

# Comparative Performance Analysis of MCDM Approaches with Plithogenic and Neutrosophic Sets for Sustainable Mobility

Igno Mary<sup>1</sup>, S. Sandhiya<sup>\*2</sup>

<sup>1,2</sup>Department of Mathematics, Vels Institute of Science, Technology and Advanced Studies, Chennai, Tamil Nadu, India  
Emails: [ignomary.7115@gmail.com](mailto:ignomary.7115@gmail.com); [sandhya86.sbs@vistas.ac.in](mailto:sandhya86.sbs@vistas.ac.in)

**Abstract:** For the first time in Multi-Criteria Decision Making (MCDM) study, this paper investigates a comparison analysis using the novel Plithogenic Neutrosophic technique. Here, many options for reducing vehicle-related air pollution are compared using two well-known MCDM techniques, VIKOR and TOPSIS. The study makes use of actual data from cities with varying pollution levels and car fleets. The study's purpose is to identify which of the several types of petrol is best for automobiles through a rigorous review procedure that combines the depiction of uncertainty and inconsistency using Plithogenic Neutrosophic sets. The methodology carefully incorporates real-world data on vehicle emissions, fuel efficiency, and environmental effect. The outcomes of this comparison research, supported by real-life data, are succinctly displayed using a radar graph. This graph strikingly displays the greater performance of electric vehicles in mitigating air pollution as compared to other choices such as petrol, diesel, and hybrid automobiles. This research emphasises the efficacy of incorporating Plithogenic Neutrosophic sets into MCDM frameworks, while emphasising the necessity of informed decision-making processes based on real-life data for solving significant environmental concerns within the transportation industry.

**Keywords:** Plithogenic sets, Neutrosophic set, Plithogenic Neutrosophic sets, TOPSIS, VIKOR, Extensions, Applications.

## 1. Introduction

In the modern period, air pollution, mostly caused by the internal combustion engine, has become a major global problem in the environmental affects (Gurjar et al. 2010). These occur largely owing to rapid increase in the automobile sector driven by substantial urbanisation, economic development, and industrialization (Sharma et al. 2020). In addition to boosting mobility to support economic growth, this quick expansion also sparked worries about air pollution. Vehicle emissions consist of complex combinations of particulate matter and gases, which become substantial contributors to poor India's air quality (Indirajith et al., 2022). Using the MCDM approach, the article outlines the various issues brought on by automobile emissions in India and looks at their causes, effects, and potential solutions within the context of the country's evolving socioeconomic situation. (Indirajith et al., 2021, 2022).

In general, multiple research suggest that, across varied sectors, MCDM has a vital role in helping decision-makers handle complicated problems (Isola et al. 2017). This method is used to simultaneously analyse various criteria and rate the best alternative solutions and decision-solving by offering a structural method for the decision-making, particularly when dealing with uncertainty or conflicting objectives (Saaty and Vargas 1998). MCDM offers a perfect way to get the desired results by methodically taking into account many factors and their relationships. Moreover, in the MCDM principles, the assignment of alternatives is significant, notably in the topic of vehicle selection depending on types of fuel (Keshavarz Ghorabae 2016). In the context of various forms of fuel-based vehicle air pollution, alternatives act as a doorway for appropriate problem solutions. In this study, we have not only picked the alternative ranges from traditional diesel and petrol to hydrogen fuel cell vehicles, electric vehicles (EVs), and hybrid electric vehicles (HEVs) (Peivandi et al. 2020). Alternative ranges include some state-of-the-art technology such as shared mobility services, autonomous vehicles, and enhanced public transport systems ([CSL STYLE ERROR: reference

with no printed form.]). In the framework of offering the greatest option following a thorough analysis, each alternative value offers unique characteristics for addressing worries about air pollution issues.

Before addressing MCDM issues, it is first important to determine the criteria's weight and evaluate them (Mishra et al. 2020). Apart from addressing many choices pertaining to the issue of air pollution, a number of considerations are important when selecting automobiles depending on fuel type. Cost, emission levels, the viability of implementing technology, and the degree of infrastructure availability are only a few of the evaluations that make up this criterion (Khurana et al. 2020a). According to Gkartzonikas and Gkritza (2019), the assessment method also takes into account a number of important factors, including manufacturability, energy efficiency, public acceptance, noise levels, testing vehicle range, and maintenance requirements. When evaluating the viability and feasibility of alternative fuel-based cars (i.e., to assist decrease air pollution from vehicles), evaluations pertaining to emission rates, pricing, and infrastructure availability criteria are crucial. The aforementioned criteria will be ranked according to how easy they are to implement and how they affect environmental health. It is these assessments that will guide the process of further investigating effective sustainable transportation alternatives.

The goal of the article is to explore the comparison between VIKOR and TOPSIS in MCDM approaches through the plithogenic with neutrosophic approach, to try to tackle vehicular air pollution (Daiy et al. 2021). Smarandache was the first person to establish the plithogenic set (Smarandache 2022a). A plithogenic set is a set that has one or more attributes and each membership function has more than one value, as follows (Abdel-Basset et al. 2021). Also plithogenic logic could be broke down into the following categories, (i) fuzzy logic, (ii) classical logic, (iii) neutrosophic logic and (iv) intuitionistic fuzzy logic. A logic is said to as classical logic if it simply contains one property (true). Fuzzy logic is defined as logic with two attribute values (truth and falsehood). It has three values (falsehood, truth, and indeterminacy), just like intuitionistic fuzzy logic. Finally, neutrosophic logic in general may be characterised by more than four degrees of truth-values originating from multiple qualities (Sankar et al. 2020; Smarandache 2022b). This work is innovative in that it uses plithogenic neutrosophic logic sets and MCDM techniques like VIKOR and TOPSIS to handle the difficult decision-making problems associated with air pollution. Different approaches to ranking and solving complicated decision issues are provided by these two MCDM techniques. A compromise solution was employed by the Vikor approach to assess the alternative. Additionally, it functioned as a robust method for resolving pollution-related issues with vehicles that use alternative fuels (Shekhovtsov and Salabun 2020). Similarly, TOPSIS approaches try to provide the optimal alternative based on a compromise solution. By selecting the optimal solution with respect to the positive ideal solutions close to the Euclidean distance and the farthest Euclidean distance from the negative ideal solutions, this compromise solution can be found (Hwang and Yoon 1981a).

