PESTEL analysis of environment state responsibility in Ecuador

Alba Rosa Pupo Kairuz[1], Dionisio Vitalio Ponce Ruiz [2], Gonzalo Favián Viteri Pita[3] and Fernando Samuel Bustillo Mena[4]

[1] Professor, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: apupokairuz@gmail.com
[2] Professor, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: manzanillo1962@gmail.com
[3] Professor, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: favigonza@hotmail.com
[4] Professor, Universidad Regional Autónoma de Los Andes, Ecuador. E-mail: sbustillosmena@outlook.com

Abstract: The care and conservation of the environment is currently a task to ensure human survival. Various are the negative environmental impacts to which the planet is subjected. Quantifying the adverse events that the planet faces constitutes an activity little addressed by science. The present investigation describes a solution to the problem posed from the development of a method for environmental evaluation. It uses a multicriteria approach and models its inference by means of Neutrosophics Cognitive Maps.

Keywords: Method; Environmental evaluation; Neutrosophics Cognitive Maps.

1 Introduction

Environmental problems affect sustainable and ecologically sustainable development. These problems occupy the center of concerns in today's world. This is largely due to the fact that the environmental deterioration has reached very high levels. Currently it is necessary to think about the search for solutions, to help reduce the impacts caused by man in his nature-society relationship. The protection of the environment is one of the most important responsibilities of the society that works in entities, companies and in the community in general [1], [2], [3].

Environmental problems have changed the way we relate to the environment and society, making it clear those human beings is essential elements in the composition of the environment. Law as instrumental social science cannot afford to be oblivious to this problem that affects humanity to the point of compromising its existence in a mediated future.

The knowledge of environmental problems promotes individual and collective responsibility to face the ecological and social deterioration manifested in many underdeveloped countries. The search for sustainable development for all must be a worldwide government priority [4], [5], [6].

Ecuador is a country with 278,000 square km of surface and has 50 areas within the National System of Protected Areas. The biological diversity of Ecuador places it among the most important countries on the planet.

Ecuador has a privileged geographical location in the geotropic. Its varied relief and influence of sea currents converge to build the context of the most varied life forms of flora and fauna. The 49 existing protected areas comprise 19.1 million Hectares, which represents 19% of the total area of the country. It has 11 national parks, 9 ecological reserves, 6 biological reserves, 1 geobotanical reserve, 4 wildlife production reserves and 10 wildlife refuges [8], [9], [10].

Ecuador maintains an important interest in preserving the natural spaces that place it as one of the most diverse countries on the planet. The reasons are based on the fact that it is the first mega diverse country in the world, second in diversity of endemic vertebrates, third country in diversity of amphibians, fourth in diversity of birds and fifth in diversity of papillonic butterflies [11], [12], [13]. As an important part of social services, environmental protection constitutes a political interest in Ecuador to reduce the adverse effects listed above.

In Ecuador, the Constitution of the Republic, in its article 397 No. 4, provides that in order to guarantee the right of the population to live in a healthy and ecologically balanced environment, the state undertakes to ensure the intangibility of protected natural areas , in such a way that the conservation of biodiversity and the maintenance of the ecological functions of ecosystems are guaranteed [14], [15], [16].

2 Preliminaries

This section of the research describes the set of elements that facilitates the understanding of the proposal from the theoretical point of view. It starts by addressing the environmental issue. The negative effects on the environment that climate change fosters are introduced. The Neutrosophical Cognitive Maps are characterized as an element of inference for the development of the present investigation. In addition, the theory of neutrosophics numbers is introduced.

2.1 Medio Environment

The environment is defined as a system of abiotic, biotic and social elements with which man interacts, while adapting to it, transforming it and using it to meet his needs. It must be conceived in its entirety, being part of it; the built, the personal and the collective; the economic, the social, the cultural, the technological, the ecological, the aesthetic, which demonstrates the integrality and what this term represents [17], [18].

Concern for environmental problems became evident in the mid-twentieth century, as a result of pollution caused by accelerated industrial development. The prevailing economic growth model had direct implications for environmental degradation and the impact of natural resources [19].

Preventing the environment from being mistreated implies ensuring its recomposition, repairing the effects caused and eliminating the causes that have caused its deterioration. This implies a high level of civil responsibility, which displays the legal treatment of environmental damage [17], [20]. In general, environmental damage is irreversible.

