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ADVANCING SUSTAINABLE MOBILITY: COMPARATIVE ANALYSIS OF MCDM METHODS WITH PLITHOGENIC AND NEUTROSOPHIC SETS

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Abstract

This paper explores a comparative analysis for the first time in Multi-Criteria Decision Making (MCDM) research with the new Plithogenic Neutrosophic approach. Here, two well-established MCDM methods, TOPSIS and VIKOR, are used to compare a number of alternatives to reduce air pollution due to vehicles. The paper utilizes real-life data from urban areas characterized by different levels of pollution and types of vehicle fleets. Through a rigorous evaluation process, which incorporates the representation of uncertainty and inconsistency using Plithogenic Neutrosophic sets, the goal of the study is to determine which of the many gasoline kinds is best for automobiles. Real-life data on vehicle emissions, fuel efficiency, and environmental impact are meticulously integrated into the analysis. The findings of this comparative analysis, supplemented by real-life data, are succinctly presented using a radar graph. This graph conspicuously showcases the superior performance of electric vehicles in mitigating air pollution when compared to other alternatives such as petrol, diesel, and hybrid vehicles. This article underscores the efficacy of integrating Plithogenic Neutrosophic sets into MCDM frameworks, while emphasizing the significance of informed decision-making processes based on real-life data for addressing pressing environmental challenges within the transportation sector.

Keywords: Neutrosophic set, Plithogenic sets, VIKOR Method, Plithogenic Neutrosophic sets, Extensions, Applications.

1. Introduction

In the present era, air pollution, mainly caused by the internal combustion engine, has become a major global concern in the environmental affects(Gurjar et al. 2010). These occur mostly due to rapid growth in the vehicle sector caused by extensive urbanization, economic development, and industrialization(Sharma et al. 2020). This rapid development not only increased mobility for facilitating economic development but also raised the concern of

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airborne pollution. Vehicle emissions consist of complex mixtures of particulate matter and gases, which become significant contributors to deteriorating India's air quality (Indirajith, K, Jaya, N, Naveen Kumar 2022). The article states the multifaceted problems caused by vehicle emissions in India and examines their consequences, causes, and possible remedies in the framework of the nation's progressing socio-economic scenario by using MCDM method. (Indirajith et al. 2021, 2022).

In general, countless studies state that, across diverse realms, MCDM has a significant role in helping decision-makers solve complex problems(Isola et al. 2017). This method is used to simultaneously evaluate multiple criteria and rank the best alternative solutions and decision-solving by providing a structural method for the decision-making, particularly when dealing with uncertainties or conflicting objectives(Saaty and Vargas 1998). By methodologically considering numerous aspects and their connections, MCDM provides an ideal approach for attaining the envisioned outcomes.

Moreover, in the MCDM concepts, the assignment of alternatives is essential, specifically in the theme of vehicle selection based on types of fuel (Keshavarz Ghorabaee 2016). Alternatives serve as a door for providing suitable problem solutions in the context of different types of fuel-based vehicle air pollution. In this article, we have not only chosen the alternative ranges from conventional diesel and petrol to hydrogen fuel cell vehicles, electric vehicles (EVs), and hybrid electric vehicles (HEVs) (Peivandi et al. 2020). We have stated that alternative ranges extend up to some cutting-edge technologies like autonomous vehicles, improved public transportation systems, and shared mobility services ([CSL STYLE ERROR: reference with no printed form.]). Every alternative value provides distinct features for addressing concerns about air pollution problems in the context of providing the best alternative after performing an in-depth examination.

Initially, it is necessary to assess the weight of the criteria and evaluate the criteria before dealing with MCDM problems (Mishra et al. 2020). In addition to solving multiple decisions related to the air pollution problem, multiple factors play a major role in choosing different vehicles based on the type of fuel. This criterion consists of a range of assessments, including cost, emission levels, technology implementation feasibility, and level of infrastructure availability (Khurana et al. 2020a). Moreover, maintenance requirements, reliability, public acceptance, energy efficiency, noise levels, testing vehicle range, and manufacturability are core elements considered in the assessment process (Gkartzonikas and Gkritza 2019). The assessments related to emission rates, costs, and level of infrastructure availability criteria are central assessments in the process when determining feasibility and viability of alternative fuel-based vehicles (i.e., to help mitigate air pollution from vehicles). The criteria mentioned will be weighted based on their impact on environmental health and ease of realization. It is these assessments that will guide the process of further exploring sound sustainable transportation solutions.

