Neutrosophic MABAC Method for Solutions of Ecotourism Centers (EC) in COVID-19

Patricio Jaramillo Guerrero[1], Edwin Omaña Duran[1], María G. Balarezo García[1], Mansur Eshov[2]

[1]Universidad Regional Autónoma de los Andes, Ecuador

[2]Tashkent state university of Economics, Uzbekistan

Emails: ua.patriciojaramillo@uniandes.edu.ec; docentetp48@uniandes.edu.ec; ua.mariabalrezo@uniandes.edu.ec; m.eshov@tsue.uz

Abstract

The Covid-19 epidemic has had devastating effects on the economy and generated many issues for enterprises worldwide. As a result, it is imperative that during periods of pandemic, options be made available to help impacted companies recover and enhance their operations. One industry that has encountered this issue and has had to overcome substantial obstacles is ecotourism centres. In the first part of this study, we offer several valuable and realistic action strategies for ecotourism centres. Tourism professionals, faculty members, executives, proprietors, and some staff from eco-tourism centres got together for brainstorming meetings to come up with implementation plans. The stated action plans are prioritised based on four factors. One MCDM approach, known as Multi-Attributive Border Approximation area Comparison (MABAC), uses distance and area-based computing algorithms to systematically represent a complicated choice. In this study, we suggest a bipolar neutrosophic MABAC that incorporates the three possible memberships truth, indeterminate, and false into a single set. Using a bipolar neutrosophic language scale, a panel of specialists was asked to rate the outcome values of requirements and options. The major output of the suggested approach is the distances of options from the Border Approximation Area of bipolar neutrosophic MABAC.

Keywords: Covid-19; MABAC; Ecotourism Centers; MCDM; Neutrosophic Sets

1. Introduction

One of the greatest threats of the 20th century, known as Covid-19, is about to be unleashed on the globe. Originating in Wuhan, China, the Covid-19 epidemic quickly spread over the globe and had far-reaching consequences on many facets of society, most notably the global economy[1], [2].

Many sectors face difficulties as a result of this pandemic's global expansion. The travel and tourist sector is particularly vulnerable to the effects of the current epidemic. Many nations' economies and populations rely heavily on the tourism industry, which is often regarded as being one of the world's most dynamic, expansive, and substantial economic sectors. There are two reasons why this sector is crucial. First, how one sees the world from a social and cultural standpoint. This ensures that visitors are well-versed in the languages, cuisines, traditions, and sights of the

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

host nation. From a purely economic standpoint, visitors are valuable to the host nation because they bring in much-needed foreign currency. Therefore, most nations have considered this business because of its financial, social, and cultural consequences. In addition, the World Travel & Tourism Council (WTTC) reports that the travel and tourism industry was already one of the biggest when the COVID-19 epidemic hit[3], [4].

Ecotourism Centres (ECs) are one of the most successful and busy segments of the travel industry. Ecotourism businesses often spring up in areas where visitors can enjoy the outdoors while also making use of the amenities offered there. The major reasons for creating ECs are to make money and to help the local community grow. ECs, like many other companies, have been hit hard by the pandemic, and the coronavirus has had significant effects on their operations. As a result, EC operations have slowed down, and in some cases, ECs have been shut down entirely. As a result of this predicament, there is an urgent want for recovery methods to advance the existing state of ECs[5], [6].

In addition to ensuring the continued viability of these facilities, pandemic recovery strategies may pave the way for the development and expansion of ECs both during and after the outbreak. Therefore, this highlights the significance of EC recovery solutions during coronavirus season. As a result, the horrific and dreadful circumstances brought about by the Covid-19 outbreak served as the primary impetus for us to perform this research. Due to the terrible circumstances brought on by the epidemic, many of them have been forced to shut indefinitely. In light of this terrible predicament, we sought to provide them with helpful and workable remedies. Recovery tourism throughout this pandemic epidemic has received little attention in the literature, and no publications have specifically addressed ECs[7], [8].