In the field of environment and ecosystem prevention is the starting point for environmental protection and a need for study and development, being considered as a guiding principle [21], [22]. The process that governs the implementation of activities aimed at preserving the environment and the quality of life of society is called environmental management [23].

Environmental management is a continuous process of actions that generates the definition of environmental sustainability policy, planning, action, review and improvement of the performance of a company. Environmental damages are mainly caused by the overexploitation of natural resources and the environmental degradation to which ecosystems are subjected.

2.2 Climate change

Climate change is considered as the biggest problem to be confronted by humanity. The United Nations framework convention on climate change to Paris defined climate change as the climate change that is directly or indirectly attributed to human activity that alters the composition of the world atmosphere and adds to the natural variability of the climate observed during periods of comparable time [24], [25].

Among the most analyzed consequences of climate change is the increase in greenhouse gases [26], [27], [28], the increase of the temperature, the decrease of the water resources, deterioration of the biodiversity, alterations in the agriculture and the vegetal cover and the contamination of the oceanic environments [29], [30]. Figure 1 shows an image that illustrates the negative effect of climate change on the environment.

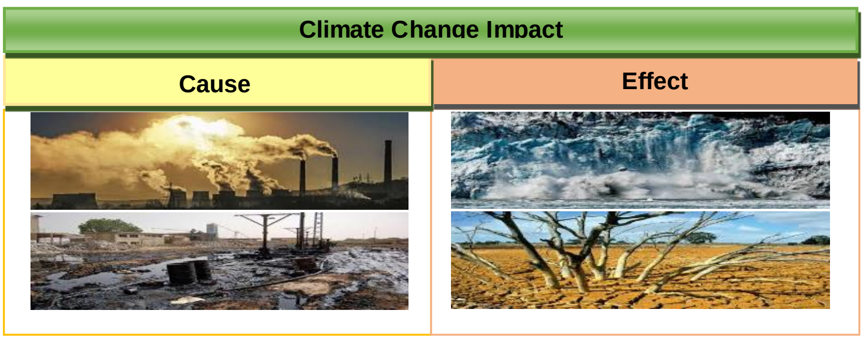

Figure 1. Negative effects of climate change on the environment

2.3 Fuzzy Cognitive Map

Causal modeling is useful for understanding the decision making process. Causality is generally seen as a precise relationship: the same cause always causes the same effect. But in the everyday world, the links between cause and effect are often imprecise or imperfect by nature [31], [32].

In many problems it is impossible to express the probabilities accurately to represent causation. One option in this scenario is to represent the degree of influence between one concept and another through diffuse logic using the Diffuse Cognitive Map (MCD) [33, 34].

DCMs are diffuse models with feedback to represent caution, they combine the theoretical tools of cognitive maps, fuzzy logic, neural networks, semantic networks, expert systems and nonlinear dynamic same line [35].

This technique allows modeling the system with feedback. In the diagram, each node represents a fuzzy set or event that occurs to some degree. With the use of this technique, the benefits of visual modeling, simulation and prediction are also obtained.

A DCM can be represented through a directed graph in which nodes represent concepts and arcs indicate causal relationship. The intensity of the causal relationship is represented by diffuse values. An adjacency matrix is used to represent the connectivity between nodes [36 , 37].

Scenario analysis contributes to the identification of different alternatives to reach a future state. It is a flexible strategic planning method frequently used in technology management [38, 39].

2.4 Neutrosophic Cognitive Map

Neutrosophy was proposed by Florentín Smarandache for the treatment of neutralities [40]. This has formed the basis for a series of mathematical theories that generalizes classical and fuzzy theories such as neutrosophical sets and neutrosophical logic. The original definition of truth value in neutrosophic logic is shown as:

N {(T,I,F):T,I,$F \subseteq$ [0,1]}, in which: T, represents the degree of belonging. I, the degree of undefined. F, the falsehood.

What represents a neutrosophical evaluation, considered as a mapping of a group of propositional formulas to N, and for each sentence p to obtain the result through equation 1.

$$v(p) = (T, I, F) \quad (1)$$

Mathematically a Neutrosophic Cognitive Map (NCM) can be defined using a 4-tuple (C, W, A, f)

Where:

$C = \{C_1, C_2, C_3, \ldots, C_N\}$ represents the set of graph concepts,

$W: (Ci , Cj) \rightarrow wij$ is a function that associates a causal value wij with each pair of neurons (Ci , Cj).