The purpose of the article is to explore the comparison between VIKOR and TOPSIS in MCDM methods through the plithogenic with neutrosophic approach, to try to solve vehicular

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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 plitogenic logic could be broke down into the following categories, (i) fuzzy logic, (ii) classical logic, (iii) neutrosophic logic and (iv) intuitionistic fuzzy logic. If a logic has only one attribute (true), it is called classical logic. For fuzzy logic, if the logic has two attribute values (truth and falsehood), then it is called fuzzy logic. Similar to intuitionistic fuzzy logic, it has three values (falsehood, truth, and indeterminacy). Finally, neutrosophic logic in general may be characterized by more than four degrees of truth-values resulting from various attributes (Sankar et al. 2020; Smarandache 2022b). The novelty of this paper lies in offering a solution to address the complex decision-making challenges of air pollution by employing MCDM methods such as VIKOR and TOPSIS, utilizing plithogenic neutrosophic logic sets. These two MCDM methods offer distinct solutions for solving and ranking complex decision problems. The vikor method used a compromise solution for evaluating the alternative. It also served as a resilient approach for solving alternative-based fuel-type vehicle pollution-based problems(Shekhovtsov and Salabun 2020). Similarly, TOPSIS methods aim to provide the best alternative based on a compromise solution. This compromise solution can be obtained by choosing the best solution with regard to the positive ideal solutions near the Euclidean distance and the farthest Euclidean distance from the negative ideal solutions (Hwang and Yoon 1981a).

The outline of the paper is organized into seven sections that detail the various complexities involved in selecting an alternative fuel-based vehicle as a means of reducing vehicular air pollution. The second section outlines alternative solutions available today, from standard gasoline- or diesel-powered cars to the more advanced hydrogen fuel cell vehicles and electric vehicles (EVs). The third section outlines the evaluation of criteria and weight assignments that consider various measures associated with potentially alternative vehicles, such as emissions, cost-effectiveness, and infrastructure requirements, that can assist in determining the most appropriate alternative. The fourth section focuses on the identification of conflicting criteria and how decisions can be made concerning potentially competing objectives. The fifth section introduces the VIKOR and TOPSIS ranking methods, based on plithogenic and neutrosophic set theory, that will be employed to rank alternative solutions. The sixth section describes the results of the ranking process, provides discussion regarding the effectiveness of each method, and its implications for decision making. Finally, the seventh section provides the conclusion and overall recommendations of the paper. conclusions drawn from the study's findings and outlines avenues for future research, highlighting the ongoing importance of addressing vehicular air pollution through informed decision-making processes.

2. A Preliminaries Plithogenic Sets and it classifications:

The need for a strong Mathematical instrument to approach real world problems which have data uncertainty prompted researchers to come up with different Mathematical instruments by simplifying the solutions to these problems.In 1965, Zadeh proposed the notion of fuzzy sets, wherein Every element is allotted a degree of membership represented by a solitary precise

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value within the range of [0, 1]. Extensively studied by researchers, fuzzy sets have been instrumental in solving numerous everyday challenges or practical dilemmas. However, practical situations often present challenges where defining the membership degree with a specified by a single numerical value becomes difficult due to inherent uncertainty. This led to the development of interval-valued fuzzy sets, where the membership degree is represented as an interval within [0, 1]. Subsequently, in 1986, Atanassov proposed the the notion of intuitionistic fuzzy sets (IFS), which includes the non-membership degree. IFS has found wide-ranging applications. However, the inability of IFS to handle indeterminate information, which is widespread in the belief systems ,was stated by Smarandache in 2000([CSL STYLE ERROR: reference with no printed form.]). Smarandache introduced the concept of neutrosophic sets, where indeterminacy (I), membership (T), and non-membership (F) degrees are independently quantified as T, I, F ∈ [0, 1], and their sum T + I + F is not necessarily constrained to [0, 1]. In many real-life Multiple Criteria Decision Making (MCDM) problems, attributes often require further subdivision into attribute values to enhance decision-making. Additionally, Smarandache introduced the concept of plithogenic hypersoft sets encompassing crisp, intuitionistic fuzzy, fuzzy, plithogenic and neutrosophic sets. In 2020, Smarandache developed aggregation operations on plithogenic sets and demonstrated that they represent the most generalized structure applicable to a diverse array of real-world problems.

