Yugoslav Journal of Operations Research
36 (2026), Number 1, 265–292
DOI: https://doi.org/10.2298/YJOR240415023B

Research Article

UNLOCKING THE POTENTIAL OF BATTERY ELECTRICAL VEHICLES IN WEST BENGAL: AN EFFECTIVE ACTION SELECTION APPLYING MULTI-CRITERIA GROUP DECISION-MAKING FRAMEWORK UNDER CYLINDRICAL NEUTROSOPHIC ARENA

Anita BARMAN
Department of Mathematics, Indian Institute of Engineering Science and Technology, Shibpur, Howrah-711103, India
anitabarman66@gmail.com, ORCID: 0009-0006-4525-8920

Shariful ALAM
Department of Mathematics, Indian Institute of Engineering Science and Technology, Shibpur, Howrah-711103, India
salam50in@yahoo.co.in, ORCID: 0000-0001-8263-117X

Avishek CHAKRABORTY*
Department of Engineering Science, Academy of Technology, Adisaptagram, Krishnapur-Chandanpur, Hooghly-712502, India
tirtha.avishek93@gmail.com,
avishek.chakraborty@aot.edu.in, ORCID: 0000-0002-8684-3716

Received: April 2024 / Accepted: May 2025

Abstract: In the current global scenario, the use of battery electric vehicles (BEVs) becomes very significant for sustainable transportation solutions and reduced carbon emissions. While BEVs have gained much attention as an environmentally friendly form of transport, an enormous research vacuum exists regarding the systematic evaluation and

*Corresponding author

prioritization of different aspects to achieve all the advantages. In our study, we have created "multi-criteria group decision-making (*MCGDM*)" model that employs both actual and intangible factors to assess and rank different decisions associated with battery vehicle-related obstacles in West Bengal. Here, we applied the power averaging aggregation operator in the Cylindrical Neutrosophic (CN) arena to aggregate the available information. We further discovered that the CN context did not employ the extension of the Best-Worst approach, which is an effective way of dealing with ambiguity in the process of making decisions. Therefore, in this present study, we have proposed Cylindrical Neutrosophic enhanced Best-Worst (CNEBWM) method for assessing the attributes weights and decision-specialists weights in our *MCGDM* problem. Here, Multiobjective Optimization On the basis of Ratio Analysis (MOORA) and COmbinative Distance based ASsessment (CODAS) are adopted to determine the best action. We have also performed rigorous sensitivity analysis by changing the attribute's weights to validate the reliability and acceptability of the proposed model. Furthermore, a comprehensive comparison analysis of our model outcome with the well-established previous research works has been presented. Through extensive simulation, we have observed that our proposed *MCGDM* procedure in a CN circumstance gives stable, resilient, and reliable outcomes when MOORA methodology is followed. This study further demonstrates that, among the four categories of effective actions taken plans (Infrastructure advancement, Incorporating renewable energy, Incentivizing benefits and subsidies, indigenous production and supply chain coordination), infrastructure advancement has been identified as the most crucial factor in case of West Bengal scenario.

Keywords: Battery electric vehicles, *MCGDM*, cylindrical neutrosophic arena, decision making strategies, MOORA, CODAS.

MSC: 94D05.

1. INTRODUCTION

Recently, an extensive transformation has taken place in the automobile industry due to the menace of pollution, the upsurge in greenhouse gases and absolute dependence on fossil fuels. In this scenario, the introduction of battery electric vehicles (BEVs) has come up as an alternative option to minimize these environmental issues. It has emerged as a greener mode of transportation and changed the perception of mobility worldwide. BEVs are gaining impetus in West Bengal because of grave environmental concerns of the whole country in order to reduce its reliance on imported fossil fuels and encourage eco-friendly transportation options. Unambiguously, the notion of BEVs as an alternative to conventional vehicles holds great potential. However, there is a dearth of research concerning the recognition of actions and their hierarchy required to utilize these BEVs properly. Thus, in this article, an attempt is made to prioritize different action plans to promote and/or implement the BEVs program in West Bengal. There are several attributes to be considered with regard to electric vehicles as Lower carbon footprint, expenditure, employment and economic expansion etc. These features are different with respect to different problems of electric vehicles and classifying the potential actions in accordance with these attributes is even more clumsy. In this scenario of bemusement, we generally consider the different views of several professionals and single out the best one by assessing its attribute values. However, decision-maker opinions are often ambiguous as uncertainty and imprecision encompass their judgments. The theories of vagueness have advanced significantly over the years and it has been instrumental in addressing the issues of ambiguity and fuzziness. Lately, the foundation of neutrosophic numbers has been incorporated into this citing its great potential in tackling the befuddlement present in several real-life problems. [1] incorporated quasirung orthopair fuzzy set to select charging station for electric vehicles. [2] proposed "multi-criteria group decision-making (*MCGDM*)" problems regarding eco-friendly urban conveyance to rank the "generalized interval type-2 trapezoidal fuzzy numbers". Recently, [3] employed an "multi-criteria decision making (*MCDM*)" problem to evaluate fifteen several electric vehicles with regard to their various attributes like charging time, price, maximum power, battery durability, speed, etc. and here "Shannon's entropy" and "TOPSIS" procedures are implemented to assess the weight of respective alternatives of the electric cars and rank electric vehicles respectively. Hence, our aim is to build an *MCGDM* model using definitive features of BEVs and sort the possible actions for the problems relevant to BEVs.