The values wij denote the direction and intensity of the edge that connects the concept Ci with the neuron Cj where the matrix of weights W defines the behavior of the system.

$A: (Ci) \rightarrow Ai$ is a function that associates a degree of activation $Ai \in \mathbb{R}$ every concept Ci of the system, during the time t ($t = 1,2, \ldots , T$). In addition, the map uses a function $f: \mathbb{R} \rightarrow [0,1]$ to maintain the degree of activation of each concept in the appropriate range.

3 Method for environmental assessment state responsibility

This section describes the method for environmental assessment. It bases its operation by Neutrosophic Cognitive Map. It nourishes its processing by means of static analysis with the objective of determining the most important nodes of the graph. This is achieved from the application of graph theory, specifically of centrality metrics.

While traditional relationships are appropriate to describe relationships such as inheritance. Diffuse sets are better at capturing relationships in which there are different degrees of belonging such as neighborhood. Figure 2 shows a general scheme with the operation of the proposed method.

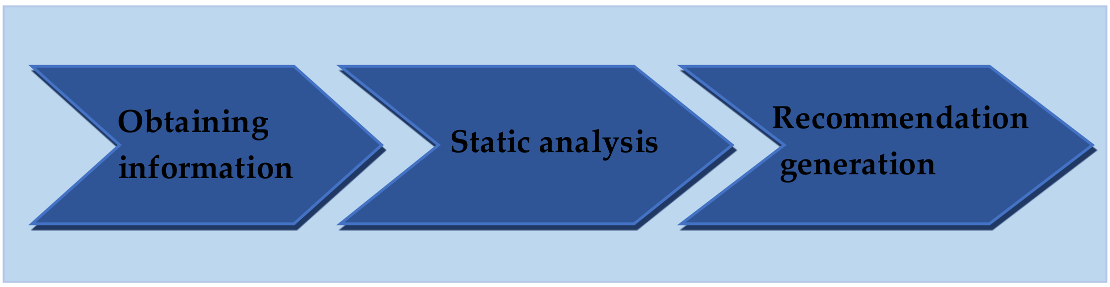

Figure 2. Scheme of the operation of the proposed method.

The proposed method is structured in three fundamental stages: Stage 1 obtaining information, Stage 2 implementation of static analysis, Stage 3 generation of recommendations. A description of the steps of the proposed method is given below.

Stage 1. Obtaining information:

The stage of obtaining the information consists in determining the environmental indicators that are evaluated. From which the assessment criteria on which the inference of the method is based are identified.

You must ensure that:

The criteria identified meet the condition expressed in equation (2).

$$C = \{C_1 ... C_n\}(n \geq 2) \tag{2}$$

The criteria domain C is finite.

Once the evaluation criteria have been determined, the causal relationships expressed on the evaluation criteria are determined. The causal relationships are expressed in the adjacency matrix representing the basis for the operation of the next stage of the method.

Stage 2 2. Static analysis:

The static analysis allows obtaining the causal conceptual centrality of the Neutrosophic Cognitive Map; it is obtained from the relationships expressed in the adjacency matrix. The modeled parameters are degree of output od, degree of input id and centrality C [41]. Using the equations (3, 4 and 5) the modeled parameters are obtained.

Degree of output obtained by the equation (3)

$$od_i = \sum_{i=1}^{n} \left\| I_{ij} \right\| \tag{3}$$

Degree of input obtained through the equation (4)

$$id_i = \sum_{i=1}^{n} \left\| I_{ji} \right\| \tag{4}$$

Centrality obtained through the equation (5)

$$C_i = od_i + id_i \tag{5}$$

Stage 3. Generation of recommendations:

Without losing generality, the inference process in an NCM can be defined mathematically using two components: a status vector $A_{1\times N}$ which represents the degree of activation of the map concepts, and a matrix of causal weights $W_{N\times N}$ which defines the interaction between neurons.

The following equation (6) summarizes this process, which consists in calculating the state vector A over time, for an initial condition A_0. Similarly to other neuronal systems, the activation of C_i the neurons that directly affect the concept will depend on the activation C_i and of the causal weights associated with said concept [22], [23].

$$A_i^{(t+1)} = f\left(\sum_{i=1;\, j\neq i}^{n} W_{ji} A_i^{(t)}\right) \tag{6}$$

Where:

$A_i^{(t+1)}$: it is the value of the concept C_i in the step t+1 of simulation.