2.1 . Plithogenic Sets :

Plithogenic sets define elements based on multiple attribute values, each with associated relevance degrees and contradiction functions to enhance precision. These sets generalize various types of sets, such as crisp, fuzzy, intuitionistic fuzzy, and neutrosophic sets, by incorporating different levels of membership, indeterminacy, and non-membership. Smarandache (2022) expanded this concept into neutrosophic sets, which address indeterminacy and compatibility issues in decision-making processes where information is incomplete or uncertain. The theory of neutrosophic sets, introduced by Smarandache (2022), enables the analysis of the "Knowledge of neural thought," thereby enhancing fuzzy logic with indeterminate membership and addressing neutral states alongside truth and falsehood. Derived from natural language, neutrosophic sets are particularly useful for handling imprecise data, offering an alternative method for decision-making in uncertain environments, where traditional fuzzy sets may fall short. While plithogenic sets define elements through all their attribute values individually, neutrosophic sets excel in resolving challenges posed by information scarcity, uncertainty, ambiguity, and imprecision. An A neutrosophic set A in X is indicated as having an A value in X as 1.

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

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.

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

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

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

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.

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

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

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

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

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

– 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.

1.Acceptable advantage

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

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

2. 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

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

Where xij 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.

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

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).

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

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

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

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

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).

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

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

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

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \qquad (17)$$

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

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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 wasteCompressed 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. These alternatives include:

15 Alternatives, by vehicle fuel type,

Dual-Fuel Vehicles: Dual-fuel vehicles operate on diesel in combination with compressed natural gas or liquefied petroleum gas, which result in operational flexibility and operational efficiencies. They run on both fuels at the same time, resolving emissions issues and increasing fuel options. They have a modification for engine fuel type that allows for transition based on driving conditions - engendering better performance and environmentally friendly attributes.

Synthetic Fuel Vehicles: Synthetic fuel vehicles run fuel from non-petroleum sources such as coal, biomass, and natural gas to produce fuel for vehicle use; thereby, introducing alternatives to traditional petroleum-based fuels. Though there are benefits to fuels such as synthetic fuels, challenges such as cost competitive nature, environmental; however, advancements in technology and supportive policy measures indicate that cleaner transportation is achievable in the future.

Methanol Vehicles: Methanol Vehicles operate primarily on methanol that is produced from a variety of sources including natural gas or biomass, thereby creating alternatives to petroleum-based options. Methanol also provides different alternatives for both energy dense: it is also produced from both versatile sources, which may result in lower emissions and gaining energy security - while providing viable fuel options for transportation.

Propane Vehicles (LPG):

Propane vehicles, or LPG vehicles, use propane as their primary fuel and are considered a cleaner alternative to gasoline and diesel. They have emissions that are lower than conventional cars and have improved safety features, making propane vehicles a good option for improving air quality, reducing the impact on the environment, improving energy security, and improving cost-efficacy.

Dimethyl Ether Vehicles (DME)

DME vehicles run on dimethyl ether fuel which burns clean, is low in emissions and extremely versatile. DME is made from various incinerable materials. As DME produces almost no pollutants or Green House Gas emissions, this makes DME an environmentally and clean alternative to diesel fuel. With many of the properties and high cetane, DME is appropriate for compression ignition engines and transport electrification fuel cells.

Bioethanol Vehicles (E85):

Bioethanol vehicles, also referred to as E85 vehicles, use ethanol as a renewable fuel source. Ethanol decreases GHG emissions and has lower GHG emissions down to the purpose of their

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production, i.e., from biomass. Ethanol is used for years in the auto industry for optimizing gasoline formulations and delivering leaner combusting fuels with more oxygen. This has benefits in emissions and reducing harmful pollutants for a more sustainable solution for the Transportation sector.

Biodiesel Vehicles (B100):

Biodiesel vehicles using B100 represent a greener alternative to fossil fuels, helping to reduce emissions and pollutants and to support local economies. The compatibility of B100 with existing diesel engines, regenerative sourcing of biodiesel, and use of waste in biodiesel production all contribute to its sustainability. However, issues associated with feedstocks and limitations of the existing infrastructure may hinder widespread adoption of biodiesel, but it provides promise for clean transportation in the future.

Flex-Fuel Vehicles (FFVs):

Flex Fuel Vehicles (FFVs) will offer flexibility for drivers wishing to utilize ethanol-gasoline blends to limit fossil fuel consumption and emissions. FFVs further the production of ethanol supporting rural economies, produce lower greenhouse gas emissions, and require no modifications to engine operation. Issues associated with infrastructure for E85 blends, along with lower fuel efficiency than gasoline, remain issues for FFVs. Positive changes in technology and public policies can help to promote the advancement of sustainable biofuels policy and use of biofuels in transportation.