Various kinds of uncertainty appear in daily life. [4] invented a very useful tool that is renowned as an Intuitionistic Fuzzy set (IFS) for capturing the uncertainty of real-life data in an extended manner and a lot of researchers have demonstrated a keen interest in the domain of IFS. Some creative research efforts in the IFS environment can be seen in the following research articles:([5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24]). Although IFS is capable of handling partial and unclear data, it is unable to tackle inconsistent and ambiguous data that arises in many instances in everyday life. To conquer these limitations, [25] pioneered the Neutrosophic set (NS) that is the more expanded version of IFS to describe and navigate unreliable, inadequate, and irreconcilable information successfully and effectively. Precisely, the idea of NS is a compatible mixture of the certainty function, the inconclusiveness function and the falseness function. Basically, neutrosophic set involves membership function of truthness ($K_{\tilde{S}}(h)$), membership function of indeterminate ($L_{\tilde{S}}(h)$) and membership function of regarding falseness ($M_{\tilde{S}}(h)$) satisfying the condition $0 \leq K_{\tilde{S}}(h) + L_{\tilde{S}}(h) + M_{\tilde{S}}(h) \leq 3$ and $K_{\tilde{S}}(h)$, $L_{\tilde{S}}(h)$, $M_{\tilde{S}}(h) \in [0,1]$ for $h \in H$ where H is a universal set. Some remarkable research publications regarding neutrosophic theory have burgeoned in the field of problems related to shortest route ([26]), data interpretation([27]), methodology for goal programming ([28], [29]) etc. Moreover, Manifold advancements took place in this field and researchers studied on "Single Valued Neutrosophic set(SVNS)"([30], [31], [32]) and implemented "triangular and trapezoidal neutrosophic numbers" in many indecisive problems. [33] had employed the idea of neutrosophic sets to handle certain real-world issues. [34] exposed "extended TOPSIS" in neutrosophic environment and effectually utilized it in decision-making problems. Lately, [35] used single valued cylindrical neurosophic number for the safety modeling of marine systems. Subsequently, the idea of "N-cylindrical neutrosophic number" has been presented by [36]. [37] applied "N-cylindrical neutrosophic set" in education applying "Similarity Index and Ratio of scores" of NS. [38] manifested a solution that has been applied to solve some transportation problems under neutrosophic circumstances. [39] used DEMATEL for accuracy purposes under Pythagorean neutrosophic environment. [40] experimented on autonomous vehicles related problem with the help of neutrosophic fuzzy sets. [41] focused on interval neutrosophic environment to obtain the best result for urban public transport systems.

The uncertainty theory plays a pivotal role in dealing with several realistic problems in the domain of science and engineering. Thus, *MCDM* or *MCGDM* has attracted many researchers as it may resolve many ambiguous real-world challenging concerns in many fields like money investment, hiring employees, medical diagnosis, and intricate circuit design etc. Basically, decision-making is an intricate cognitive process that looks for a suitable result or choice out of several alternatives taking into account the relevant aspects of the given choices. Methods such as EDAS ([42]), CODAS ([43]), VIKOR ([44]), TOPSIS ([45]), MOORA ([46]) are significantly used in the arena of decision-making where *MCGDM* is frequently took part. Researchers from diverse fields have done some notable work employing the *MCDM* techniques under the neutrosophic arena. The research regarding optimization is followed by the work of [47] for determining the best number and suitable place of ”charging stations” for electric vehicles. [48] exposed the use of triangular neutrosophic sets integrated with *MCDM* to sort the renewable energy alternatives in a suitable order. [49] researched regarding the solution of massive health care waste for the sustainability of the environment and lower the expenditure using *MCDM*. [50] used a neutrosophic *MCDM* based approach to estimate the risk of cyber security in power management. [51] implemented decision-making to grant the facilities to bank loan applicants under an uncertain fuzzy set. [52] employed *MCDM* methodology for determining supplier selection-related problem in neutrosophic arena. [53] explored Support Vector Machine method in decision making model. [54] created an *MCDM* problem based on the developed operator. [55] applied a *MCDM* approach based on a linear programming model by applying COPRAS and MOORA decision-making techniques. [56] employed trapezoidal based *MCGDM* problem to sort out transportation path through MULTIMOORA method. [57] and [58] demonstrated *MCGDM* model for the site choosen of power station and “power bank supplier selection” respectively. Multiple research studies have effectively employed the “Best-Worst” technique to access criteria weights for decision-making problems. [59] proposed extension of “Best-Worst” method in IF context. Then, [60] and [61] enhanced “fuzzy Best-Worst method ” with additive consistency in interval-valued IFS arena. [62] exhibited “ Best-Worst method” in NS environment.

Aggregation operators are crucially important in the circumstances of decision-making, particularly when discussing *MCDM/MCGDM*. They are used to combine all the data collected from different attributes to generate a total assessment of the possibilities. [63] and [64] manifested power averaging operators and “power geometric operators” in “trapezoidal intuitionistic fuzzy (TIF)” arena respectively and employed them in MCGDM problems with TIF information. [65] proposed “t-norms” and “t-conorms” based power average operators in TIF arena.

1.1. Research gaps and Motivation

The following gaps in research have been identified based on the aforementioned entire analysis of the literature:

- We have observed that Cylindrical Neutrosophic set (*CNS*) is more potent than FS and IFS to describe and navigate unreliable, inadequate, and irreconcilable information. *CNS* can handle and address uncertainty in a robust and effective manner.

- A "Multi-Criteria Decision Analysis (MCDA)" strategy named the Best-Worst Method (BWM) includes two sets of pairwise comparisons to identify the optimal weights of evaluation criteria: one analyzes all criteria with the "worst criterion", and the other compares the "best criterion" with all others. BWM's main advantages involve its straightforwardness, its ability to effectively deal with variations in pairwise comparisons and the fact that it needs fewer comparisons than procedures like the "Analytic Hierarchy Process (AHP)". We further discovered that the CN context did not employ the extension of the Best-Worst approach, which is an effective way of dealing with ambiguity in the process of making decisions. Therefore, in our research, we have proposed Cylindrical Neutrosophic enhanced Best-Worst method (CNEBWM) for assessing the criteria weights and decision-makers weights in our *MCGDM* problem.
- Moreover, a maximum number of researchers have examined and explored decision-making issues employing a single expert (i.e., *MCDM* approach) in *CNS* environment, which cannot be used for multiple group decision-making processes in CN environment. In this article, we have explored the *MCGDM* process using MOORA and CODAS in *CN* environment, which has been applied to identify the most potential factor to promote battery-run electric vehicles in West Bengal.