$A_i^{(t)}$: it is the value of the concept C_j in the step t of the simulation.

W_{ji}: it is the weight of the connection which goes from the concept C_j to the concept C_i and f (x) is the activated function.

4 Method implementation through a case study in Ecuador

The proposal has been implemented in the social context in the Quevedo city of Ecuador. The environmental situation of the Quevedo Canton is not exceptional in terms of the deterioration exhibited by the remaining small cantons in the country. The main elements of the implemented method are described below.

Stage 1: Obtaining information.

During the process of obtaining information, scientific research methods were used from which environmental assessments were identified. Table 1 shows the criteria obtained.

Table 1. Evaluation criteria.

Criteria	Description
C_1	Natural resources with degradation
C_2	Deforestation by logging of primary forests
C_3	Biodiversity loss
C_4	Loss of water quality
C_5	Imbalance in the food chain - ecological
C_6	Soil erosion - sedimentation
C_7	Fragmentation - isolation of populations
C_8	Pollution (soil, air, water)
C_9	Species migration

With the use of a multi-expert approach, the causal relationships of the criteria presented are determined. For the process, three experts were consulted who issued their ratings. As a final result, the aggregate adjacency matrix shown in Table 2 was obtained.

Table 2. Adjacency matrix added.

	C_1T, I, F	**C_2 T, I, F**	**C_3 T, I, F**	**C_4 T, I, F**	**C_5 T, I, F**	**C_6 T, I, F**	**C_7 T, I, F**	**C_8 T, I, F**
C_1 T, I, F	[0, 0,0]	[0.25, 0.5,0.75]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.25,0]	[0.5, 0.25,0]	[0.25, 0,0]	[0.25, 0,0]
C_2 T, I, F	[0.50, 0.25,0.75]	[0, 0,0]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.25, 0.25,0]	[0.75, 0.5,0.25]
C_3 T, I, F	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.25,0]
C_4 T, I, F	[0.75, 0.5,0.25]	[0.25, 0.5,0.75]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C_5 T, I, F	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.25,0]
C_6 T, I, F	[0.25, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.5,0.75]	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C_7 T, I, F	[0.25, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.25, 0.5,0.75]
C_8 T, I, F	[0.5, 0.25,0]	[0.25, 0.5,0.75]	[0.25, 0.25,0]	[0.25, 0.25,0]	[0.25, 0.5,0.75]	[0.50, 0.25,0.75]	[0.25, 0.5,0.75]	[0, 0,0]

Stage 2: Static analysis implementation.

From the processing carried out of the adjacency matrix, the values of the static criteria Od, Id, C are obtained. Table 3 presents the result of the values obtained.

Table 3. Behavior of static analysis

Criteria	Description	id	od	c
C_1	Natural resources with degradation	3,00	2,50	5,50
C_2	Deforestation by logging of primary forests	1,75	3,75	5,50
C_3	Biodiversity loss	3,00	3,25	6,25
C_4	Loss of water quality	3,25	2,75	6,00
C_5	Imbalance in the food chain - ecological	3,25	2,50	5,75

C_6	Soil erosion - sedimentation	3,25	2,50	5,75
C_7	Fragmentation - isolation of populations	2,50	2,75	5,25
C_8	Species migration	2,50	2,25	4,75

The essential knowledge of the static analysis carried out of the evaluation criteria, expresses that the most preferred indicators are: Deforestation by logging of primary forests and y Biodiversity loss.

Stage 3: Generation of recommendations.

The stage obtains the values attributed to the weights of the criteria that represents the normalization of the values of the degree of output. Subsequently, the preferences on the case study being analyzed are obtained. This part of the process consists in determining the level of presence possessing the evaluative criteria in the Quevedo city of Ecuador. Once the values of the weights and preferences have been obtained, the process of aggregation of information is carried out.

The information aggregation process is carried out by means of the information aggregation operator (Ordered Weighted Averaging) OWA as expressed in equation (7).

$$F(a_1, a_2 .. a_n) = W^t B \quad (7)$$

Where:

W: it is the weight OWA vector associated with aggregation.

B: it is the ordered aggregate vector, where the jth largest component of B is b_j being this the jth largest of the a_i. Table 4 shows the result.

Table 4. The attributed weight to criteria.