EC solutions employing a multi-criteria decision-making (MCDM) method provide a more workable answer to this issue. When there is a need to make a choice based on a number of conflicting or contradicting signs or considerations, and when preferences must be determined or expressed, MCDM techniques may be very helpful. Then, depending on the specified criteria or options, the optimum solution of action may be determined with the assistance of MCDM techniques. When making a choice, it's common for there to be competing factors to consider. One MCDM situation in which several conflicting intangible factors must be addressed is the selection of EC solutions for COVID-19. In this study, we provide a strategy for choosing solutions for EC that rely on MCDM.[9], [10]

The MABAC technique is one of the numerous MCDM approaches presented in the research. Scientists in Belgrade devised the MABAC, a distance-based MCDM technique. Because of its easy calculation and consistent results, the MABAC approach is an especially pragmatic and dependable instrument for sound decision-making. This fundamental principle of MABAC separates the effectiveness of every option into an Upper Approximation Area (UAA) with the best options and a Lower Approximation Area (LAA) with anti-ideal options, according to the distance of the standard function of every solution from the border approximation area (BAA). The MABAC approach is applicable for choosing the best option since option effectiveness is affected by the ratio of UAA to LAA[11], [12].

Smarandache's neutrosophic set (NS) is an expansion on the traditional set, fuzzy set, intuitionistic fuzzy set, and interval-valued intuitionistic set. Neutrosophy is the study of neutralities and their relationships to other ideational spectra, hence an NS is a subset of this larger field of study[13], [14]. Neutrosophic is composed of the 3 parts truth (T), indeterminacy (I), and falsehood (F)[15]. Every neutrosophic group member number is a real part of the measurement interval]0_,0+[. After that, Wang et al. suggested the single-valued neutrosophic set (SVNS), an extension of the neutrosophic set that only accepts values between zero and one[12]. Numerous researchers have focused on the T, I, and F parts, which has led to the definition of special types of NS[16].

The term "bipolarity" describes the human tendency to weigh the potential benefits and drawbacks of a course of action before committing to a course of action. Possible, appropriate, authorized, desirable, or deemed suitable are all examples of positive data, whereas unattainable, denied, or prohibited are examples of incorrect data. In the same way that positive choices define which items are more desired than others without dismissing those that do not match the

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

wants, bad choices explain what principles or objects must be refused to meet the restrictions[17]. According to traditional Chinese medicine, yang represents the masculine or good aspect of a system, whereas yin represents the feminine or negative aspect. Many researchers believe that humans make decisions based on weighing the pros and cons of certain actions. In light of these considerations, Deli et al. explored the beneficial and detrimental membership degrees of bipolar neutrosophic sets in addition to their operations[18], [19]. When confronted with ambiguous real-world issues, bipolar fuzzy sets become useful since they may be used for both positive and negative membership values. Therefore, in this research, we integrate the bipolar neutrosophic perspective with the MCDM approach to improve the decision by taking into account bipolarity assessments. Specifically, this study will offer a novel bipolar neutrosophic MABAC in which T, I, and F memberships may be either positive or negative. The instance of EC solutions is also used to demonstrate the efficacy of the suggested strategy[20].

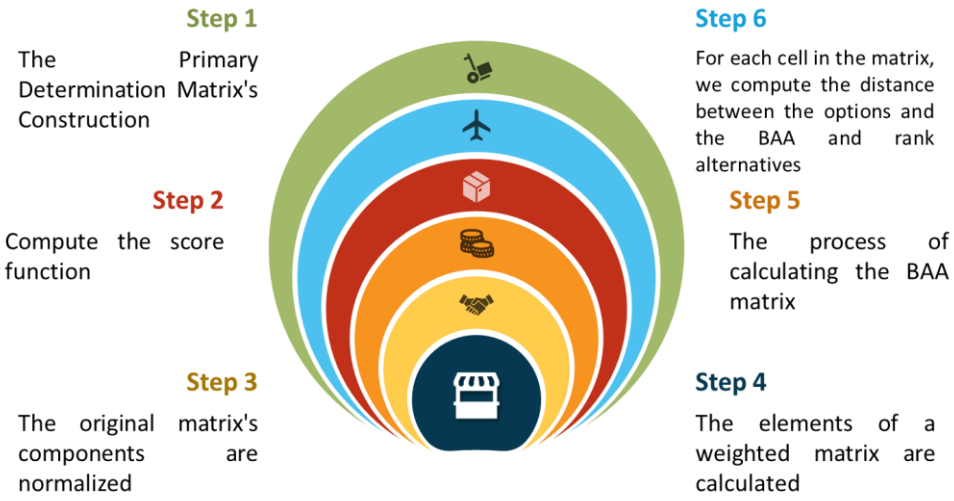

Figure 1: The satges of the neutrosophic MABAC method.