The overview of the article is organised into seven sections that illustrate the many complications involved in selecting an alternative fuel-based vehicle as a means of minimising vehicular air pollution. The second section describes current alternatives, ranging from conventional gasoline or diesel-powered automobiles to the more sophisticated hydrogen fuel cell vehicles and electric vehicles (EVs). The review of criteria and weight assignments that take into account several metrics related to potentially alternative vehicles—such as emissions, cost-effectiveness, and infrastructure requirements—that might help identify the best option is described in the third part. The identification of conflicting criteria and decision-making processes with possibly competing aims are the main topics of the fourth section. The VIKOR and TOPSIS ranking techniques, which are based on plithogenic and neutrosophic set theory, are presented in the fifth section and will be used to rate potential solutions. The sixth section discusses the findings of the ranking procedure, gives discussion regarding the usefulness of each technique, and its implications for decision making. The paper's conclusion and general recommendations are given in the seventh part. conclusions derived from the study's findings and provides opportunities for future research, underlining the continuous necessity of tackling vehicular air pollution through educated decision-making processes.

## **2. A Preliminaries Plithogenic Sets and it classifications:**

The growing complexity of real-world problems involving uncertainty, vagueness, and incomplete information has motivated the development of advanced mathematical frameworks for uncertainty modeling. A significant milestone was achieved by Lotfi A. Zadeh with the introduction of fuzzy set theory in 1965, where each element is assigned a membership degree within the interval  $[0, 1]$ . Although fuzzy sets have been successfully applied in numerous fields, representing uncertainty using a single membership value is often insufficient for practical decision-making problems. This limitation led to the development of interval-valued fuzzy sets, in which the membership degree is expressed as an interval to better capture imprecision.

Subsequently, Krassimir Atanassov introduced intuitionistic fuzzy sets (IFS) in 1986 by incorporating both membership and non-membership degrees. While IFS provides a richer representation of uncertainty, it cannot

adequately model indeterminate information encountered in many real-world applications. To overcome this limitation, Florentin Smarandache proposed neutrosophic sets, which independently represent truth, indeterminacy, and falsity memberships without imposing restrictive constraints on their sum, thereby offering greater flexibility for handling inconsistent and incomplete information.

To address increasingly complex Multiple Criteria Decision Making (MCDM) problems involving multiple attributes and attribute values, Smarandache further introduced plithogenic sets and subsequently plithogenic hypersoft sets. These generalized frameworks integrate the characteristics of crisp, fuzzy, intuitionistic fuzzy, and neutrosophic sets while incorporating the degree of contradiction among attribute values. Furthermore, the development of aggregation operators for plithogenic sets has significantly enhanced their applicability in MCDM, making them powerful mathematical tools for solving complex decision-making problems under uncertainty.

### 2.1 . Plithogenic Sets :

Plithogenic sets provide a generalized mathematical framework for representing uncertainty by describing each element through multiple attribute values, each associated with a corresponding degree of appurtenance and a contradiction degree relative to a dominant attribute value. This structure extends classical set theories, including crisp, fuzzy, intuitionistic fuzzy, and neutrosophic sets, thereby enabling a more comprehensive representation of complex, uncertain, and conflicting information.

The concept of neutrosophic sets, introduced by Florentin Smarandache, further enhances uncertainty modeling by characterizing each element with three independent membership functions: truth ( $T$ ), indeterminacy ( $I$ ), and falsity ( $F$ ). Unlike intuitionistic fuzzy sets, these components are independent and are not constrained by a fixed summation condition, allowing the framework to effectively capture incomplete, inconsistent, and indeterminate information. Consequently, neutrosophic sets have become a robust mathematical tool for addressing uncertainty in complex decision-making problems.

By integrating neutrosophic theory with the concept of attribute contradiction, plithogenic sets offer greater flexibility and descriptive capability than conventional uncertainty models. Their ability to simultaneously accommodate multiple attribute values and conflicting information makes them particularly suitable for solving real-world Multiple Criteria Decision Making (MCDM) problems involving ambiguity, imprecision, and heterogeneous data. A neutrosophic set  $A$  defined on a universe of discourse  $X$  is expressed as follows:

$$A = \{X(T_A(x), I_A(x); F_A(x)) | x \in X\} \quad (1)$$

For each element  $x$  in the interval  $(0,1)$ , the sum of those memberships is no greater than three. Therefore, Neutrosophic sets provide a syntax of decision-maker preferences and priorities that adequately defines membership behaviors in situations where decision-maker statements are made in a state of indeterminate membership or insufficient information.

$$0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3 \quad (2)$$

Interval Neutrosophic Sets (INS) were presented by Wang et al. in (2005) to deal with uncertainty as well as information inconsistency in decision-making. INS, which is a specific Neutrosophic set that can accommodate imprecision by viewing the truth, falsehood, and indeterminacy as interval values along with membership, non-membership, and hesitance measures.

$$X = ([T^L, T^U], [I^L, I^U], [F^L, F^U]) \quad (3)$$

The Interval Neutrosophic set provides an easier and less complicated way of expressing incomplete, uncertain and contradictory pieces of information and is therefore a versatile and powerful method of solving decision-making problems. Certainly in its comparison with other extensions of fuzzy sets, INS provides significant benefits:

(A) Decision-makers (DM) can express positive, negative, and hesitant judgments simultaneously with membership degree, non-membership degree, and degree of hesitation, unlike fuzzy sets.

(B) INS also gives decision-makers more flexibility in expressing positive, negative, and uncertain judgments separately than that of an intuitionistic fuzzy set and accommodates their discussions of uncertain and contradictory information.

### 2.2. Vise Kriterijumska optimizacija Kompromisno Resenje (VIKOR)

Opricovic proposed the method known as VIKOR[19], which is the acronym for Multi criteria optimization, and a compromise solution. It is one of the methods of MCDM that deals with conflicting criteria that can provide decisions. VIKOR is mainly based on vector normalization. Alternative ranking is mainly based on distance from their ideal alternatives. The steps involved in vikor are described below.

- Step 1 Based on the assessment of the decision-maker, the decision matrix is developed.
- Step 2 The normalized decision matrix is obtained by solving Eq.4

$$(f_{ij})_{m \times n} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (4)$$

where m defined the alternatives present and n defined the criteria present.

– Step 3: Classify the criteria into beneficial and non-beneficial categories. For non-beneficial criteria, identify the highest value, and for beneficial criteria, find the lowest value, which is represented as (xi+). Conversely, for non-beneficial criteria, select the lowest value, and for beneficial criteria, select the highest value, denoted as (xi-).

– Step 4: Calculate Si and Ri by inserting the values of ( xi + ) and ( xi - ) into the respective equations from Steps 2 and 3.

$$S_i = \sum_{j=1}^n w_j * \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \quad (5)$$

where wj is defined as the criteria weights that are pivotal factors.

– Step 5 Calculate the Qi value from the Eq 6 .

$$R_i = \max[w_j * \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}] \quad (6)$$

$$Q_i = V * \frac{S_i - S^*}{S^- - S^*} + (1 - V) * \frac{R_i - R^*}{R^- - R^*} \quad (7)$$

– Step 6 The Qi is used to find the performance value of criteria. Rank the alternative in descending order based on the value of Qi.

– Step 7 in vikor method for determining rank two prerequisites needs to be fulfilled.