Criteria	Weights	Preferences	Adding
C_1	0,1123	1	0,1685
C_2	0,1685	1	0,1460
C_3	0,1460	0.75	0,1235
C_4	0,1235	0.75	0,1235
C_5	0,1123	1	0,0842
C_6	0,1123	1	0,0842
C_7	0,1235	0.75	0,0842
C_8	0,1011	0.25	0,0252
Index			0.8394

From the above mentioned analysis of the data in Table 4, an incidence index of the environmental variables of a 0.83 can be identified, representing a high index of environmental deterioration over the exposed indicators.

Once the scenario simulation has been applied using equation (6), the results are presented in Figure 3.

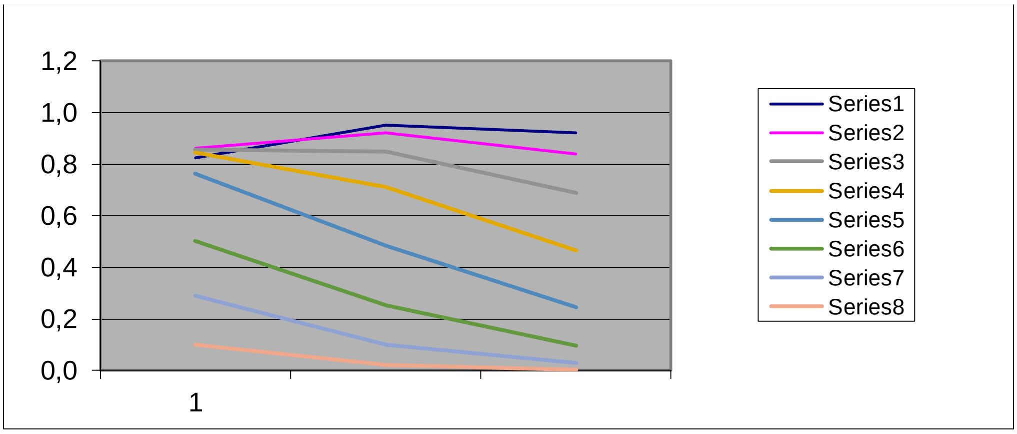

Figure 3. Result of the simulation of scenarios.

From the simulation result, a set of behaviors such as:

There is an increase in indicators over time. However, based on the strategies implemented, a recovery of different criteria is expected over time.

5 Conclusions

This research presented a method for the evaluation of environmental variables. The method used as an inference process the Neurosophical Congnitive Maps through a multicriteria approach. The proposed method obtained the set of causal relationships that relate the environmental variables from which the inference process of the proposed solution was generated. The proposal was implemented as a case study in the Quevedo city of Ecuador, from which an incidence index of the environmental variables of 0.83 was obtained according to the method considered high according to international standards.

Future work will concentrate on extending the model to group decision making allowing to taking into account multiples stakeholder point of views. Another area of work is in developing and integration to the of a consensus process to make decision making more reliable.

References

[1] C. R. L. Fernández, "Visión holística de la educación ambiental y el desarrollo sostenible. Buenas prácticas en la universidad Metropolitana del Ecuador," *Revista Conrado,* vol. 13, no. 1, pp. 138-141, 2017.

[2] T. H. Tietenberg, and L. Lewis, *Environmental and natural resource economics*: Routledge, 2016.

[3] Z. A. Smith, *The environmental policy paradox*: Routledge, 2017.

[4] T. Brenton, *The greening of Machiavelli: the evolution of international environmental politics*: Routledge, 2019.

[5] G. Nicoletti, N. Arcuri, G. Nicoletti, and R. Bruno, "A technical and environmental comparison between hydrogen and some fossil fuels," *Energy Conversion and Management,* vol. 89, pp. 205-213, 2015.

[6] L. Sánchez-Vázquez, M. G. Espinosa, and M. B. Eguiguren, "Perception of socio-environmental conflicts in mining areas: the case of the mirador project in Ecuador," *Ambiente & Sociedade,* vol. 19, no. 2, pp. 23-44, 2016.

[7] G. L. Ampuero, and J. P. H. Moncayo, "Buenas prácticas en el ecoturismo. Caso de estudio: provincia del Guayas, Ecuador," *Universidad y Sociedad,* vol. 10, no. 1, pp. 150-155, 2018.