The following is an overview of the reasons for seeking our study.

The NS is useful in uncertain contexts because it may effectively address uncertainty by expressing incomplete, irreconcilable, and inaccurate information. The idea of Cylindrical Neutrosophic Number(*CNN*) is a newly explored area that can be applied in decision-making theory. Electric vehicles are desirable substitutes for traditional automobiles because they generate no emissions and consequently reduce greenhouse gas emissions, especially in polluted urban areas. Moreover, diesel engines consume more energy to function than electric vehicles, resulting in decreased energy consumption and reducing the demand for fossil fuels. In order to tackle the increasing air pollution in the state caused by motor fuel emissions, the West Bengal government has decided to utilize only electric vehicles for all administrative tasks: Reported on 21st September 2023 in The Economic Times ([66]). As we have observed in our previous research work([67]), MOORA and CODAS decision-making methods are unexplored and calculation processes are comparatively simple and observations show that our provided *MCGDM* procedure in a Cylindrical Neutrosophic environment achieves stable, resilient, and reliable outcomes when MOORA methodology is followed after analyzing stability with other various decision-making techniques; these occurrences enormously push us to explore an *MCGDM* technique for an effective action selection to unlock the potential of BEVs in West Bengal under CN environments.

1.2. Novelty

Some important thoughts and concepts have been accomplished and included in this research which are listed as follows:

I) Implemented our proposed Cylindrical Neutrosophic enhanced Best-Worst method (CNEBWM) to obtain the attribute weights and decision-makers weights for our specified *MCGDM* problem.

II) Decision-making techniques MOORA and CODAS have been implemented to analyze the optimal ranking of the alternatives.

III) Sensitivity analysis using MATLAB has been done by changing the weights of the attributes to verify the efficacy of our implemented methods.

IV) Comparative analysis has been done with well-established works. Moreover, we have compared the stability of our proposed methods with other methods with the help of numerical simulation using MATLAB by adjusting the weights of decision experts to make our research work more robust.

Our proposed work has been discussed in this way: section 2 depicts some basic mathematical preliminaries. In section 3, the *MCGDM* process with our proposed CNEBWM has been described and numerical calculations are performed. In this section, sensitivity analysis has also been performed. Section 4 addresses comparative analysis, which confirms the robustness of our proposed model. The conclusion part and future scope are illustrated in section 5.

2. SOME BASIC MATHEMATICAL PRELIMINARIES

2.1. Definition (Neutrosophic set)

A set $\tilde{S}$ in the discourse H is called a "Neutrosophic set (NS)" if $\tilde{S} = \{h; [K_{\tilde{S}}(h), L_{\tilde{S}}(h), M_{\tilde{S}}(h)] : h \in H\}$ where $K_{\tilde{S}}(h) : H \to [0,1]$ is said to be the certainty function which denotes the value of certainty. $L_{\tilde{S}}(x) : H \to [0,1]$ is called an inconclusiveness function which signifies the ambiguity of a function. $M_{\tilde{S}}(H) : H \to [0,1]$ is called a falseness function which gives information regarding the falsity of a function. Here, $K_{\tilde{S}}(h)$, $L_{\tilde{S}}(h)$ and $M_{\tilde{S}}(h)$ must satisfy the criteria given below.

$$0 \leq K_{\tilde{S}}(h) + L_{\tilde{S}}(h) + M_{\tilde{S}}(h) \leq 3 \tag{1}$$

2.2. Definition (Cylindrical Neutrosophic set)

A set $\widetilde{CS}$ in the arena of discourse H, usually indicated by h, is named to be a "Cylindrical Neutrosophic set (CNS)" if $\widetilde{CS} = \{h; [K_{\widetilde{CS}}(h), L_{\widetilde{CS}}(h), M_{\widetilde{CS}}(h)] : h \in H\}$ where $K_{\widetilde{CS}}(h) : H \to [0,1]$ is indicated the function of certainty which denotes the value of certainty. $L_{\widetilde{CS}}(h) : H \to [0,1]$ is named an inconclusiveness function which expresses the uncertainty of a function. $M_{\widetilde{CS}}(h) : H \to [0,1]$ is called the falseness function which gives information regarding the falsity of a function. They must obey the following relationship, given by:

$$(K_{\widetilde{CS}}(h))^2 + (L_{\widetilde{CS}}(h))^2 \leq 1^2, M_{\widetilde{CS}}(h) \leq 1 \tag{2}$$

We may represent a cylindrical neutrosophic number (CNN) by a notation given by $CS = (K_{CS}, L_{CS}, M_{CS})$.

2.3. Definition (Reference comparison)

If i symbolizes the most advantageous option and j represents the worst one, then the pair-wise comparison $\tilde{G_{ij}}$ is regarded as a "reference comparison" ([68]).

2.4. Score function

The "score function" is significantly instrumental in the theories of vagueness. Basically, it helps establish a relationship between a fuzzy number and a crisp number. We may state an example as follows: Let $r = (K_s, L_s, M_s)$ be a cylindrical neutrosophic number. Then,

- value of certainty membership function = $K_r + 2$
- value of inconclusiveness membership function = L_r
- value of falseness membership function = M_r
- Then, the "score function" ([69]) is described as follows,

$$\widetilde{SC_r} = \frac{(K_r + 2 - L_r - M_r)}{3}, where \widetilde{SC_r} \in [0,1] \quad (3)$$

2.5. Basic Operations

Let $S_1 = (p_1, q_1, r_1)$ and $S_2 = (p_2, q_2, r_2)$ be two neutrosophic numbers and $\lambda > 0$. In this article, we have used the following algebraic operations [67]:

- $S_1 + S_2 = (\sqrt{p_1{}^2 + p_2{}^2 - p_1{}^2 p_2{}^2}, q_1 q_2, r_1 r_2)$
- $S_1 S_2 = (p_1 p_2, \sqrt{q_1{}^2 + q_2{}^2 - q_1{}^2 q_2{}^2}, r_1 + r_2 - r_1 r_2)$
- $\lambda S_1 = (\sqrt{1 - (1 - p_1{}^2)^\lambda}, q_1{}^\lambda, r_1{}^\lambda)$
- $S_1{}^\lambda = (p_1{}^\lambda, \sqrt{1 - (1 - q_1{}^2)^\lambda}, \sqrt{1 - (1 - r_1{}^2)^\lambda})$

The above operations are used to develop the power averaging aggregation operator for *CNNs*, which has been used in our study.