2. MCDM Method

The computational steps of the suggested methodology are described below[21]. Figure 1 shows the steps of thr neutrosophic MABAC method[22].

Step 1: The Primary Determination Matrix's Construction

Step 2: Compute the score function

Step 3: The original matrix's components are normalized

$$r_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-} \quad (1)$$

$$r_{ij} = \frac{x_{ij} - x_i^+}{x_i^+ - x_i^-} \quad (2)$$

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

$$x_i^+ = \max(x_1, x_2, x_3 \dots x_m) \quad (3)$$

$$x_i^- = \min(x_1, x_2, x_3 \dots x_m) \quad (4)$$

Step 4: The elements of a weighted matrix are calculated.

$$d_{ij} = w_i \cdot (r_{ij}) \quad (5)$$

Step 5: The process of calculating the BAA matrix

$$b_i = \left(\prod_{j=1}^{m} d_{ij}\right)^{1/m} \quad (6)$$

Step 6: For each cell in the matrix, we compute the distance between the options and the BAA.

$$T = D - G \quad (7)$$

$$T = \begin{bmatrix} d_{11} & \cdots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{m1} & \cdots & d_{mn} \end{bmatrix} - \begin{bmatrix} b_1 & \cdots & b_n \\ \vdots & \ddots & \vdots \\ b_1 & \cdots & b_n \end{bmatrix} \quad (8)$$

Step 7: Rank the alternatives

$$A_i = \sum_{j=1}^{n} t_{ij} \quad (9)$$

3. An Illutsrtive Example

The ecotourism centers have been hit hard by the recent coronavirus epidemic, and their owners and management are desperately seeking for ways to remedy their facilities' dreadful circumstances. This pressing problem has motivated us to investigate potential means of aiding in their recovery from the pandemic illness now ravaging the world.

This section presented the application of the proposed method in 10 locations and four criteria.

The recommended action plan is prioritized based on four factors: time, cost, need, and efficiency. Amounts of emphasis are assigned to each of the four criteria.

First, build the initial matrix. Then compute the weights of the criteria. Figure 2 shows the weights of the criteria. Table 1 shows the initial decision matrix.

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

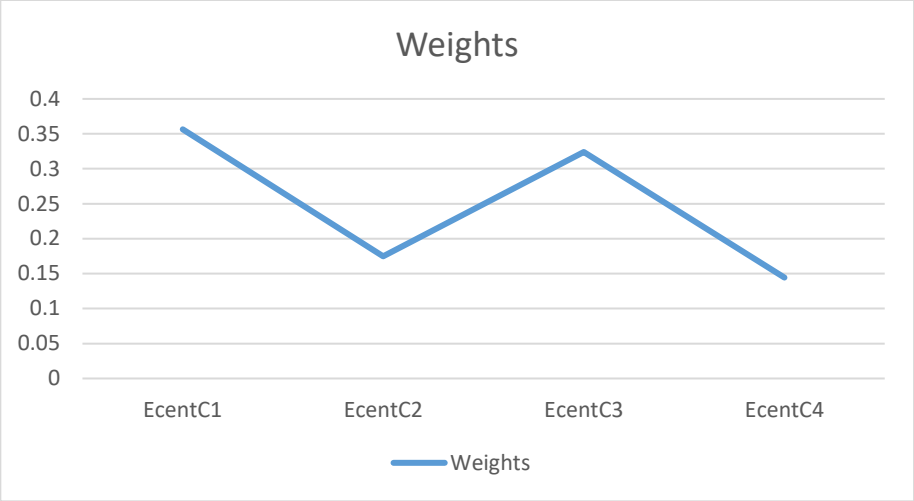

Figure 2: The weights of standards.

Table 1. The initial decision matrix.