[8] M. A. Zambrano-Monserrate, F. F. García–Albán, and K. A. Henk-Vera, "Bounds testing approach to analyze the existence of an environmental Kuznets curve in Ecuador," *International Journal of Energy Economics and Policy,* vol. 6, no. 2, pp. 159-166, 2016.

[9] P. A. Andrade, "The government of nature: Post-neoliberal environmental governance in Bolivia and Ecuador," *Environmental Governance in Latin America*, pp. 113-136: Palgrave Macmillan, London, 2016.

[10] E. C. Uve, L. M. G. Luna, and A. R. Ruenes, "Análisis de los problemas ambientales en el cantón la concordia, provincia santo domingo de los Tsáchilas, Ecuador," *Investigación y Saberes,* vol. 4, no. 1, pp. 1-16, 2015.

[11] C. O. D. Junco, and R. E. M. de la Rosa, "Fundamentos jurídico-metodológicos para un sistema de pagos por servicios ecosistémicos en bosques del Ecuador," *Revista científica agroecosistemas,* vol. 5, no. 1, pp. 109-117, 2017.

[12] H. F. Gricelda, C. M. Paúl, and A. M. Niurka, "Participatory Process for Local Development: Sustainability of Water Resources in Rural Communities: Case Manglaralto-Santa Elena, Ecuador," *Handbook of Sustainability Science and Research*, pp. 663-676: Springer, 2018.

[13] J. P. Hidalgo-Bastidas, and R. Boelens, "The political construction and fixing of water overabundance: rural–urban flood-risk politics in coastal Ecuador," *Water International,* vol. 44, no. 2, pp. 169-187, 2019.

[14] R. d. Ecuador. "Constitución de la República del Ecuador," http://www.derecho-ambiental.org/Derecho/Legislacion/Constitucion_Asamblea_Ecuador.htm.

[15] T. Partridge, "Rural intersections: Resource marginalisation and the "non-Indian problem" in highland Ecuador," *Journal of rural studies,* vol. 47, pp. 337-349, 2016.

[16] R. Ray, and A. Chimienti, "A line in the equatorial forests: Chinese investment and the environmental and social impacts of extractive industries in Ecuador," Anthem Press, 2017.

[17] P. Cullet, *Differential treatment in international environmental law*: Routledge, 2017.

[18] M. W. Manulak, "Multilateral solutions to bilateral problems: The 1972 Stockholm conference and Canadian foreign environmental policy," *International Journal,* vol. 70, no. 1, pp. 4-22, 2015.

[19] D. Pearce., and R. Turner., "Economía de los Recursos Naturales y del Medio Ambiente," 1995.

[20] O. McIntyre, *Environmental protection of international watercourses under international law*: Routledge, 2016.

[21] S. Qi, "Prevention of the Environmental Risk--From the view of food safety."

[22] A. MASHHADI, and A. SHAHHOSSEINI, "Prevention of environmental damages according to International Law Commission's Draft Articles on prevention of trans boundary harm from hazardous activities (2001)," 2016.

[23] M. Faber, and D. Rapport, *Ecosystem health: new goals for environmental management*: Island Press, 1992.

[24] M. C. V. Crismatt, and J. S. G. Martínez, "Sinergias entre la Convención sobre Diversidad Biológica y la Convención Marco de Naciones Unidas sobre el cambio climático desde una perspectiva de la agenda internacional," *Biodiversidad en la Práctica,* vol. 4, no. 1, pp. 141-149, 2019.

[25] Y. Gao, X. Gao, and X. Zhang, "The 2 C global temperature target and the evolution of the long-term goal of addressing climate change—from the United Nations framework convention on climate change to the Paris agreement," *Engineering,* vol. 3, no. 2, pp. 272-278, 2017.

[26] S. C. Zehr, "Public representations of scientific uncertainty about global climate change," *Public understanding of science*, 2016.

[27] M. E. Schlesinger, *Greenhouse-gas-induced climatic change: A critical appraisal of simulations and observations*: Elsevier, 2017.

[28] M. A. Ranney, and D. Clark, "Climate change conceptual change: Scientific information can transform attitudes," *Topics in Cognitive Science,* vol. 8, no. 1, pp. 49-75, 2016.

[29] M. Boko, I. Niang, A. Nyong, A. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo, and P. Z. Yanda, "Africa Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge University Press, 2018. [1] Estupiñan Ricardo, J., et al., Neutrosophic model to determine the degree of comprehension of higher education students in Ecuador. Neutrosophic Sets & Systems, 2019. 26.