2.6. Power aggregation operators for *CNN*s

Here, the Power Averaging Aggregation Operator for Cylindrical Neutrosophic number ([67]) is discussed.

Definition 1. *([67]).* $M_p = \langle r_p, s_p, t_p \rangle (p = 1, 2, \cdots, k)$ *be given set of cylindrical neutrosophic numbers (CNNs). Then a "cylindrical neutrosophic power averaging aggregation" ($\mathscr{CNPAA}$) operator is a function* $\mathscr{CNPAA} : T^k \to T$, *defined by*

$$CNPAA(M_1, M_2, \cdots, M_k) = \frac{\sum_{p=1}^{k} \Big(1 + S(M_p)\Big) M_p}{\sum_{p=1}^{k} \Big(1 + S(M_p)\Big)}$$

where $M_p \in T$ *and* $S(M_p) = \sum_{q=1, p \neq q}^{k} Sup(M_p, M_q)$. *Here,* $Sup(M_p, M_q)$ *is the greatest value of the score values of the CNNs* M_p *and* M_q.

Theorem 2. *([67]). The aggregated value is obtained utilizing $\mathscr{CNPAA}$ operator which is also a CNN and is shown below*

$$\mathscr{CNPAA}(M_1, M_2, \cdots, M_k) = \left\langle \sqrt{1 - \prod_{p=1}^{k}(1 - r_p^2)^{W_p}}, \prod_{p=1}^{k}(s_p)^{W_p}, \prod_{p=1}^{k}(t_p)^{W_p} \right\rangle \quad (1)$$

where $W_p = \frac{\left(1+S(M_p)\right)}{\sum_{p=1}^{k}(1+S(M_p))}$, *where* $M_p \in T$ *and* $S(M_p) = \sum_{q=1, p\neq q}^{k} Sup(M_p, M_q)$.

Properties of the $\mathscr{CNPAA}$ operator

$M_p = \langle r_p, s_p, t_p \rangle (p = 1, 2, \cdots, k)$ is any set of *CNN*s and $\alpha = (\alpha_1, \alpha_2, \cdots, \alpha_k)^T$ be the weight vector of $M_p(p = 1, 2, \cdots, k)$ satisfying the property $\sum_{p=1}^{k}(\alpha_p) = 1$, $\alpha_p > 0$. Then $\mathscr{CNPAA}$ displays the properties stated below:

1. (Idempotency property) Let $M_p = \langle r_1, s_1, t_1 \rangle$ for all p, then

$$\mathscr{CNPAA}(M_1, M_2, \cdots, M_k) = M$$

2. (Monotonicity property) Let $M'_p = \langle r'_p, s'_p, t'_p \rangle (p = 1, 2, \cdots, k)$ be other set of *CNN* following conditions $r_p \leq r'_p$, $s_p \leq s'_p$, $t_p \geq t'_p$. Then

$$\mathscr{CNPAA}(M_1, M_2, \cdots, M_k) \leq \mathscr{CNPAA}(M'_1, M'_2, \cdots, M'_k)$$

3. (Boundedness Property) If $M_p^- = \langle min_p(r_p), max_p(s_p), max_p(t_p) \rangle$ and $M_p^+ = \langle max_p(r_p), min_p(s_p), min_p(t_p) \rangle$ be CNNs, then

$$M^- \leq \mathscr{CNPAA}(M_1, M_2, \cdots, M_k) \leq M^+$$

3. *MCGDM* PROCESS FOR REQUIRED ACTION SELECTION USING VARIOUS KINDS OF APPROACHES

3.1. Illustration of the problem

***MCGDM* Model on *CN* arena for an effective action selection for unlocking the potential of battery electrical vehicles in West Bengal**

It is essential to utilize battery electric vehicles (BEVs) to their full potential for several reasons. By emitting no tailpipe emissions, decreasing air pollution, and assisting in climate change mitigation, BEVs develop environmental sustainability. The second reason is that BEVs have more energy security, as they run on electricity from home natural energy resources and depend less on imported fossil fuels. An ambiance related to industrial and infrastructure advancement is raised by embedding in BEVs, and this manages to encourage for creation of several recent job possibilities and economic growth. The decreased level of pollutants in the atmosphere connected to BEVs enhances public health even further as it diminishes the frequency of heart and respiratory illnesses. BEVs additionally cover an important part in encouraging green urban sustainability by minimizing congestion in the roadways, pollution from noise and the requirement for individual vehicles. They also offer greener and more economical choices, especially public transit and shared transportation services. Consequently, in order to get the most effective outcomes, an extensive selection of action methods that take into consideration several key factors is needed. We have addressed an *MCGDM* problem within a *CNN* framework to effectively address the need for action selection. In this context, we present the problem in the following way:

Infrastructure advancement (S_1), Incorporating renewable energy (S_2), Incentivizing benefits and subsidies(S_3), indigenous production and supply chain coordination (S_4) are regarded as respective alternatives. The criteria that have been taken into account are Employment and economic expansion($\mathscr{C}_1$), Lower carbon footprint and greenhouse gases($\mathscr{C}_2$), Less operating expense($\mathscr{C}_3$), Decrease reliance on the petroleum imports($\mathscr{C}_4$). In addition, We identify three separate categories of decision experts: one group of automobile experts ($\widehat{DM}_1$), one group of environmentalists($\widehat{DM}_2$) and another group of ordinary people($\widehat{DM}_3$) respectively.