	$EcentC_1$	$EcentC_2$	$EcentC_3$	$EcentC_4$
$Ecent_1$	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>
$Ecent_2$	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>
$Ecent_3$	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>
$Ecent_4$	<0.10, 0.10, 0.90, −0.10, −0.10, −0.90>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>	<0.10, 0.10, 0.90, −0.10, −0.10, −0.90>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>
$Ecent_5$	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>
$Ecent_6$	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>
$Ecent_7$	<0.10, 0.10, 0.90, −0.10, −0.10, −0.90>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.10, 0.10, 0.90, −0.10, −0.10, −0.90>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>
$Ecent_8$	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>
$Ecent_9$	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.10, 0.10, 0.90, −0.10, −0.10, −0.90>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.35, 0.20, 0.70, −0.35, −0.20, −0.70>
$Ecent_{10}$	<0.10, 0.10, 0.90, −0.10, −0.10, −0.90>	<0.80, 0.60, 0.15, −0.80, −0.60, −0.15>	<0.90, 0.80, 0.10, −0.90, −0.80, −0.10>	<0.10, 0.10, 0.90, −0.10, −0.10, −0.90>

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

Then normalize the decision matrix. The decision matrix is normalized using Eqs. (1-4) for benefit and cost criteria. In this study, the time and cost are negative criteria and others are positive criteria. Table 2 shows the normalization decision matrix.

Table 2: The normlization decision matrix.

	$EcentC_1$	$EcentC_2$	$EcentC_3$	$EcentC_4$
$Ecent_1$	1.274278	1.243805	1.269899	-0.27428
$Ecent_2$	1.111174	0.426567	1.269899	-0.11117
$Ecent_3$	1.111174	1.243805	0.405588	-0.27428
$Ecent_4$	0.200037	0.426567	0.228612	0.645107
$Ecent_5$	0.354893	1.243805	1.456302	-0.11117
$Ecent_6$	1.111174	0	1.269899	0.645107
$Ecent_7$	0.200037	1.098822	0.228612	0.645107
$Ecent_8$	0.354893	0.288916	0.405588	-0.27428
$Ecent_9$	1.111174	1.098822	1.269899	0.645107
$Ecent_{10}$	0.200037	-0.36101	1.456302	0.799963

Then multiply the weights of criteria by the normalization matrix to obtain the weighted normalized decision matrix by using Eq. (5). Table 3 shows the weighted normalized decision matrix.

Table 3: The weighted normlized decision matrix.

	$EcentC_1$	$EcentC_2$	$EcentC_3$	$EcentC_4$
$Ecent_1$	0.141005	0.074046	0.093066	0.01016
$Ecent_2$	0.130893	0.047077	0.093066	0.012444
$Ecent_3$	0.130893	0.074046	0.057629	0.01016
$Ecent_4$	0.074402	0.047077	0.050373	0.023031
$Ecent_5$	0.084003	0.074046	0.100708	0.012444
$Ecent_6$	0.130893	0.033	0.093066	0.023031
$Ecent_7$	0.074402	0.069261	0.050373	0.023031
$Ecent_8$	0.084003	0.042534	0.057629	0.01016
$Ecent_9$	0.130893	0.069261	0.093066	0.023031
$Ecent_{10}$	0.074402	0.021087	0.100708	0.025199

Then compute the border approximation area by using Eq. (6). Then compute the distance between the weighted normalized decision matrix and border approximation area by using Eqs. (7 and 8). Then compute the total score of the distance by using Eq. (9). Then rank the alternatives as shown in Figure 3.