**(i) Acceptable advantage**

where A1 is the first alternative in Q ranking and A2 is the second, and m is the number of alternatives.

$$Q(A^2) - Q(A^1) \geq \frac{1}{m-1} \quad (8)$$

**(ii) Acceptable stability:**

In rank Q, A1 should be superior to S and R. If this condition is not satisfied, a compromised alternative is suggested.

1. If condition 2 fail to meet satisfaction, both A1 and A2 will be regarded as a compromise solution.
2. In the event that condition 1 does not meet satisfaction, A1, A2, and possibly additional alternatives up to Am will be considered, with Am being determined by Equation 9.

$$A^m - Q(A^1) < \frac{1}{m-1} \quad (9)$$

**2.3 Technique in order of preference by similarity to ideal solution (TOPSIS)**

In 1981, He proposed the technique for order of preference by similarity to the ideal solution (TOPSIS), a MCDM method for solving multiple decision problems(Hwang and Yoon 1981b). To find the optimal solution, topsis used ranking the best alternatives from the Euclidian distance close to the positive ideal solution (PIS) and farthest from the negative ideal solution. The steps involved in TOPSIS are mentioned below.

– Step 1: compute a decision matrix based on alternatives and criteria. Evaluate the alternatives according to the predetermined criteria.

– Step 2: Normalize the decision matrix using eq 10

$$R = (r_{ij})_{m \times n} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (10)$$

Where  $x_{ij}$  represents the evaluation score of alternative  $i$  with respect to criterion  $j$ .

– Step 3 assign the weight for criteria and calculate the normalized weighted decision matrix by using Eq. 11.

$$V = (v_{ij})_{m \times n} = w_j * r_{ij} \quad (11)$$

where  $w_j$  is the weight of each criterion.

– Step 4 involves employing the equations (3) through (6) to identify the positive ideal solution (PIS) and negative ideal solution (NIS).

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\} \quad (12)$$

$$v^+ = \{(max_i v_{ij} | j \in J_b), (min_i v_{ij} | j \in J_{nb}) | \in [1 \dots m]\}$$

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} \quad (13)$$

$$v^- = \{(min_i v_{ij} | j \in J_b), (max_i v_{ij} | j \in J_{nb}) | \in [1 \dots m]\} \quad (14)$$

where  $J_{nb}$  is a set of beneficial criteria, and non-beneficial criteria.

– Step 5 The performance of alternative is computed by using Eqs. 15 and 16, which are used to determine the Euclidian distance near the positive ideal solution (PIS) and farthest from the negative ideal solution (NIS).

$$s_i^+ = \sqrt{\sum_{j=1}^m (V_i - V_j^+)^2} \quad (15)$$

$$s_i^- = \sqrt{\sum_{j=1}^m (V_i - V_j^-)^2} \quad (16)$$

- Step 6 calculate the rank of alternative by using Eq. 17

$$P_i = \frac{s_i^-}{s_i^+ + s_i^-} \quad (17)$$

### 3. Alternative solution:

They make informed decisions possible through distinct evaluation, selection and comparison of alternatives based upon multiple criteria to identify the best solution. (Iverson and Dervan; Viera Valencia & Garcia Giraldo 2019). In addition to the central role of alternatives in Multi-Criteria Decision-Making (MCDM) methods, a desire to reduce air pollution has stimulated interest in alternative fuel vehicles as options. These alternatives may provide an optimum option for environmental concerns while also serving basic means of transportation. There have been different types of alternative fuel vehicles that come with their own advantages and challenges. Electric vehicles (EVs) produce no emissions from a tailpipe and can be charged and powered by renewable energy sources reducing air pollution. Hybrid vehicles include an internal combustion engine coupled with an electric motor, resulting in improved fuel economy and emissions than that of a gasoline vehicle. Additionally, hydrogen fuel cell vehicles use hydrogen gas to create electricity and produce only water vapor as waste. Compressed natural gas (CNG) vehicles are operated using natural gas as fuel, inducing below maximum levels of emissions compared to a gasoline or diesel vehicle. Biofuel vehicles operate through renewable organic materials such as ethanol or biodiesel, resulting in lower emissions and the possibility of carbon neutrality.

#### 3.1 Evaluation Criteria

Decision makers often use MCDM methods for criteria evaluation and option preference based on multiple criteria. The evaluation and preference for alternate fuel types for vehicles when targeting reducing air pollution

requires a consideration of varied criteria, Clarke et al. (2023). The following are 11 assessment criteria for vehicle fuel types to help reduce air pollution using the MCDM approach:

- a) Emissions Reduction Potential: Assess how well each fuel type can reduce harmful emissions, including CO<sub>2</sub>, NO<sub>x</sub>, and particulate matter in comparison to fossil fuel;
- b) Air Quality Improvement: Consider how each fuel type can help improve local air quality, considering the emissions and their contributions to overall air pollution levels along with smog and haze.
- c) Health Impacts: Assess the health consequences associated with emissions from each fuel type, including respiratory diseases, cardiovascular problems, and other related health issues.
- d) Greenhouse Gas Emissions: Consider the greenhouse gas emissions associated with each fuel type, accounting for their contribution to climate change and global warming potential.
- e) Energy Efficiency: Evaluate the energy efficiency of each fuel type, considering its energy content per unit and the efficiency of the vehicles using it.
- f) Cost-effectiveness: Analyze the cost-effectiveness of adopting each fuel type, including initial investment costs, operating expenses, and potential savings from reduced pollution-related health care costs.
- g) Infrastructure Requirements: Assess the infrastructure needed to support each fuel type, including fueling stations, distribution networks, and technological upgrades to existing infrastructure.
- h) Resource Availability: Consideration should be given to the availability and sustainability of resources needed to produce each fuel type. Factors that should be reviewed may include feedstock availability, land use, and water usage.
- i) Technological Maturity: Consider the technological maturity and readiness for each fuel type, including the availability of vehicles, engines and related technologies in the marketplace.
- j) Policy and Regulatory Support: The level of policy and regulatory support for each fuel type should be reviewed, including available incentives, subsidies, regulations and targets used to promote cleaner fuels and reduce emissions.
- k) Public Acceptance and Perception: Assessments should be made of the public acceptance and perception of each fuel type. Factors to consider may include consumer preferences, trust in the new technology and willingness to accept alternative fuels.

Weighting can be conducted to review each variable based on the relative level of importance. The fuel types being reviewed can be evaluated against the criteria using MCDM methods such as the Multi-Attribute Utility Theory (MAUT) or Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). This procedure will provide decision-makers with data/information to determine a fuel type that will result in a reduction in air pollution and review other environmental, economic, and social considerations. Top of ForBottom of Form

### *3.2 Evaluation of Weights of Criteria*

In establishing the weights of criteria for evaluation of fuel types of vehicles for the aim of air pollution reduction via Multi-Criteria Decision Making (MCDM) methods, careful and systematic approaches are necessary (M. Abbas and H. Muhsen 2022). Consultation with experts aids in quantifying criteria importance, considering emissions reduction potential, health impacts, and climate change. Epidemiological data and cost-benefit analyses inform weight assignment, ensuring comprehensive evaluation for informed decision-making in selecting fuel types for air pollution mitigation in vehicles. Sensitivity analysis covers weight ranges for non-normally distributed data.