Compressed Natural Gas Vehicles (CNGVs):

Compressed natural gas vehicles make a cleaner alternative to gasoline and diesel vehicles. CNGVs emit fewer harmful pollutants and utilize abundant, cost-effective domestic natural gas. CNGVs will illustrate energy security by not being dependent on petroleum. CNGVs offer potential cost savings; however, it will take time and investment into further developing the necessary refueling infrastructure to support it for widespread adoption of CNGVs. Continued investment and supporting policies will be necessary to ensure sustainable transportation with CNGVs.

Liquefied Natural Gas Vehicles (LNGVs)

Using liquefied natural gas to support environmentally conscious transportation, LNGVs also improve energy security and agricultural sustainability. Although they are economically attractive and perform similarly to conventional fuel vehicles, increasing adoption of LNGVs relies on the creation of refueling infrastructure. Ongoing investments and policies are needed to fully realize the potential of LNGVs in providing a sustainable transportation option.

Plug-in Hybrid Electric Vehicles (PHEVs)

PHEVs are a mixture of electric and combustion technology, ideally suited to support emissions reductions and fuel efficiency. PHEVs provide extensions of range anxiety by operating in electric mode for the short commutes, and switching seamlessly to gasoline for

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longer commutes. Government incentives to adopt PHEVs and technology changes drive both regular consumers and fleets to PHEVs in the sustainable transportation option.

Hybrid Electric Vehicles (HEVs)

HEVs are a combination of electric motors and gasoline engines that provide improved fuel efficiency without the need for outside charging. Regenerative braking is used to have electric motors capture power while slowing down and optimize energy use through actions that reduce emissions. Not only do HEVs operate nicely while accelerating, lower maintenance costs for some consumers, become available for increased segments of operation, but also considers the environmental aspects of drivers who balance improving fuel economy and vehicle performance in their day to day driving.

Fuel Cell Range-Extended Electric Vehicles (FC-REEVs)

Combined fuel cell electric vehicles with battery electric vehicles using fuel cell technology instead of battery technology to support a clean, efficient form mobility. Using hydrogen as a fuel, fuel cell technology has a distinct advantage of only emitting water vapor when driving in urban environments, which has its advantages of enabling a zero-emission vehicle to provide range. Barriers include infrastructure hurdles and fuel cell scalability, requiring collaboration for successful adoption and a more sustainable transportation future.

Hydrogen Fuel Cell Vehicles (FCVs)

FCVs utilize hydrogen fuel cells to enable vehicles to operate without emissions, with only water vapor produced as a byproduct. They feature quick refueling and a range of options for hydrogen sources. Infrastructure and hydrogen production challenges will require collaboration for widespread adoption; however, FCVs represent a pathway for cleaner emissions as they move towards sustainable transportation.

Electric Vehicles (EVs)

These options present varied solutions to addressing air pollution and growing the sustainability of the transportation sector(Shankar and SaravanaKumar 2020; Neves et al. 2023). MCDM methods help decision makers made choices of various alternatives based on multiple criteria concerning environmental factors, energy efficiency, and cost/benefit analyses, as alternatives decisions can align with objectives and priorities. The trade-offs and benefits of alternatives can help decision makers develop cleaner and sustainable transportation systems by involving stakeholders in an informed decision-making process.

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:

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a) **Emissions Reduction Potential:** Assess how well each fuel type can reduce harmful emissions, including CO2, NOx, 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.

4.1 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

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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.

5. 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),(0.90,0.10,0.010),(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))

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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)	((0.02,0.0.99,0.99),(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

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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, 0.10, 0.010),(0.93,0.13,0.13),(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))	((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), (0.501,0.501,0.501),(0.502,0.502,0.502),(0.503, 0.503,0.503),(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))