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

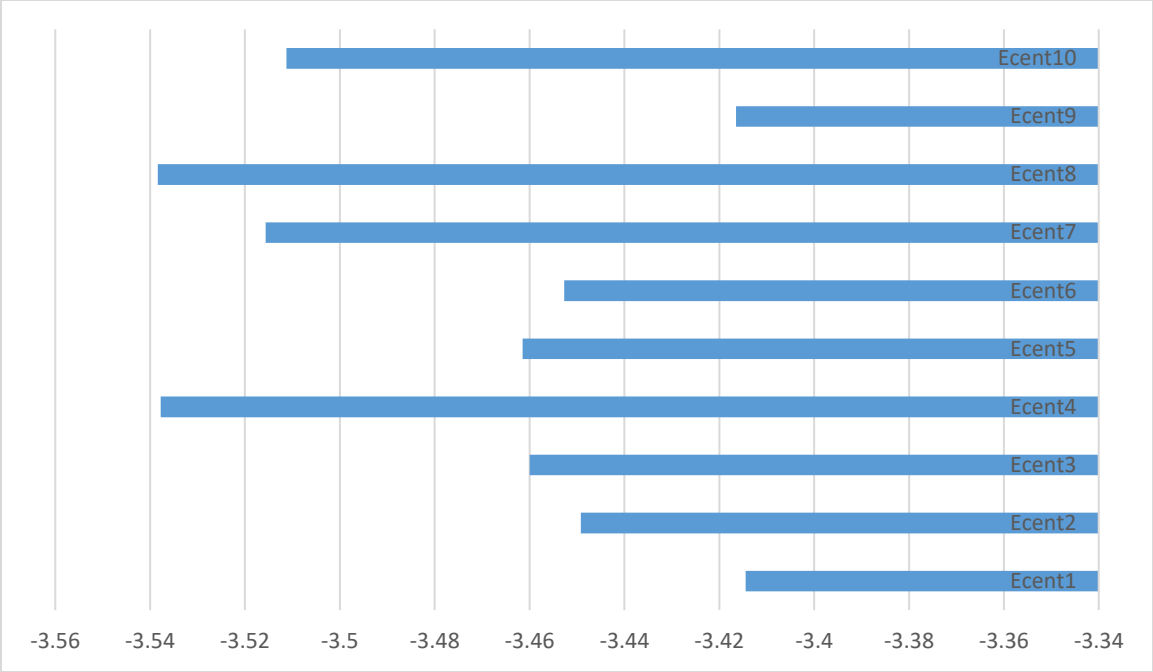

Figure 3: The rank of 10 centers.

4. Concluions

Many companies suffer significant harm as a result of the Covid-19 outbreak. ECs are a kind of these companies. During this epidemic, EC managers and owners are attempting to discover useful and effective recovery methods to improve their conditions. Because of this problem, we were compelled to do research on the current state of affairs and provide a few viable options for ECs to use in their recovery. Experts in the tourist industry, in-person interviews with EC management, and a survey of the general public all contributed to the development of the recommended courses of action. In order to address the MCDM issue, the authors of this work recommend using the MABAC technique in tandem with the bipolar neutrosophic set. The proposed approach was put to use in the context of an EC solutions selection problem; the optimum answer was offered. This empirical research made use of a set of 4 criteria and 10 options in EC solutions. This choice was made after careful consideration of the good and negative aspects of a bipolar neutrosophic perspective. The MABAC method's straightforward calculation and robust answers make it a useful instrument for sensible decision-making.

References

[1] N. Sahani, “Application of hybrid SWOT-AHP-FuzzyAHP model for formulation and prioritization of ecotourism strategies in Western Himalaya, India,” *Int. J. Geoheritage Park.*, vol. 9, no. 3, pp. 349–362, 2021.

[2] C.-C. Lin and L. Z.-H. Chuang, “Using fuzzy delphi method and fuzzy AHP for evaluation structure of the appeal of taiwan’s coastal wetlands ecotourism,” in *Business, Economics, Financial Sciences, and Management*, Springer, 2012, pp. 347–358.

[3] S. M. Hosseini, M. M. Paydar, and M. Hajiaghaei-Keshteli, “Recovery solutions for ecotourism centers during the Covid-19 pandemic: Utilizing Fuzzy DEMATEL and Fuzzy VIKOR methods,” *Expert Syst. Appl.*, vol. 185, p. 115594, 2021.

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

[4] Y.-Y. Wu, H.-L. Wang, and Y.-F. Ho, "Urban ecotourism: Defining and assessing dimensions using fuzzy number construction," *Tour. Manag.*, vol. 31, no. 6, pp. 739–743, 2010.

[5] L. Gigović, D. Pamučar, D. Lukić, and S. Marković, "GIS-Fuzzy DEMATEL MCDA model for the evaluation of the sites for ecotourism development: A case study of 'Dunavski ključ' region, Serbia," *Land use policy*, vol. 58, pp. 348–365, 2016.

[6] S. M. Hosseini, M. M. Paydar, M. Alizadeh, and C. Triki, "Ecotourism supply chain during the COVID-19 pandemic: A real case study," *Appl. Soft Comput.*, vol. 113, p. 107919, 2021.

[7] J. Balist, H. Heydarzadeh, and E. Salehi, "Modeling, evaluation, and zoning of Marivan county ecotourism potential using fuzzy logic, FAHP, and TOPSIS," *Geogr. Pannonica*, vol. 23, no. 1, 2019.