## **4. Multi Criteria Decision Making Process Case Study:**

In this section, professional experts conducted assessments for evaluation. In India, experts were selected from manufacturing, government, academic, and research sectors to ensure credibility. The Ministry of Transportation, Ministry of Environment, automotive associations, energy committees, and EV research institutions provided expert input. Previous research data, like emissions and travel capability, formed the questionnaire content. Using the Delphi

method, initial assessments were reviewed by experts for a second evaluation round. They reconsidered performance values of each alternative-fuel mode. Seventeen valid questionnaires were gathered, concluding the evaluation process. here plithogenic neutrosophic set scale value are take in linguistic variables as shown in Table 1([CSL STYLE ERROR: reference with no printed form.]; Saber et al. 2024).

**Table 1. Plithogenic Neutrosophic Set with Linguistic Variables**

LINGUISTIC VARIABLES	PLITHOGENIC NEUTROSOPHIC SET
Extremely good (EG)	$((1.00,0.01,0.01),(0.98,0.001,0.001),(0.97,0.002,0.002),(0.96,0.003,0.003),(0.95,0.004,0.004))$ & $((1.00,0.00,0.00),(0.99,0.01,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04,0.04))$
Very very good (VVG)	$((0.92,0.115,0.115),(0.91,0.126,0.126),(0.90,0.107,0.107),(0.93,0.138,0.138),(0.93,0.149,0.149))$ & $((0.92,0.11,0.11),(0.91,0.12,0.12),(0.90,0.10,0.10),(0.93,0.13,0.13),(0.94,0.14,0.14))$
Very good (VG)	$((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0.238),(0.84,0.199,0.249))$ & $((0.82,0.17,0.22),(0.81,0.16,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))$
Good (G)	$((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349))$ & $((0.72,0.27,0.32),(0.71,0.26,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29,0.34))$
Medium good (MG)	$((0.62,0.376,0.426),(0.61,0.366,0.416),(0.60,0.356,0.406),(0.63,0.387,0.437),(0.64,0.398,0.448))$ & $((0.62,0.37,0.42),(0.61,0.36,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39,0.44))$
Medium (M)	$((0.50,0.50,0.50),(0.501,0.501,0.501),(0.502,0.502,0.502),(0.503,0.503,0.503),(0.504,0.504,0.504))$
Medium bad (MB)	$((0.42,0.67,0.62),(0.41,0.66,0.61),(0.40,0.65,0.60),(0.43,0.68,0.63),(0.44,0.69,0.64))$
Bad (B)	$((0.32,0.77,0.72),(0.31,0.76,0.71),(0.30,0.75,0.70),(0.33,0.78,0.73),(0.34,0.79,0.74))$
Very bad (VB)	$((0.22,0.87,0.82),(0.21,0.86,0.81),(0.20,0.85,0.80),(0.23,0.88,0.83),(0.24,0.89,0.84))$
Very very bad (VVB)	$((0.12,0.91,0.91),(0.11,0.92,0.92),(0.10,0.90,0.90),(0.13,0.93,0.93),(0.14,0.94,0.94))$
Extremely bad (EB)	$((0.02,0.99,0.99),(0.01,0.98,0.98),(0.00,1.00,1.00),(0.03,0.97,0.97),(0.04,0.96,0.96))$

The intervals of weight stability for a single criterion indicate the sensitivity of the compromise solution derived from VIKOR (as illustrated in Table 2) to changes in criteria weights (Dey and Ray 2023).

**Table 2. Criteria Weights**

WEIGHT VALUES	0.045	0.045	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11

Plotting of linguistic variables in a normalized matrix is displayed in Table 3.

**Table 3. Linguistic Variables**

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	B	MB	MG	G	EG	VVG	EB	VB	M	VG	VVB
A2	MB	MG	G	EG	VVG	EB	VB	M	VG	VVB	B
A3	MG	G	EG	VVG	EB	VB	M	VG	VVB	B	MB
A4	G	EG	VVG	EB	VB	M	VG	VVB	B	MB	MG
A5	EG	VVG	EB	VB	M	VG	VVB	B	MB	MG	G
A6	VVG	EB	VB	M	VG	VVB	B	MB	MG	G	EG
A7	EB	VB	M	VG	VVB	B	MB	MG	G	EG	VVG
A8	VB	M	VG	VVB	B	MB	MG	G	EG	VVG	EB
A9	M	VG	VVB	B	MB	MG	G	EG	VVG	EB	VB
A10	VG	VVB	B	MB	MG	G	EG	VVG	EB	VB	M
A11	VVB	B	MB	MG	G	EG	VVG	EB	VB	M	VG
A12	EG	VG	G	EG	VG		EG	VG	VVG	EG	VG
A13	VG	EG	VG	G	EG	VG	VVG	EG	VG	G	EG
A14	VVG	G	EG	VG	VVG	EG	VG	G	EG	VG	VVG
A15	G	VVG	VVG	VVG	G	VVG	G	VVG	G	VVG	G

As shown in Table 4, the normalized decision matrix is obtained by substituting the plithogenic neutrosophic values.

**Table 4. Plithogenic Neutrosophic Values**

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	((0.32, 0.77,0.72),(0.31,0.76,0.71),(0.30,0.75,0.70),(0.33,0.78,0.73),(0.34,0.79,0.74))	((0.42, 0.67,0.62),(0.41,0.66,0.61),(0.40,0.65,0.60),(0.43,0.68,0.63),(0.44,0.69,0.64))	((0.62, 0.37,0.42),(0.61,0.36,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39,0.44))	((0.72, 0.27,0.32),(0.71,0.26,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29,0.34))	((1.00, 0.00,0.00),(0.99,0.01,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04,0.04))	((0.92, 0.11,0.11),(0.91,0.12,0.12),(0.90,0.13,0.13),(0.89,0.14,0.14))	((0.02, 0.99,0.99),(0.01,0.98,0.98),(0.00,0.97,0.97),(0.00,0.96,0.96))	((0.02, 0.87,0.82),(0.01,0.86,0.81),(0.00,0.85,0.80),(0.00,0.84,0.84))	((0.50, 0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.504,0.504,0.504))	((0.82, 0.17,0.22),(0.81,0.16,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))	((0.12, 0.91,0.91),(0.11,0.90,0.90),(0.10,0.89,0.89),(0.13,0.93,0.93),(0.14,0.94,0.94))
A2	((0.42, 0.67,0.62),(0.41,0.66,0.61),(0.40,0.65,0.60),(0.43,0.68,0.63),(0.44,0.69,0.64))	((0.62, 0.37,0.42),(0.61,0.36,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39,0.44))	((0.72, 0.27,0.32),(0.71,0.26,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29,0.34))	((1.00, 0.00,0.00),(0.99,0.01,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04,0.04))	((0.92, 0.11,0.11),(0.91,0.12,0.12),(0.90,0.13,0.13),(0.89,0.14,0.14))	((0.02, 0.99,0.99),(0.01,0.98,0.98),(0.00,0.97,0.97),(0.00,0.96,0.96))	((0.22, 0.87,0.82),(0.21,0.86,0.81),(0.20,0.85,0.80),(0.23,0.88,0.83),(0.24,0.89,0.84))	((0.50, 0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.504,0.504,0.504))	((0.82, 0.17,0.22),(0.81,0.16,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))	((0.12, 0.91,0.91),(0.11,0.90,0.90),(0.10,0.89,0.89),(0.13,0.93,0.93),(0.14,0.94,0.94))	((0.32, 0.77,0.72),(0.31,0.76,0.71),(0.30,0.75,0.70),(0.33,0.78,0.73),(0.34,0.79,0.74))