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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),(0.90,0.10,0.010),(0.93,0.13,0.13),(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))	((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),(0.501,0.501,0.501),(0.502,0.502,0.502),(0.503,0.503,0.503),(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))
A3	((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),(0.90,0.10,0.010),(0.93,0.13,0.13),(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))	((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),(0.501,0.501,0.501),(0.502,0.502,0.502),(0.503,0.503,0.503),(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))
A4	((0.72,0.27,0.32),(0.71,0.26,0.31),	((1.00,0.00,0.00),(0.99,0.01,0.01),	((0.92,0.11,0.11),(0.91,0.12,0.12),	((0.02,0.0.99,0.99),(0.01,0.98,0.	((0.22,0.87,0.82),(0.21,0.86,0.81),	((0.50,0.50,0.50),(0.501,0.501,0.	((0.82,0.17,0.22),(0.81,0.16,0.21),	((0.12,0.91,0.91),(0.11,0.92,0.92),	((0.32,0.77,0.72),(0.31,0.76,0.71),	((0.42,0.67,0.62),(0.41,0.66,0.61),	((0.62,0.37,0.42),(0.61,0.36,0.41),

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	(0.70, 0.25, 0.30), (0.73, 0.28, 0.33), (0.74, 0.29, 0.34))	(0.98, 0.02, 0.02), (0.97, 0.03, 0.03), (0.96, 0.04, 0.04))	(0.90, 0.10, 0.010),(0.93,0.13,0.13),(0.94,0.14,0.14))	98),(0.00,1.00,1.00),(0.03,0.97,0.97),(0.04,0.96,0.96))	(0.20, 0.85, 0.80), (0.23, 0.88, 0.83), (0.24, 0.89, 0.84))	501),(0.502,0.502,0.502),(0.503, 0.503,0.503),(0.504,0.504, 0.504))	(0.80, 0.15, 0.20), (0.83, 0.18, 0.23), (0.84, 0.19, 0.24))	(0.10, 0.90, 0.90), (0.13, 0.93, 0.93), (0.14, 0.94, 0.94))	(0.30, 0.75, 0.70), (0.33, 0.78, 0.73), (0.34, 0.79, 0.74))	(0.40, 0.65, 0.60), (0.43, 0.68, 0.63), (0.44, 0.69, 0.64))	(0.60, 0.35, 0.40), (0.63, 0.38, 0.43), (0.64, 0.39, 0.44))
A5	((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, 0.010),(0.93,0.13,0.13),(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))	((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), (0.501,0.501,0.501),(0.502,0.502,0.502),(0.503, 0.503,0.503),(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))
A6	((0.92,0.11, 0.11), (0.91, 0.12, 0.12), (0.90, 0.10, 0.010),(0.93,0.13,0.1	((0.02,0.0.99,0.99),(0.01,0.98,0.98),(0.00,1.00,1.00),(0.03,0.97,0.	((0.22,0.87, 0.82), (0.21, 0.86, 0.81), (0.20, 0.85, 0.80), (0.23, 0.88, 0.83),	((0.50,0.50, 0.50), (0.501,0.501,0.501),(0.502,0.502,0.502),(0.503,	((0.82,0.17, 0.22), (0.81, 0.16, 0.21), (0.80, 0.15, 0.20), (0.83, 0.18, 0.23),	((0.12,0.91, 0.91), (0.11, 0.92, 0.92), (0.10, 0.90, 0.90), (0.13, 0.93, 0.93),	((0.32,0.77, 0.72), (0.31, 0.76, 0.71), (0.30, 0.75, 0.70), (0.33, 0.78, 0.73),	((0.42,0.67, 0.62), (0.41, 0.66, 0.61), (0.40, 0.65, 0.60), (0.43, 0.68, 0.63),	((0.62,0.37, 0.42), (0.61, 0.36, 0.41), (0.60, 0.35, 0.40), (0.63, 0.38, 0.43),	((0.72,0.27, 0.32), (0.71, 0.26, 0.31), (0.70, 0.25, 0.30), (0.73, 0.28, 0.33),	((1.00,0.00, 0.00), (0.99, 0.01, 0.01), (0.98, 0.02, 0.02), (0.97, 0.03, 0.03),

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	3),(0.94,0.14,0.14))	97),(0.04,0.96,0.96))	(0.24, 0.89, 0.84))	0.503,0.503),(0.504,0.504, 0.504))	(0.84, 0.19, 0.24))	(0.14, 0.94, 0.94))	(0.34, 0.79, 0.74))	(0.44, 0.69, 0.64))	(0.64, 0.39, 0.44))	(0.74, 0.29, 0.34))	(0.96, 0.04, 0.04))
A7	((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), (0.501,0.501,0.501),(0.502,0.502,0.502),(0.503, 0.503,0.503),(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, 0.010),(0.93,0.13,0.13),(0.94,0.14,0.14))
A8	((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), (0.501,0.501,0.501),(0.502,0.502,0.502),(0.503, 0.503,0.503),(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, 0.010),(0.93,0.13,0.13),(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))