[2] Segura, C.M.L., C.V.V. Vargas, and N.B. Hernández, POBREZA, MEDIO AMBIENTE Y PROACTIVIDAD DEL DERECHO. Revista Órbita Pedagógica. ISSN 2409-0131, 2016. 3(2): p. 83-92.

[3] Batista Hernández, N. and N. Valcárcel Izquierdo, Determinación de la prefactibilidad en la aplicación de una estrategia pedagógica para la formación de la competencia Emprender en la educación preuniversitaria como contribución a la formación integral del estudiante. Dilemas Contemporáneos: Educación, Política y Valores, 2018.

[4] Cruz, M.F., et al., ESTUDIO SITUACIONAL PARA DETERMINAR ESTRATEGIAS FORMATIVAS EN LA ATENCIÓN A ESCOLARES CON NECESIDADES EDUCATIVAS ESPECIALES EN LA ZONA 5 DEL ECUADOR. Investigación Operacional, 2019. 40(2): p. 255-266.

[5] Leyva-Vázquez, M. and F. Smarandache, Inteligencia Artificial: retos, perspectivas y papel de la Neutrosofía. 2018: Infinite Study.

[30] N. Bindo, J. Willebrand, V. Artale, A. Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, and Y. Nojiri, "Observations: Oceanic Climate Change and Sea Level, Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change," Cambridge University Press, S Solomon, D Qin, M Manning, M Marquis, KB …, 2018.

[31] O. Mar, and J. Gulín, "Model for the evaluation of professional skills in a remote laboratory system," *Revista científica,* vol. 3, no. 33, pp. 332-343, 2018.

[32] M. Alipour, R. Hafezi, M. Amer, and A. N. Akhavan, "A new hybrid fuzzy cognitive map-based scenario planning approach for Iran's oil production pathways in the post–sanction period," *Energy,* vol. 135, pp. 851-864, 2017.

[33] O. Mar, I. Santana, and J. Gulín, "Competency assessment model for a virtual laboratory system and distance using fuzzy cognitive map," *Revista Investigación Operacional* vol. 38, no. 2, pp. 170-178, 2017.

[34] S. H. Saleh, S. D. L. Rivas, A. M. M. Gomez, F. S. Mohsen, and M. L. Vàzquez, "Representación del conocimiento mediante mapas cognitivos difusos y conjuntos de términos lingüísticos difusos dudosos en la biomedicina [Knowledge representation using fuzzy cognitive maps and hesitant fuzzy linguistic term sets]," *International Journal of Innovation and Applied Studies,* vol. 17, no. 1, pp. 312, 2016.

[35] O. A. Osoba, and B. Kosko, "Fuzzy cognitive maps of public support for insurgency and terrorism," *The Journal of Defense Modeling and Simulation,* vol. 14, no. 1, pp. 17-32, 2017.

[36] J. Kim, M. Han, Y. Lee, and Y. Park, "Futuristic data-driven scenario building: Incorporating text mining and fuzzy association rule mining into fuzzy cognitive map," *Expert Systems with Applications,* vol. 57, pp. 311-323, 2016.

[37] A. Azadeh, M. Zarrin, M. Abdollahi, S. Noury, and S. Farahmand, "Leanness assessment and optimization by fuzzy cognitive map and multivariate analysis," *Expert Systems with Applications,* vol. 42, no. 15-16, pp. 6050-6064, 2015.

[38] O. Mar, I. Santana, and J. Gulín, "Algorithm to determine and eliminate neutral nodes in Cognitive Neutrosophic Map," *Neutrosophic Computing and Machine Learning,* vol. 8, pp. 4-11, 2019.

[39] A. Amirkhani, E. I. Papageorgiou, A. Mohseni, and M. R. Mosavi, "A review of fuzzy cognitive maps in medicine: Taxonomy, methods, and applications," *Computer methods and programs in biomedicine,* vol. 142, pp. 129-145, 2017.
[40] F. Smarandache, "Neutrosophic Overset, Neutrosophic Underset, and Neutrosophic Offset. Florentin Smarandache Similarly for Neutrosophic Over-/Under-/Off-Logic, Probability, and Statistics," 2017.
[41] J. Salmeron, "Augmented fuzzy cognitive maps for modeling LMS critical success factors," *Knowledge-Based Systems,* vol. 22 no. 4, pp. 275-278, 2009.

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