	3,0.13, 0.13),( 0.94.0. 14,0.14 )	03,0.97 ,0.97),( 0.04.0. 96,0.96 )	0.88,0. (83),(0. 24,0.89 ,0.84))	),(0.50 3,0.503 ,0.503) ,0.504 ,0.504, 0.504))	0.18,0. 23),(0. 84,0.19 ,0.24))	0.93,0. 93),(0. 14,0.94 ,0.94))	0.78,0. 73),(0. 34,0.79 ,0.74))	0.68,0. 63),(0. 44,0.69 ,0.64))	0.38,0. 43),(0. 64,0.39 ,0.44))	0.28,0. 33),(0. 74,0.29 ,0.34))	0.03,0. 03),(0. 96,0.04 ,0.04))
A 7	((0.02, 0.0.99, 0.99),( 0.01.0. 98,0.98 ,0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),( 0.04.0. 96,0.96 )	((0.22, 0.87.0. 82),(0. 21,0.86 ,0.81),( 0.20.0. 85,0.80 ,0.23, 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 ,0.5 02,0.50 2,0.502 ,0.50 3,0.503 ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),( 0.80,0. 15,0.20 ,0.83, 0.18,0. 23),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),( 0.10,0. 90,0.90 ,0.13, 0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),( 0.30,0. 75,0.70 ,0.33, 0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),( 0.40,0. 65,0.60 ,0.43, 0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),( 0.60,0. 35,0.40 ,0.63, 0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),( 0.70,0. 25,0.30 ,0.73, 0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),( 0.98,0. 02,0.02 ,0.97, 0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),( 0.90,0. 10,0.01 0),(0.9 0.13),( 0.94,0. 14,0.14 )
A 8	((0.22, 0.87.0. 82),(0. 21,0.86 ,0.81),( 0.20.0. 85,0.80 ,0.23, 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 ,0.5 02,0.50 2,0.502 ,0.50 3,0.503 ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),( 0.80,0. 15,0.20 ,0.83, 0.18,0. 23),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),( 0.10,0. 90,0.90 ,0.13, 0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),( 0.30,0. 75,0.70 ,0.33, 0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),( 0.40,0. 65,0.60 ,0.43, 0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),( 0.60,0. 35,0.40 ,0.63, 0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),( 0.70,0. 25,0.30 ,0.73, 0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),( 0.98,0. 02,0.02 ,0.97, 0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),( 0.90,0. 10,0.01 0),(0.9 0.13),( 0.94,0. 14,0.14 )	((0.02, 0.0.99, 0.99),( 0.01.0. 98,0.98 ,0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),( 0.04.0. 96,0.96 )
A 9	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 ,0.5 02,0.50 2,0.502 ,0.50 3,0.503 ,0.504 ,0.504, 0.504))	((0.82, 0.17,0. 22),(0. 81,0.16 ,0.21),( 0.80,0. 15,0.20 ,0.83, 0.18,0. 93),(0. 84,0.19 ,0.24))	((0.12, 0.91,0. 91),(0. 11,0.92 ,0.92),( 0.10,0. 90,0.90 ,0.13, 0.93,0. 93),(0. 14,0.94 ,0.94))	((0.32, 0.77,0. 72),(0. 31,0.76 ,0.71),( 0.30,0. 75,0.70 ,0.33, 0.78,0. 73),(0. 34,0.79 ,0.74))	((0.42, 0.67,0. 62),(0. 41,0.66 ,0.61),( 0.40,0. 65,0.60 ,0.43, 0.68,0. 63),(0. 44,0.69 ,0.64))	((0.62, 0.37,0. 42),(0. 61,0.36 ,0.41),( 0.60,0. 35,0.40 ,0.63, 0.38,0. 43),(0. 64,0.39 ,0.44))	((0.72, 0.27,0. 32),(0. 71,0.26 ,0.31),( 0.70,0. 25,0.30 ,0.73, 0.28,0. 33),(0. 74,0.29 ,0.34))	((1.00, 0.00,0. 00),(0. 99,0.01 ,0.01),( 0.98,0. 02,0.02 ,0.97, 0.03,0. 03),(0. 96,0.04 ,0.04))	((0.92, 0.11,0. 11),(0. 91,0.12 ,0.12),( 0.90,0. 10,0.01 0),(0.9 0.13),( 0.94,0. 14,0.14 )	((0.02, 0.0.99, 0.99),( 0.01.0. 98,0.98 ,0.00, 1.00,1. 00),(0. 03,0.97 ,0.97),( 0.04.0. 96,0.96 )	
A 10	((0.82, 0.17,0. 22),(0. 81,0.16 11,0.92	((0.12, 0.91,0. 91),(0. 11,0.92 81,0.16	((0.32, 0.77,0. 72),(0. 31,0.76 41,0.66	((0.42, 0.67,0. 62),(0. 41,0.66 61,0.36	((0.62, 0.37,0. 42),(0. 61,0.36 99,0.01	((0.72, 0.27,0. 32),(0. 71,0.26 91,0.12	((1.00, 0.00,0. 00),(0. 99,0.01 0.01,0.	((0.92, 0.11,0. 11),(0. 91,0.12 0.01,0.	((0.02, 0.0.99, 0.99),( 0.01.0. 98,0.98 ,0.81),( 0.20.0. 85,0.80 ,0.23, 0.88,0. 83),(0. 24,0.89 ,0.84))	((0.50, 0.50,0. 50),(0. 501,0.5 01,0.50 ,0.5 02,0.50 2,0.502 ,0.50 3,0.503 ,0.504 ,0.504, 0.504))	