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		0.504))									
A9	((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))	((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),(0.90,0.10,0.010),(0.93,0.13,0.13),(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))	((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))
A10	((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),(0.90,0.10,0.010),(0.93,0.13,0.13),(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))	((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),(0.501,0.501,0.501),(0.502,0.502,0.502),(0.503,0.503,0.503),(0.504,0.504,0.504))

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A11	((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),(0.90,0.10,0.010),(0.93,0.13,0.13),(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))	((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),(0.501,0.501,0.501),(0.502,0.502,0.502),(0.503,0.503,0.503),(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))
A12	((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))	((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))	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349))	((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))	((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))	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349))	((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))	((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))	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0.238),(0.84,0.199,0.249))	((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))	((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))
A13	((0.92,0.115,0.115),(0.91,0.126,0.126),	((1.00,0.01,0.01),(0.98,0.001,0.001),(0.	((0.92,0.115,0.115),(0.91,0.126,0.126),	((0.72,0.278,0.328),(0.71,0.267,0.317),	((1.00,0.01,0.01),(0.98,0.001,0.001),(0.	((0.92,0.115,0.115),(0.91,0.126,0.126),	((0.82,0.175,0.225),(0.81,0.166,0.216),	((1.00,0.01,0.01),(0.98,0.001,0.001),(0.	((0.92,0.115,0.115),(0.91,0.126,0.126),	((0.72,0.278,0.328),(0.71,0.267,0.317),	((1.00,0.01,0.01),(0.98,0.001,0.001),(0.

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	(0.90,0.107,0.107),(0.93,0.138,0.138),(0.93,0.149,0.149))	97,0.002,0.002),(0.96,0.003,0.003),(0.95,0.004,0.004))	(0.90,0.107,0.107),(0.93,0.138,0.138),(0.93,0.149,0.149))	(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349))	97,0.002,0.002),(0.96,0.003,0.003),(0.95,0.004,0.004))	(0.90,0.107,0.107),(0.93,0.138,0.138),(0.93,0.149,0.149))	(0.80,0.157,0.207),(0.83,0.188,0.238),(0.84,0.199,0.249))	97,0.002,0.002),(0.96,0.003,0.003),(0.95,0.004,0.004))	(0.90,0.107,0.107),(0.93,0.138,0.138),(0.93,0.149,0.149))	(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349))	97,0.002,0.002),(0.96,0.003,0.003),(0.95,0.004,0.004))
A14	((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))	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349))	((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))	((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))	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0.238),(0.84,0.199,0.249))	((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))	((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))	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0.338),(0.74,0.299,0.349))	((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))	((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))	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0.238),(0.84,0.199,0.249))
A15	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0	((0.82,0.175,0.225),(0.81,0.166,0.216),(0.80,0.157,0.207),(0.83,0.188,0	((0.72,0.278,0.328),(0.71,0.267,0.317),(0.70,0.256,0.306),(0.73,0.288,0

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	.338), (0.74, 0.299 ,0.34 9))	.238), (0.84, 0.199 ,0.24 9))	.238), (0.84, 0.199 ,0.24 9))	.238), (0.84, 0.199 ,0.24 9))	.338), (0.74, 0.299 ,0.34 9))	.238), (0.84, 0.199 ,0.24 9))	.338), (0.74, 0.299 ,0.34 9))	.238), (0.84, 0.199 ,0.24 9))	.338), (0.74, 0.299 ,0.34 9))	.238), (0.84, 0.199 ,0.24 9))	.338), (0.74, 0.299 ,0.34 9))

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

Table 5. Triangular Neutroscopic 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