3.2. A new strategy for group decision-making based upon cylindrical neutrosophic enhanced BWM (CNEBWM)

This subsection provides an extension of the Best-Worst technique in *CNN* that is applied to evaluate the criteria weights for our proposed *MCGDM* problem. According to Rezaei ([70], [71]), the original BWM is a five-step methodology. The new CNEBWM approach, constructed for group decision-making (GDM), includes additional processes. Assuming there are u decision-makers $F_1, F_2, \cdots, F_u$ and v criteria $C_1, C_2, \cdots, C_v$, the procedures for using CNEBWM technique for GDM are in the following way:

Step-1. Formation of criteria: construct a list of decision criteria c in order to decide and do an analysis.

Step-2. Selection of the "best" and "worst" criteria: Every decision expert has selected the "best" (most favourable) and "worst" (least favourable) criterion.

Step-3. Formation of "best-to-others" vector: Definition 2.3 states that, the "best-to-others" vector is formed through comparing the most favorable criterion to the rest of the criteria for a reference comparison G_{ij}. Here, i refers the "best criterion", and j symbolizes the "other criteria", including the case when j=i. This best-to-others vector is subsequently converted into *CNN* adopting the relevant reference standards listed in Table 1. The resultant vector depicts the reference comparison for decision-maker F_q where $q = 1, 2, \cdots, u$ is denoted as $\widehat{G_B}^q = (G^q_{B1}, G^q_{B2}, \cdots, G^q_{Bv})$, where G^q_{Bj} expresses that the best criterion B is more desirable than j th criterion where $j = 1, 2, \cdots, v$. Specifically, $G^q_{Bj} = (0.5, 0.5, 0.5) when B = j$.

Step-4. Formation of "others-to-worst" vector: This step seems identical to step 3. The others-to-worst vector is computed as specified in Definition 2.3. The optimal pair of other vectors is identified by comparing the rest of the criteria against the "worst" criterion for a reference comparison G_{ij}. Here, i refers to the other remaining criteria, and j symbolizes the worst criterion, including the case when i=j. This others-to-worst vector is subsequently converted into *CNN* adopting the relevant reference standards listed in Table 1. The resultant vector reflects the reference comparison for decision maker F_q where $q = 1,2,\cdots,u$ is denoted as $\widehat{G_W}^q = (G^q_{1W}, G^q_{2W}, \cdots, G^q_{vW})$, where G^q_{jW} expresses that the criterion j is more preferable than the worst criterion W where $j = 1,2,\cdots,v$. Specifically, $G^q_{jW} = (0.5, 0.5, 0.5) when W = j$.

Step-5. Uncertain confidence of decision makers in preferences for "best-to-others" outcomes: Each decision maker is requested to convey their confidence in the "best-to-others preferences", that may involve expressing uncertainty about their selection of the best criterion. A cylindrical neutrosophic number representing the decision specialist's confidence in the "best-to-others preferences" (λ^+) is provided.

Step-6. Uncertain confidence of decision makers in preferences for "others-to-worst" outcomes: Each decision expert is requested to convey their confidence in the "others-to-worst preferences" that may involve expressing uncertainty about their selection of the best criterion. A cylindrical neutrosophic number representing the decision specialist's confidence in the "others to worst preferences" (λ^-) is provided.

Step-7. Evaluation of optimum criteria weights: In this part, the criteria weights are obtained for decision maker F_q where $q = 1,2,\cdots,u$ by following the established optimization model, which is provided as follows:

$$minmax\{|(\widehat{W}_B/\widehat{W}_j) - G^q_{Bj}|, |(\widehat{W}_j/\widehat{W}_W) - G^q_{jW}|\}$$

subject to the constraints,

$$\begin{aligned} &\sum_{j=1}^{v} \widetilde{SC}(\widehat{W}_j) = 1; j = 1,2,\cdots,v \\ &(K(\widehat{W}_j))^2 + (L(\widehat{W}_j))^2 \leq 1^2, M(\widehat{W}_j) \leq 1 \\ &0 \leq K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j) \leq 1, j = 1,2,\cdots,v \end{aligned} \tag{4}$$

Where, $\widehat{W}_B$, $\widehat{W}_j$, $\widehat{W}_W$, G^q_{Bj}, G^q_{jW} are all *CNN* and they are denoted as:
$\widehat{W}_B = \langle K(\widehat{W}_B), L(\widehat{W}_B), M(\widehat{W}_B)\rangle$, $\widehat{W}_j = \langle K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j)\rangle$,
$\widehat{W}_W = \langle K(\widehat{W}_W), L(\widehat{W}_W), M(\widehat{W}_W)\rangle$, $G^q_{Bj} = \langle K(G^q_{Bj}), L(G^q_{Bj}), M(G^q_{Bj})\rangle$,
$G^q_{jW} = \langle K(G^q_{jW}), L(G^q_{jW}), M(G^q_{jW})\rangle$.

The constrained nonlinear optimization model that follows can be obtained using the above mathematical model.

$$min\phi$$

subject to the constraints,

$$|(\widehat{W}_B/\widehat{W}_j) - G^q_{Bj}| \leq \phi$$

$$|(\widehat{W}_j/\widehat{W}_W) - G^q_{jW}| \leq \phi \tag{5}$$

$$\sum_{j=1}^{v} \widetilde{SC}(\widehat{W}_j) = 1; j = 1,2,\cdots,v$$

$$(K(\widehat{W}_j))^2 + (L(\widehat{W}_j))^2 \leq 1^2, M(\widehat{W}_j) \leq 1$$

$$0 \leq K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j) \leq 1, j = 1,2,\cdots,v$$

Where, ϕ is also *CNN*.

$$minmax\{\lambda^+|(\widehat{W}_B/\widehat{W}_j) - G^q_{Bj}|, \lambda^-|(\widehat{W}_j/\widehat{W}_W) - G^q_{jW}|\}$$

subject to the constraints,

$$\sum_{j=1}^{v} \widetilde{SC}(\widehat{W}_j) = 1; j = 1,2,\cdots,v$$

$$(K(\widehat{W}_j))^2 + (L(\widehat{W}_j))^2 \leq 1^2, M(\widehat{W}_j) \leq 1 \tag{6}$$

$$0 \leq K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j) \leq 1, j = 1,2,\cdots,v$$

Where, λ^+ and λ^- are also *CNN*.