	,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))	,0.92),(0.10,0.90),(0.13,0.93),(0.14,0.94),(0.94))	,0.71),(0.30,0.70),(0.33,0.78,0.73),(0.34,0.79),(0.74))	,0.61),(0.40,0.60),(0.43,0.68,0.63),(0.44,0.69),(0.64))	,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39),(0.44))	,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29),(0.34))	,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04),(0.04))	,0.12),(0.90,0.10,0.01),(0.9,0.03,0.13),(0.94,0.04,0.14))	98,0.98),(0.00,1.00,1.00),(0.03,0.97),(0.97),(0.04,0.96))	,0.81),(0.20,0.85,0.80),(0.23,0.88,0.83),(0.24,0.89),(0.84))	01,0.501),(0.502,0.502),(0.503,0.504),(0.504,0.504))
A 1 1	((0.12,0.91,0.91),(0.11,0.92,0.92),(0.10,0.90,0.90),(0.13,0.93,0.93),(0.14,0.94,0.94))	((0.32,0.77,0.72),(0.31,0.76,0.71),(0.30,0.75,0.70),(0.33,0.78,0.73),(0.34,0.79,0.74))	((0.42,0.67,0.62),(0.41,0.66,0.61),(0.40,0.65,0.60),(0.43,0.68,0.63),(0.44,0.69,0.64))	((0.62,0.37,0.42),(0.61,0.36,0.41),(0.60,0.35,0.40),(0.63,0.38,0.43),(0.64,0.39,0.44))	((0.72,0.27,0.32),(0.71,0.26,0.31),(0.70,0.25,0.30),(0.73,0.28,0.33),(0.74,0.29,0.34))	((1.00,0.00,0.00),(0.99,0.01,0.01),(0.98,0.02,0.02),(0.97,0.03,0.03),(0.96,0.04,0.04))	((0.92,0.11,0.11),(0.91,0.12,0.12),(0.90,0.11,0.11),(0.89,0.12,0.12),(0.88,0.13,0.13),(0.87,0.14,0.14))	((0.02,0.99,0.99),(0.01,0.98,0.98),(0.01,0.97,0.97),(0.01,0.96,0.96))	((0.22,0.87,0.82),(0.21,0.86,0.81),(0.20,0.85,0.80),(0.23,0.88,0.83),(0.24,0.89,0.84))	((0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50),(0.50,0.50,0.50))	((0.82,0.17,0.22),(0.81,0.16,0.21),(0.80,0.15,0.20),(0.83,0.18,0.23),(0.84,0.19,0.24))
A 1 2	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))	((0.72,0.278,0.278),(0.71,0.28,0.28),(0.7,0.29,0.29),(0.69,0.3,0.3),(0.68,0.31,0.31),(0.67,0.32,0.32))	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))	((0.72,0.278,0.278),(0.71,0.28,0.28),(0.7,0.29,0.29),(0.69,0.3,0.3),(0.68,0.31,0.31),(0.67,0.32,0.32))	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))	((0.82,0.175,0.225),(0.81,0.18,0.16),(0.8,0.19,0.23),(0.79,0.2,0.28),(0.78,0.21,0.29))	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))
A 1 3	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))	((0.72,0.278,0.278),(0.71,0.28,0.28),(0.7,0.29,0.29),(0.69,0.3,0.3),(0.68,0.31,0.31),(0.67,0.32,0.32))	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))	((0.82,0.175,0.225),(0.81,0.18,0.16),(0.8,0.19,0.23),(0.79,0.2,0.28),(0.78,0.21,0.29))	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))	((0.92,0.115,0.115),(0.91,0.12,0.12),(0.9,0.13,0.13),(0.89,0.14,0.14),(0.88,0.15,0.15),(0.87,0.16,0.16),(0.86,0.17,0.17))	((0.72,0.278,0.278),(0.71,0.28,0.28),(0.7,0.29,0.29),(0.69,0.3,0.3),(0.68,0.31,0.31),(0.67,0.32,0.32))	((1.00,0.01,0.01),(0.99,0.02,0.02),(0.98,0.03,0.03),(0.97,0.04,0.04),(0.96,0.05,0.05),(0.95,0.06,0.06),(0.94,0.07,0.07))

A14	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((0.72, 0.278, 0.328), (0.71, 0.267, 0.16), (0.73, 0.288, 0.338), (0.74, 0.299, 0.249))	((1.00, 0.01, 0.01), (0.97, 0.02, 0.02), (0.96, 0.03), (0.95, 0.04))	((0.92, 0.115, 0.091, 0.26), (0.93, 0.138, 0.093), (0.92, 0.115, 0.091), (0.93, 0.138, 0.093))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((1.00, 0.01, 0.01), (0.97, 0.02, 0.02), (0.96, 0.03), (0.95, 0.04))	((0.92, 0.115, 0.091, 0.26), (0.93, 0.138, 0.093), (0.92, 0.115, 0.091), (0.93, 0.138, 0.093))	((0.72, 0.278, 0.328), (0.71, 0.267, 0.16), (0.73, 0.288, 0.338), (0.74, 0.299, 0.249))	((1.00, 0.01, 0.01), (0.97, 0.02, 0.02), (0.96, 0.03), (0.95, 0.04))	((0.92, 0.115, 0.091, 0.26), (0.93, 0.138, 0.093), (0.92, 0.115, 0.091), (0.93, 0.138, 0.093))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))
A15	((0.72, 0.278, 0.328), (0.71, 0.267, 0.16), (0.73, 0.288, 0.338), (0.74, 0.299, 0.249))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((0.72, 0.278, 0.328), (0.71, 0.267, 0.16), (0.73, 0.288, 0.338), (0.74, 0.299, 0.249))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((0.72, 0.278, 0.328), (0.71, 0.267, 0.16), (0.73, 0.288, 0.338), (0.74, 0.299, 0.249))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((0.72, 0.278, 0.328), (0.71, 0.267, 0.16), (0.73, 0.288, 0.338), (0.74, 0.299, 0.249))	((0.82, 0.175, 0.225), (0.81, 0.166, 0.177), (0.83, 0.188, 0.238), (0.84, 0.199, 0.249))	((0.72, 0.278, 0.328), (0.71, 0.267, 0.16), (0.73, 0.288, 0.338), (0.74, 0.299, 0.249))

The single values are calculated from triangular neutrosophic interval using  $([T, I, F]) = 2+T-I-F/3a$  as shown in Table 5. (Dey and Ray 2023)

**Table 5. Triangular Neutrosophic Interval**

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933
A2	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765
A3	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765
A4	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61
A5	0.98	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71
A6	0.893	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98
A7	0.02	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893
A8	0.1765	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02
A9	0.4993	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765
A10	0.8095	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993
A11	0.0933	0.2765	0.3765	0.61	0.71	0.98	0.893	0.02	0.1765	0.4993	0.8095
A12	0.9869	0.8887	0.705	0.9869	0.8887	0.705	0.9869	0.8887	0.8389	0.9869	0.8887
A13	0.8887	0.9869	0.8887	0.705	0.9869	0.8887	0.8389	0.9869	0.8887	0.705	0.9869
A14	0.8389	0.705	0.9869	0.8887	0.8389	0.9869	0.8887	0.705	0.9869	0.8887	0.8389
A15	0.705	0.8389	0.8389	0.8389	0.705	0.8389	0.705	0.8389	0.705	0.8389	0.705

The weight values from the normalized decision matrix are substituted using the VIKOR method to derive the weighted decision matrix. The values for  $\rho$ ,  $\sigma$ , and  $\tau$  are then calculated, as shown in Table 6 (Bahramipour et al., 2023).