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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 S_i, R_i, S^*, and $R^*$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	0.0119	0.0284	0.0355	0.0261	0.0007	0.0088	0.091	0.0763	0.0459	0.0167	0.0841		0.4253	0.091
A2	0.0166	0.0175	0.0261	0.0006	0.0088	0.091	0.0763	0.0459	0.0167	0.0841	0.0669		0.4505	0.091
A3	0.0275	0.0129	0.0007	0.0088	0.091	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574		0.4881	0.091
A4	0.0321	0.0003	0.0088	0.091	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574	0.0355		0.5150	0.091
A5	0.0447	0.0044	0.091	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574	0.0355	0.0261		0.5488	0.091
A6	0.0406	0.045	0.0763	0.0459	0.0167	0.0841	0.0669	0.0574	0.0355	0.0261	0.0005		0.4951	0.0841
A7	0	0.0377	0.0459	0.01667	0.0841	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088		0.3797	0.0841
A8	0.0073	0.0227	0.0167	0.0841	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088	0.091		0.4171	0.091
A9	0.0223	0.0083	0.0841	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088	0.091	0.0763		0.4773	0.091
A10	0.0367	0.0416	0.0669	0.0574	0.0355	0.0261	0.0006	0.0088	0.091	0.0763	0.0459		0.4868	0.091
A11	0.0034	0.0331	0.0574	0.0355	0.0261	0.0006	0.0088	0.091	0.0763	0.0459	0.0167		0.3948	0.091

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A 12	0.045	0.0046	0.0265	0	0.0092	0.0265	0	0.0092	0.0139	0	0.0092		0.1443	0.045
A 13	0.0404	0	0.0092	0.0265	0	0.0092	0.0139	0	0.0092	0.0265	0		0.1351	0.0404
A 14	0.0381	0.0131	0	0.0092	0.0139	0	0.0092	0.0265	0	0.0092	0.0139		0.1333	0.0381
A 15	0.0318	0.0069	0.0139	0.0139	0.0265	0.0139	0.0265	0.0139	0.0265	0.0139	0.0265		0.2145	0.03189
												S* R*	0.1333	0.0319
												S- R-	0.5488	0.091

Q_i values are calculated using the formula $Q_i = v^* \frac{s_i - s^*}{s^- - s^*} + (1-v)^* \frac{R_i - R^*}{R^- - R^*}$ 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 $P_i = \frac{S_i^-}{S_i^+ + S_i^-}$

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
A 1	0.0018	0.0025	0.008	0.0096	0.0132	0.0121	0.000269	0.002375	0.00672	0.010894	0.001256	0.000542	0.023288	0.025341	0.521107
A 2	0.0025	0.0041	0.0096	0.0132	0.0121	0.0003	0.0024	0.00672	0.010894	0.001256	0.003721	0.000601	0.024505	0.024392	0.498839
A 3	0.004	0.0047	0.0132	0.0120	0.0003	0.0024	0.0067	0.010894	0.001256	0.003721	0.005067	0.000661	0.02571	0.022961	0.471759
A 4	0.0047	0.0065	0.0120	0.0003	0.0024	0.0067	0.0109	0.001256	0.003721	0.005067	0.00821	0.000689	0.026249	0.02098	0.444221

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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	0.002375	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	0.002375	0.00672	0.000594	0.024381	0.02317	0.487268
A11	0.0006	0.0018	0.0051	0.0082	0.0096	0.0132	0.0120	0.000269	0.002375	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	0.0133	0.01196	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	0.0113	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				
V-	0.0066	0.0001	0.0003	0.0003	0.0003	0.0003	0.003	0.003	0.003	0.003	0.003				

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5.1. 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 show the performance of each alternative according to the criteria used in the analysis as illustrated in Figure 1. Each axis represents a different criterion, and the values plotted on each axis represent the performance of each alternative on that criterion. The different 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, while the further away from the center, the better the performance. This graph provides a visual comparison of how alternatives perform according to both methods. The diesel bus achieves 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) demonstrate notably high average performance values (Khurana et al., 2020b). EVs also perform the best in reducing air and noise pollution, but their scores are relatively low concerning vehicle capability and the required road infrastructure. From this analysis, it can be

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inferred that EVs excel in criteria such as energy, environmental impact, industrial relationships, and implementation cost. In contrast, diesel-powered vehicles rank higher in terms of vehicle capability and the infrastructure needed for their operation. Transportation modes using natural gas, methanol, and hydrogen typically present intermediate performance levels across the various criteria.