Next, model 6 has been converted into following model 7 and model 8.

$$min\{(\phi/\lambda^+) + (\phi/\lambda^-)\}$$

subject to the constraints,

$$|(\widehat{W}_B/\widehat{W}_j) - G^q_{Bj}| \leq \phi/\lambda^+$$

$$|(\widehat{W}_j/\widehat{W}_W) - G^q_{jW}| \leq \phi/\lambda^- \tag{7}$$

$$\sum_{j=1}^{v} \widetilde{SC}(\widehat{W}_j) = 1; j = 1,2,\cdots,v$$

$$(K(\widehat{W}_j))^2 + (L(\widehat{W}_j))^2 \leq 1^2, M(\widehat{W}_j) \leq 1$$

$$0 \leq K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j) \leq 1, j = 1,2,\cdots,v$$

Ultimately, the criteria weights are derived by executing model 8.

$$min\{\phi * (\lambda^- + \lambda^+)/(\lambda^- * \lambda^+)\}$$

subject to the constraints,

$$|(\widehat{W}_B/\widehat{W}_j) - G^q_{Bj}| \leq \phi/\lambda^+$$

$$|(\widehat{W}_j/\widehat{W}_W) - G^q_{jW}| \leq \phi/\lambda^- \tag{8}$$

$$\sum_{j=1}^{v} \widetilde{SC}(\widehat{W}_j) = 1; j = 1,2,\cdots,v$$

$$(K(\widehat{W}_j))^2 + (L(\widehat{W}_j))^2 \leq 1^2, M(\widehat{W}_j) \leq 1$$

$$0 \leq K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j) \leq 1, j = 1,2,\cdots,v$$

By continuing to execute the transformation, the mathematical programming structure that follows is generated.
$min\{\phi * (\lambda^- + \lambda^+)/(\lambda^- * \lambda^+)\}$

subject to the constraints,

$$|(\langle K(\widehat{W}_B), L(\widehat{W}_B), M(\widehat{W}_B)\rangle / \langle K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j)\rangle) - \langle K(G^q_{Bj}), L(G^q_{Bj}), M(G^q_{Bj})\rangle| \leq \langle K(\phi), L(\phi), M(\phi)\rangle / \langle K(\lambda^+), L(\lambda^+), M(\lambda^+)\rangle$$

$$|(\langle K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j)\rangle / \langle K(\widehat{W}_W), L(\widehat{W}_W), M(\widehat{W}_W)\rangle) - \langle K(G^q_{jW}), L(G^q_{jW}), M(G^q_{jW})\rangle| \leq \langle K(\phi), L(\phi), M(\phi)\rangle / \langle K(\lambda^-), L(\lambda^-), M(\lambda^-)\rangle \tag{9}$$

$$\sum_{j=1}^{v} \widetilde{SC}(\widehat{W}_j) = 1; j = 1,2,\cdots,v$$

$$(K(\widehat{W}_j))^2 + (L(\widehat{W}_j))^2 \leq 1^2, M(\widehat{W}_j) \leq 1$$

$$0 \leq K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j) \leq 1, j = 1,2,\cdots,v$$

The aforementioned mathematical model cannot be implemented directly because both subtraction and division are not defined for *CNN* sets. To overcome this restriction, the model requires more modification, which creates its own set of challenges. After performing numerous experiments, the present study recommends transforming all *CNN*s in the model to crisp values through the score function provided in subsection 2.4. Model 9 can then be transformed into the mathematical model that follows.
$min\{\phi * (\lambda^- + \lambda^+)/(\lambda^- * \lambda^+)\}$

subject to the constraints,

$$|(\widetilde{SC}(\widehat{W}_B)/\widetilde{SC}(\widehat{W}_j)) - \widetilde{SC}(G^q_{Bj})| \leq \widetilde{SC}(\phi)/\widetilde{SC}(\lambda^+)$$

$$|(\widetilde{SC}(\widehat{W}_j)/\widetilde{SC}(\widehat{W}_W)) - \widetilde{SC}(G^q_{jW})| \leq \widetilde{SC}(\phi)/\widetilde{SC}(\lambda^-) \tag{10}$$

$$\sum_{j=1}^{v} \widetilde{SC}(\widehat{W}_j) = 1; j = 1,2,\cdots,v$$

$$(K(\widehat{W}_j))^2 + (L(\widehat{W}_j))^2 \leq 1^2, M(\widehat{W}_j) \leq 1$$

$$0 \leq K(\widehat{W}_j), L(\widehat{W}_j), M(\widehat{W}_j) \leq 1, j = 1,2,\cdots,v$$

Step-8. Access consistency ratio ($\widetilde{CR}$): This part describes the consistency ratio for the proposed CNEBWM. The present study has been utilized the same strategy to evaluate consistency ratio as the reference [59], [62], [60], [61]. The following equation 11 can be performed to determine the highest possible value of ϕ for decision-maker F_q where $q = 1, 2, \cdots, u$.

$$(\frac{1}{\lambda^- * \lambda^+}) * (\phi)^2 - (\frac{G^q_{BW} * (\lambda^- + \lambda^+) + \lambda^- + \lambda^+}{\lambda^- * \lambda^+}) * \phi + ((G^q_{BW})^2 - G^q_{BW}) = 0 \quad (11)$$

The highest possible values of ϕ that are obtained from the above equation 11 are known as the consistency index $\widetilde{CI_q}$ values. The $\hat{\phi}$ is calculated by solving model 10, and then the following equation 12 can be employed to determine the consistency ratio $\widetilde{CR_q}$ for decision-expert F_q where $q = 1, 2, \cdots, u$.

$$\widetilde{CR_q} = \frac{\hat{\phi}}{10 * \widetilde{CI_q}} \quad (12)$$

where $q = 1, 2, \cdots, u$.