**Table 6. Normalized decision matrix weight values using VIKOR method**

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11		Si	Ri
A1	0.01 19	0.02 84	0.03 55	0.026 1	0.00 07	0.00 88	0.09 1	0.07 63	0.04 59	0.01 67	0.08 41		0.42 53	0.091
A2	0.01 66	0.01 75	0.02 61	0.000 6	0.00 88	0.09 1	0.07 63	0.04 59	0.01 67	0.08 41	0.06 69		0.45 05	0.091
A3	0.02 75	0.01 29	0.00 07	0.008 8	0.09 1	0.07 63	0.04 59	0.01 67	0.08 41	0.06 69	0.05 74		0.48 81	0.091
A4	0.03 21	0.00 03	0.00 88	0.091	0.07 63	0.04 59	0.01 67	0.08 41	0.06 69	0.05 74	0.03 55		0.51 50	0.091
A5	0.04 47	0.00 44	0.09 1	0.076 3	0.04 59	0.01 67	0.08 41	0.06 69	0.05 74	0.03 55	0.02 61		0.54 88	0.091
A6	0.04 06	0.04 5	0.07 63	0.045 9	0.01 67	0.08 41	0.06 69	0.05 74	0.03 55	0.02 61	0.00 05		0.49 51	0.084 1
A7	0	0.03 77	0.04 59	0.016 67	0.08 41	0.06 69	0.05 74	0.03 55	0.02 61	0.00 06	0.00 88		0.37 97	0.084 1
A8	0.00 73	0.02 27	0.01 67	0.084 1	0.06 69	0.05 74	0.03 55	0.02 61	0.00 06	0.00 88	0.09 1		0.41 71	0.091
A9	0.02 23	0.00 83	0.08 41	0.066 9	0.05 74	0.03 55	0.02 61	0.00 06	0.00 88	0.09 1	0.07 63		0.47 73	0.091
A10	0.03 67	0.04 16	0.06 69	0.057 4	0.03 55	0.02 61	0.00 06	0.00 88	0.09 1	0.07 63	0.04 59		0.48 68	0.091
A11	0.00 34	0.03 31	0.05 74	0.035 5	0.02 61	0.00 06	0.00 88	0.09 1	0.07 63	0.04 59	0.01 67		0.39 48	0.091
A12	0.04 5	0.00 46	0.02 65	0.00	0.00 92	0.02 65	0.00	0.00 92	0.01 39	0.00	0.00 92		0.14 43	0.045
A13	0.04 04	0.00	0.00 92	0.026 5	0.00	0.00 92	0.01 39	0.00	0.00 92	0.02 65	0.00		0.13 51	0.040 4
A14	0.03 81	0.01 31	0.00	0.009 2	0.01 39	0.00	0.00 92	0.02 65	0.00	0.00 92	0.01 39		0.13 33	0.038 1
A15	0.03 18	0.00 69	0.01 39	0.013 9	0.02 65	0.01 39	0.02 65	0.01 39	0.02 65	0.01 39	0.02 65		0.21 45	0.031 89
												S*	0.13	0.031
												R*	33	9
												S-	0.54	
												R-	88	0.091

Qi values are calculated using the formula  $Q_i = v^* + (1-v)^*$  as shown in Table 6. Here set  $v = 0.5$  interval value. Then based on step 6 and 7 VIKOR method for determining rank two prerequisites needs to be fulfilled. 1. Accepted advantage and 2. Accepted stability vikor Qi rank is determined.

TOPSIS method of weighted normalized matrix with  $S_i^+$   $S_i^-$  are calculated and shown in Table 7. performance rank is calculated using equation  $P_i =$

**Table 7. Weighted normalized matrix using TOPSIS method**

	Vij		WEIGHTED NORMALISED MATRIX												
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	$S_i^+$		$S_i^-$	$P_i$
A1	0.018	0.025	0.008	0.0096	0.00132	0.00121	0.00269	0.002375	0.00672	0.00894	0.001256	0.000542	0.003288	0.005341	0.521107
A2	0.0025	0.0041	0.0096	0.00132	0.00121	0.00003	0.0024	0.00672	0.00894	0.001256	0.003721	0.000601	0.004505	0.004392	0.498839
A3	0.0004	0.0047	0.00132	0.00120	0.00003	0.00024	0.0067	0.00894	0.001256	0.003721	0.005067	0.000661	0.00571	0.002961	0.471759
A4	0.00047	0.00065	0.00120	0.00003	0.00024	0.00067	0.0009	0.001256	0.003721	0.005067	0.00821	0.000689	0.006249	0.00098	0.444221

A5	0.0065	0.0059	0.0003	0.0024	0.0067	0.0109	0.0013	0.003721	0.005067	0.00821	0.009555	0.000721	0.026859	0.019439	0.419874
A6	0.0060	0.0001	0.0024	0.0067	0.0109	0.0013	0.0037	0.005067	0.00821	0.009555	0.013189	0.000586	0.024208	0.022615	0.482991
A7	0.0001	0.0012	0.0067	0.0109	0.0013	0.0037	0.0051	0.00821	0.009555	0.013189	0.012018	0.000423	0.020557	0.026214	0.56047
A8	0.0012	0.0033	0.0109	0.0013	0.0037	0.0051	0.0082	0.009555	0.013189	0.012018	0.000269	0.000531	0.023052	0.025344	0.523679
A9	0.0033	0.0054	0.0013	0.0037	0.0051	0.0082	0.0096	0.013189	0.012018	0.000269	0.0002375	0.000645	0.025389	0.023081	0.476191
A10	0.0054	0.0006	0.0037	0.0051	0.0082	0.0096	0.0132	0.012018	0.000269	0.0002375	0.000672	0.000594	0.024381	0.02317	0.487268
A11	0.0006	0.0018	0.0051	0.0082	0.0096	0.0132	0.020	0.0269	0.02375	0.00672	0.010894	0.000468	0.021641	0.025971	0.545468
A12	0.0066	0.0059	0.0095	0.0133	0.0120	0.0095	0.0033	0.00196	0.01129	0.013282	0.01196	7.98E-05	0.008935	0.035255	0.79781
A13	0.0059	0.0066	0.0120	0.0095	0.0133	0.0120	0.0013	0.013282	0.01196	0.009488	0.013282	7.14E-05	0.008451	0.035374	0.807166
A14	0.0056	0.0047	0.0133	0.0120	0.0113	0.0133	0.0120	0.009488	0.013282	0.01196	0.01129	6.08E-05	0.007797	0.035605	0.820358
A15	0.0047	0.0056	0.0113	0.0113	0.0095	0.0113	0.0095	0.01129	0.009488	0.01129	0.009488	9.92E-05	0.009958	0.031313	0.758713
V+	0.0001	0.0066	0.0133	0.0133	0.0133	0.0133	0.0133	0.0133	0.0133	0.0133	0.0133	0.0133			
V-	0.0066	0.0001	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003			

#### 4.1. Multicriteria Ranking Results

A comparative analysis is presented in the radar graph shown in Figure 1, which contrasts the VIKOR and TOPSIS methods. The rankings determined through this analysis are summarized in Table 8.