[8] S. M. Hosseini, M. M. Paydar, and C. Triki, "Implementing sustainable ecotourism in Lafour region, Iran: Applying a clustering method based on SWOT analysis," *J. Clean. Prod.*, vol. 329, p. 129716, 2021.

[9] H. Zabihi, M. Alizadeh, I. D. Wolf, M. Karami, A. Ahmad, and H. Salamian, "A GIS-based fuzzy-analytic hierarchy process (F-AHP) for ecotourism suitability decision making: A case study of Babol in Iran," *Tour. Manag. Perspect.*, vol. 36, p. 100726, 2020.

[10] Ç. K. Kaymaz, Ç. Çakır, S. Birinci, and Y. Kızılkan, "GIS-Fuzzy DEMATEL MCDA model in the evaluation of the areas for ecotourism development: A case study of 'Uzundere', Erzurum-Turkey," *Appl. Geogr.*, vol. 136, p. 102577, 2021.

[11] I. Irvanizam, N. N. Zi, R. Zuhra, A. Amrusi, and H. Sofyan, "An extended MABAC method based on triangular fuzzy neutrosophic numbers for multiple-criteria group decision making problems," *Axioms*, vol. 9, no. 3, p. 104, 2020.

[12] X. Peng and J. Dai, "Algorithms for interval neutrosophic multiple attribute decision-making based on MABAC, similarity measure, and EDAS," *Int. J. Uncertain. Quantif.*, vol. 7, no. 5, 2017.

[13] R. Şahin and F. Altun, "Decision making with MABAC method under probabilistic single-valued neutrosophic hesitant fuzzy environment," *J. Ambient Intell. Humaniz. Comput.*, vol. 11, pp. 4195–4212, 2020.

[14] P. Liu and S. Cheng, "An improved MABAC group decision-making method using regret theory and likelihood in probability multi-valued neutrosophic sets," *Int. J. Inf. Technol. Decis. Mak.*, vol. 19, no. 05, pp. 1353–1387, 2020.

[15] I. E. Ahmed Sleem, "An Interval Valued Neutrosophic Sets Integrated with the AHP MCDM Methodology to Assess the Station of 5G Network," *Neutrosophic Inf. Fusion*, vol. 1, no. 1, pp. 34–40, 2023, doi: 10.54216/NIF.010104.

[16] M. I. Ismail and S. Zaki, "Neutrosophic MCDM Methodology to Select Best Industrial Arc Welding Robot," *Neutrosophic Inf. Fusion*, vol. 1, no. 1, pp. 08–16, 2023, doi: 10.54216/nif.010101.

[17] D. Pamucar, M. Yazdani, R. Obradovic, A. Kumar, and M. Torres-Jiménez, "A novel fuzzy hybrid neutrosophic decision-making approach for the resilient supplier selection problem," *Int. J. Intell. Syst.*, vol. 35, no. 12, pp. 1934–1986, 2020.

[18] D. Pamučar and D. Božanić, *Selection of a location for the development of multimodal logistics center: Application of single-valued neutrosophic MABAC model*. Infinite Study, 2019.

[19] X. Peng and J. Dai, "Approaches to single-valued neutrosophic MADM based on MABAC, TOPSIS and new similarity measure with score function," *Neural Comput. Appl.*, vol. 29, pp. 939–954, 2018.

[20] A. M. Ali, "Ranking Renewable Energy Alternatives by using Triangular Neutrosophic Sets Integrated with MCDM," *Neutrosophic Inf. Fusion*, vol. 1, no. 1, pp. 17–26, 2023, doi: 10.54216/nif.010102.

[21] N. Rahim, L. Abdullah, and B. Yusoff, "A border approximation area approach considering bipolar

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023

neutrosophic linguistic variable for sustainable energy selection," *Sustainability*, vol. 12, no. 10, p. 3971, 2020.

[22] RICARDO, Jesús Estupiñán, et al. Analysis of Sustainable Development Indicators through Neutrosophic Correlation Coefficients. Neutrosophic Sets and Systems., vol. 52, no 1, p. 42, 2022,

DOI: https://doi.org/10.54216/IJNS.210114
Received: February 14, 2023 Revised: April 26, 2023 Accepted: May 18, 2023