Step-9. Evaluation of weights of decision-experts : Compute the weight vector of the decision-expert, $\widehat{D} = (D_1, D_2, \cdots, D_u)$, where, D_p indicates the weight of the decision-expert F_q and $q = 1, 2, \cdots, u$. The weight of decision-expert F_q is expressed by the following equation 13:

$$D_p = \frac{\frac{1}{\widetilde{CR_q}}}{\sum_{q=1}^{u} \frac{1}{\widetilde{CR_q}}} \quad (13)$$

Where $\widetilde{CR_q}$ is the initial $\widetilde{CR}$ of decision-maker F_q determined in Step 8, and $p = 1, 2, \cdots, u$.

3.3. MOORA Methodology

This subsection describes the MOORA approach ([46]), which is employed to figure out the best course of action for unlocking the potential of BEVs in West Bengal. The following steps provide an overview of the MOORA strategy.

Step-1: Make the decision matrix by identifying the available alternatives and the related criteria which is displayed in the following equation (I).

$$\mathbf{AB} = [d_{ij}]_{n \times m} = \begin{array}{c} \\ S_1 \\ S_2 \\ \vdots \\ S_n \end{array} \begin{array}{c} \begin{array}{cccc} \mathscr{C}_1 & \mathscr{C}_2 & \cdots & \mathscr{C}_m \end{array} \\ \begin{bmatrix} d_1^1 & d_2^1 & \cdots & d_m^1 \\ d_1^2 & d_2^2 & \cdots & d_m^2 \\ \vdots & \vdots & \ddots & \vdots \\ d_1^n & d_2^n & \cdots & d_m^n \end{bmatrix} \end{array} \quad \text{(I)}$$

Step-2: Make the above matrix **AB** normalized in the following manner:

$$\eta_{ij} = d_{ij} / \sqrt{\sum_{i=1}^{n} (d_j^i)^2}; \quad where, j = 1, 2, \cdots, m; \quad \text{(II)}$$

Step-3: "The weighted normalized decision matrix" is upgraded by

$$Z_{ij} = \omega_j.\eta_{ij} \qquad (III)$$

where $\omega_j (0 < \omega_j < 1)$ indicates the j th criteria's weight.
Step-4: Next, consider equation (IV) to identify the beneficial criteria and equation (V) to discover the cost criteria respectively.

$$\sum_{i=1}^{p} Z_i \qquad (IV)$$

and

$$\sum_{j=p+1}^{m} Z_j \qquad (V)$$

Step-5 Compute the coefficient index

$$\Gamma_i = \sum_{i=1}^{p} Z_i - \sum_{j=p+1}^{m} Z_j \qquad (VI)$$

Step-6: Obtain the ranking order of the options in a certain order.

3.4. CODAS Methodology

This subsection describes the CODAS technique ([43]), which is employed to figure out the best course of action for unlocking the potential of BEVs in West Bengal. The following steps provide an overview of the CODAS strategy.
Step-1: Make the decision matrix by identifying the available alternatives and the related criteria which is displayed in the following equation (VII).

$$\mathbf{AB} = [d_{ij}]_{n\times m} = \begin{array}{c} \\ S_1 \\ S_2 \\ \vdots \\ S_n \end{array} \begin{array}{c} \begin{array}{cccc} \mathscr{C}_1 & \mathscr{C}_2 & \cdots & \mathscr{C}_m \end{array} \\ \begin{bmatrix} d_1^1 & d_2^1 & \cdots & d_m^1 \\ d_1^2 & d_2^2 & \cdots & d_m^2 \\ \vdots & \vdots & \ddots & \vdots \\ d_1^n & d_2^n & \cdots & d_m^n \end{bmatrix} \end{array} \qquad \text{(VII)}$$

In which $d_{ij} (d_{ij} \geq 0)$ indicates the performance measure of the i th option related to the j th criterion, where range of i from 1 to n and j ranges from 1 to m.
Step-2: Compute the decision matrix's normalization by utilizing linear normalization to the performance information as provided by equation (VIII).

$$\eta_{ij} = \begin{cases} d_{ij}/max_i d_{ij}; & \text{for "benefit criteria" } \mathscr{C}_j, j = 1,2,\cdots,m; \\ min_i d_{ij}/d_{ij}; & \text{for "cost criteria" } \mathscr{C}_j, j = 1,2,\cdots,m; \end{cases} \qquad \text{(VIII)}$$

Step-3: Assess the weighted normalization performance scores employing equation (IX) and construct the weighted normalizing decision matrix.

$$Z_{ij} = \omega_j.\eta_{ij} \qquad (IX)$$

where $\omega_j (0 < \omega_j < 1)$ indicates the j th criteria's weight.