**Table 8. Comparison of VIKOR and TOPSIS Methods**

ALTERNATIVES	VIKOR (Qi) V=0.5	RANK	TOSIS(Pi)	RANK
A1	0.8514	8	0.5211	8
A2	0.8817	10	0.4988	9
A3	0.9269	13	0.4718	13
A4	0.9593	14	0.4442	14
A5	1	15	0.4199	15
A6	0.8770	9	0.4830	11
A7	0.7381	5	0.5605	5
A8	0.8415	7	0.5237	7
A9	0.9139	11	0.4762	12
A10	0.9254	12	0.4873	10
A11	0.8146	6	0.5455	6
A12	0.1241	4	0.7978	3
A13	0.0745	2	0.8072	2
A14	0.0527	1	0.8204	1
A15	0.0977	3	0.7587	4

The radar graph would display the performance of each alternative according to the criteria employed in the analysis as illustrated in Figure 1. Each axis represents a distinct criterion, and the values represented on each axis represent the performance of each alternative on that criterion. The distinct lines representing the performance of each alternative according to VIKOR and TOPSIS rankings. The closer the line is to the center of the graph, the poorer the performance, whereas the further out from the center, the better the performance. The performance of options according to both approaches is visually compared in this graph. The diesel bus earns the highest average performance value (0.820) based on the energy supply criterion, while the hydrogen bus records the lowest value (0.360). In terms of energy efficiency, electric vehicles (EVs) display significantly high average performance values (Khurana et al., 2020b). EVs are also the best at lowering noise and air pollution, but they rank poorly when it comes to vehicle capability and the necessary road infrastructure. This analysis suggests that EVs are superior in terms of energy, environmental effect, industry relationships, and implementation cost. In contrast, diesel-powered vehicles rank better in terms of vehicle capability and the infrastructure needed for their operation. Natural gas, methanol, and hydrogen-powered transportation modes generally exhibit intermediate performance levels across the many criteria.

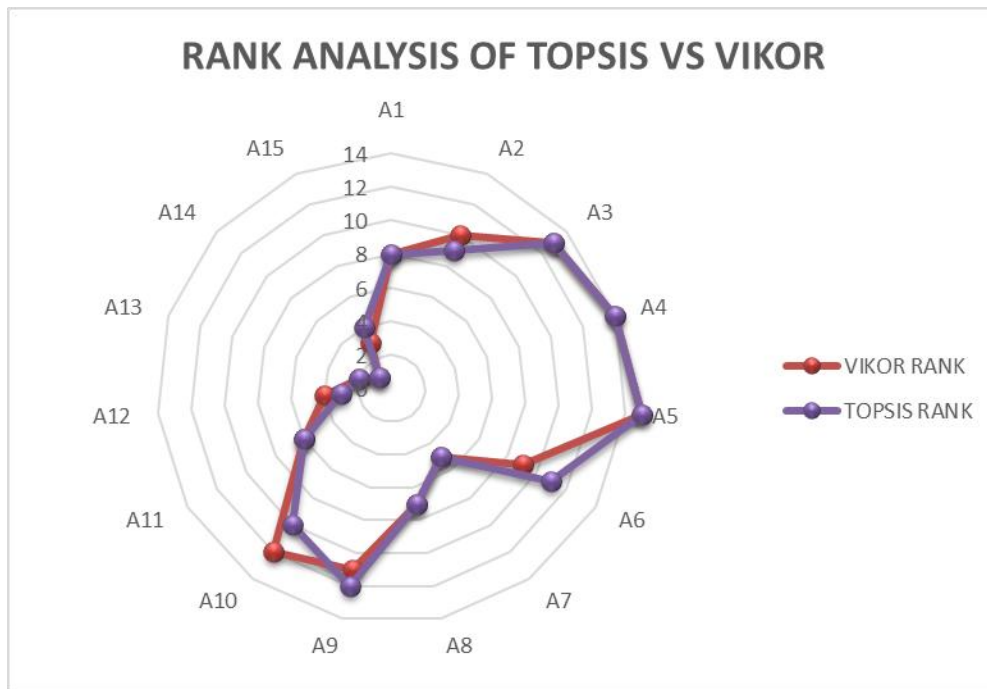


Figure 1. The comparative study of VIKOR and TOPSIS rank

## 5. Conclusion

This study presented a comparative evaluation of the VIKOR and TOPSIS methods within a Plithogenic Neutrosophic Multi-Criteria Decision Making (MCDM) framework to identify the most suitable vehicle technology for mitigating air pollution. Fifteen alternative fuel-based vehicle technologies were assessed using eleven evaluation criteria encompassing environmental, economic, and technological aspects. The integration of plithogenic neutrosophic sets enabled the effective representation of uncertainty, indeterminacy, and contradictory information, thereby enhancing the reliability of the decision-making process. The comparative analysis demonstrated that both VIKOR and TOPSIS produced consistent rankings, highlighting the robustness of the proposed framework. The radar chart further illustrated the comparative performance of the two MCDM methods and provided an intuitive visualization of the ranking results. Among the evaluated alternatives, Electric Vehicles (EVs) achieved the highest overall ranking, indicating their superior potential for reducing vehicular air pollution. Their zero tailpipe emissions, higher energy efficiency, and compatibility with renewable energy sources make EVs an environmentally sustainable transportation solution. Furthermore, continuous advancements in battery technology, charging infrastructure, and renewable electricity generation are expected to strengthen the environmental and economic viability of electric mobility. The proposed Plithogenic Neutrosophic MCDM framework offers a robust and flexible approach for solving

complex decision-making problems characterized by uncertainty and conflicting criteria. The methodology can be readily extended to other sustainability-related applications, including renewable energy planning, smart transportation systems, environmental management, and policy evaluation. Future research may incorporate additional MCDM techniques, dynamic weighting strategies, and real-time datasets to further improve the accuracy and applicability of the proposed decision-making framework.

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