.

[4] Yusuf, M., Saiyed, R., and Sahala, J. (2022, December). Swot Analysis in Making Relationship Marketing Program. In Proceeding of The International Conference on Economics and Business (Vol. 1, No. 2, pp. 573-588).

[5] Longsheng, C., Shah, S. A. A., Solangi, Y. A., Ahmad, M., and Ali, S. (2022). An integrated SWOT-multi-criteria analysis of implementing sustainable waste-to-energy in Pakistan. Renewable Energy, 195, 1438-1453.

[6] Farrokhnia, M., Banihashem, S. K., Noroozi, O., and Wals, A. (2024). A SWOT analysis of ChatGPT: Implications for educational practice and research. Innovations in education and teaching international, 61(3), 460-474.

[7] Vázquez, M. L., Hernández, J. H., Batista-Hernández, N.., Salvatierra, J. A. A., and Baryolo, O. G. (2018). A framework for PEST analysis based on fuzzy decision maps. Espacios, 39, 13.

[8] Matović, I. M. (2020, September). PESTEL analysis of the external environment as a success factor of a startup business. In ConScienS conference proceedings (pp. 96-102). Scientia Moralitas Research Institute.

[9] Cox, J. (2021). The higher education environment driving academic library strategy: A political, economic, social and technological (PEST) analysis. The Journal of Academic Librarianship, 47, 102219.

[10] Batista-Hernández, N., Vega, J. A. F., Cuzco, N. E. U., and Merchán, M. M. F. (2020). Método Neutrosófico para latoma de decisiones sobre procedimiento de licitación para la adquisición de bienes y servicios en la contratación pública. Neutrosophics Computing and Machine Learning, 11, 1-8.

[11] Batista-Hernández, N., Leyva-Vázquez, M. Y., González-Caballero, E., Cruzaty, L. E. V., Ortega-Chávez, W., and Smarandache, F. (2021). A new method to assess entrepreneurship competence in university students using based on plithogenic numbers and SWOT analysis. International Journal of Fuzzy Logic and Intelligent Systems, 21, 280-292.

[12] Obbineni, J., Kandasamy, I., Vasantha, W. B., and Smarandache, F. (2023). Combining SWOT analysis and neutrosophic cognitive maps for multi-criteria decision making: a case study of organic agriculture in India. Soft Computing, 27, 18311-18332.

[13] Chaudhary, G. Mahmoud, A. A., J. (2023). Sentiment Analysis for Social Media Tweets Using Single-Valued Neutrosophic Sets and Fuzzy Sets. Journal of Journal of Neutrosophic and Fuzzy Systems, 5(2), 51-59. DOI: https://doi.org/10.54216/JNFS.050205

[14] Elisabeth, Nery. , I., Anderson. , E., Isaac. , N., Mirian. , Kümmel, Christian. Neutrosophic Delphi method to analyze the impact of Internships on the comprehensive development of university students. International Journal of Neutrosophic Science, vol. 24, no. 4, 2024, pp. 223-232.

[15] Dhouib, S. (2021). Optimization of travelling salesman problem on single valued triangular neutrosophic number using dhouib-matrix-TSP1 heuristic. International Journal of Engineering, 34, 2642-2647.

[16] Kumar, S. Edalatpanah, S. (2020). A new ranking function of triangular neutrosophic number and its application in integer programming. International Journal of Neutrosophic Science, 4(2), 82-92.

[17] Mathew, L. P., and Sebastian, L. (2023, June). An introduction to single valued neutrosophic fuzzy numbers, trapezoidal single valued neutrosophic fuzzy numbers and triangular single valued neutrosophic fuzzy numbers. In AIP Conference Proceedings (Vol. 2875, No. 1). AIP Publishing.

[18] S., A. Emad, M. Ismail, M. Rashad, H. M., A. Abdelhafeez, A. S., S. (2023). An Intelligent Multi-Criteria Decision-Making Model for selecting an optimal location for a data center: Case Study in Egypt. Journal of Intelligent Systems and Internet of Things, 9(2), 23-35.

[19] B., J. Mauricio, K. Marks, A. (2024). Fusion of Forensic Analysis of Mobile Devices: Integrating Multi-Criteria Decision Methods and Case Study Insights. Fusion: Practice and Applications, 16(2), 32-42.

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