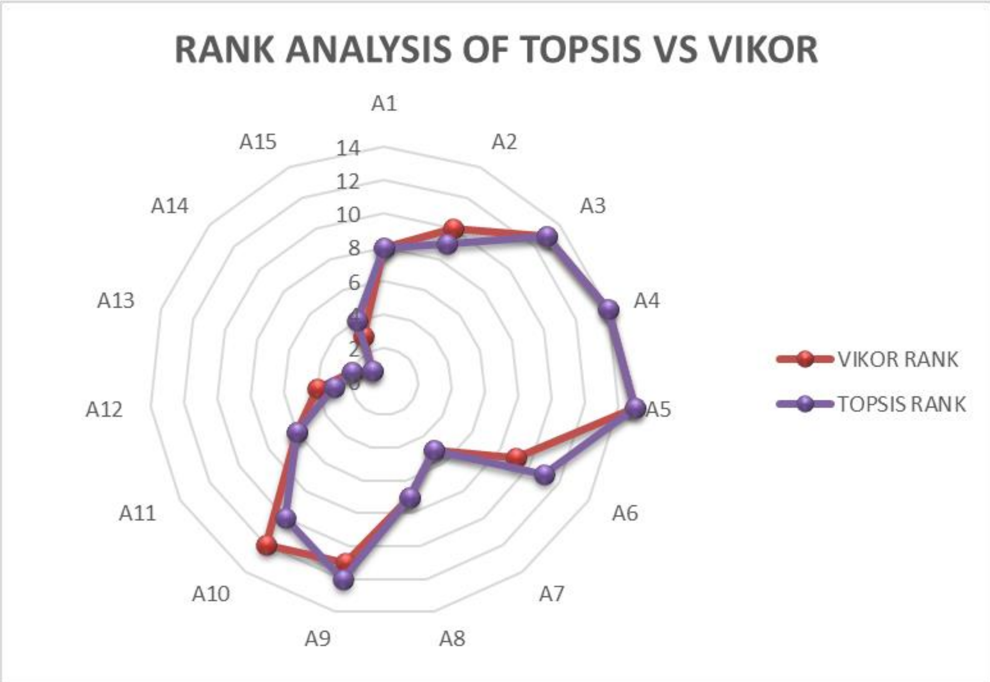

Figure 1. The comparative study of VIKOR and TOPSIS rank

6. Conclusion

In conclusion, the utilization of Plithogenic Neutrosophic sets in Multi-Criteria Decision Making (MCDM) for evaluating alternatives in the context of reducing air pollution from vehicle emissions has demonstrated promising results. Through the analysis of 15 alternatives, including Dual-Fuel Vehicles, Synthetic Fuel Vehicles, Methanol Vehicles, and the latest Electric Vehicles, over 11 criteria for fuel types, we have been able to effectively assess the viability of each option. Utilizing MCDM methods like VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) allowed for thorough evaluations, permitting us to select the best alternatives for addressing reductions in air pollution. As a result of Plithogenic Neutrosophic sets, we were able to represent uncertain and inconsistent information more effectively for better decision-making. We generated a radar graph that represented the evaluation rank performance of TOPSIS and VIKOR for the vehicle air pollution MCDM problem. This graph served as a effective measure of the performance of the two methods in addressing the MCDM problem, which asparted easy decision in selecting the best options. Upon analysis, it was concluded that the Electric Vehicle option was the highest ranked alternative with respect to evaluating reduction in air pollution, ranking #1 overall. This result provides an evidence of the role of electric vehicles in reducing vehicles emissions in environmental move forward.

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Among the 15 alternatives, Electric Vehicles (EVs) clearly were the best alternative in terms of having low air pollution. The electric vehicles operate using electric power only and have a 0 emissions while in operation for the tail pipe which is considered "zero tail pipe emissions." With this quality, EVs can be valuable in addressing air quality issues related to transportation.. Electric Vehicles (EVs) are non-emitting vehicles, in contrast to internal combustion engine vehicles that produce a range of pollutants such as nitrogen oxides carbon monoxide, and particulate matter (PM). EVs are powered by electricity that's produced and stored in batteries, or generated by a fuel cell, at the point-of-use, resulting in cleaner air quality in cities and urban settings. The increasing availability of clean or renewable energy for electricity generation adds yet an additional layer of environmental benefits to EVs. Charging EVs with energy produced from a renewable energy source, such as solar, wind, or hydro electrification, can further reduce a vehicle's life cycle greenhouse gas (GHG) emissions. Additionally, the improvements in battery technology continue to enhance EV range, charging infrastructure, and affordability, especially for the expanding consumer market for EVs.

In conclusion, EVs are the best option for reducing air pollution in the transportation sector. In addition to EVs operating without emissions, they can be paired with renewable energy, making them an important technology and part of the air pollution and climate change issue.

7. Declaration & Conflict of interest

- Funding – The author does not have relevant funding provided for author.
- Conflicts of Interest - The author has no conflicts of interest to disclose.

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