Step-4: Obtain the point as a negative ideal solution (NIS).

$$\widetilde{NS} = [\widetilde{NS_j}]_{1\times m}; \quad \text{(X)}$$

where, $\widetilde{NS_j} = min_i Z_{ij}; i = 1,2,\cdots,n; j = 1,2,\cdots,m;$

Step-5: Determine the Euclidean distance between alternatives and NIS as provided in equation (XI) and also calculate the Taxicab distance between alternatives and NIS by using equation (XII).

$$\widehat{E_i} = \sqrt{\sum_{j=1}^{m} \{Z_{ij} - \widetilde{NS_j}\}^2} \quad (XI)$$

$$\widehat{T_i} = \sum_{j=1}^{m} \{|Z_{ij} - \widetilde{NS_j}|\} \quad (XII)$$

Step-6: Generate the "relative evaluation matrix" by employing the formula (XIII).

$$\widetilde{RA} = [\widetilde{r_{ik}}]_{n\times n}; \quad \text{(XIII)}$$

where, $\widetilde{r_{ik}} = (\widehat{E_i} - \widehat{E_k}) + (\phi(\widehat{E_i} - \widehat{E_k}) * (\widehat{T_i} - \widehat{T_k})); i = 1,2,\cdots,n; k = 1,2,\cdots,n;$

and ϕ is indicated as a threshold function that checks the Euclidean's equivalence.

$$\phi_a = \begin{cases} 1; & \text{if } |a| \geq \tilde{\tau}; \\ 0; & \text{if } |a| < \tilde{\tau}; \end{cases} \quad \text{(XIV)}$$

where $\tilde{\tau}$ presents the threshold factor that the decision-maker may define. The ideal range of this parameter ϕ is 0.01 to 0.05. The Taxicab distance is also used to compare two alternatives if the gap between their Euclidean distance is lesser than $\tilde{\tau}$. In our present research, a value of 0.01 is considered for implementation in the computation purpose.

We have used MOORA ([46]), CODAS ([43]), so as to rank the alternatives. The numerical simulation has been done utilizing MOORA and CODAS methods using MATLAB and discerned the fluctuation in the ranking among the options. The method strategy is clearly described in Figure 1. In our next section, a numerical example for selecting an effective action to unlock the potential of BEVs in West Bengal is illustrated.

3.5. A numerical example

Step 1: Initially, numerical computation involves utilizing decision matrices provided by decision experts. The $\widehat{DM}_1$, $\widehat{DM}_2$, and $\widehat{DM}_3$ matrices provided below the perspective of decision experts concerning the mode of alternatives versus criteria.

$$\widehat{DM}_1 = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{pmatrix} \mathscr{C}_1 & \mathscr{C}_2 & \mathscr{C}_3 & \mathscr{C}_4 \\ \langle 0.5,0.6,0.7\rangle & \langle 0.7,0.5,0.6\rangle & \langle 0.4,0.6,0.7\rangle & \langle 0.6,0.7,0.4\rangle \\ \langle 0.2,0.8,0.7\rangle & \langle 0.5,0.8,0.2\rangle & \langle 0.7,0.5,0.4\rangle & \langle 0.6,0.5,0.3\rangle \\ \langle 0.8,0.6,0.5\rangle & \langle 0.8,0.5,0.6\rangle & \langle 0.5,0.7,0.5\rangle & \langle 0.7,0.2,0.5\rangle \\ \langle 0.4,0.6,0.7\rangle & \langle 0.6,0.4,0.8\rangle & \langle 0.2,0.8,0.7\rangle & \langle 0.7,0.5,0.6\rangle \end{pmatrix} \quad (14)$$

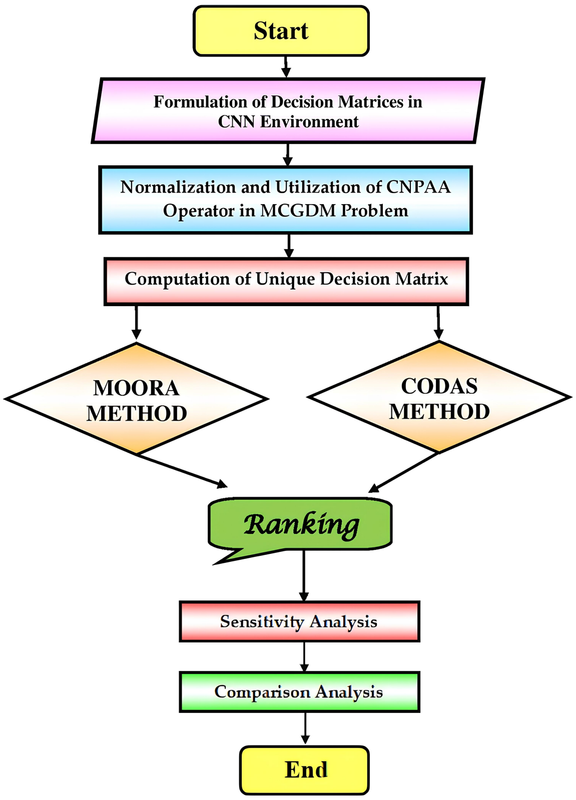

Figure 1: Method strategy of *MCGDM* problem for selecting an effective action for unlocking the potential of BEVs in West Bengal

$$\widehat{DM}_2 = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{c} \begin{array}{cccc} \mathscr{C}_1 & \mathscr{C}_2 & \mathscr{C}_3 & \mathscr{C}_4 \end{array} \\ \begin{pmatrix} \langle 0.7,0.5,0.4\rangle & \langle 0.5,0.6,0.4\rangle & \langle 0.3,0.8,0.7\rangle & \langle 0.6,0.7,0.4\rangle \\ \langle 0.8,0.6,0.5\rangle & \langle 0.5,0.8,0.2\rangle & \langle 0.6,0.5,0.3\rangle & \langle 0.2,0.8,0.7\rangle \\ \langle 0.8,0.5,0.6\rangle & \langle 0.3,0.8,0.7\rangle & \langle 0.5,0.6,0.4\rangle & \langle 0.7,0.5,0.6\rangle \\ \langle 0.4,0.7,0.8\rangle & \langle 0.4,0.6,0.7\rangle & \langle 0.6,0.4,0.8\rangle & \langle 0.7,0.7,0.5\rangle \end{pmatrix} \end{array} \tag{15}$$

$$\widehat{DM}_3 = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{c} \begin{array}{cccc} \mathscr{C}_1 & \mathscr{C}_2 & \mathscr{C}_3 & \mathscr{C}_4 \end{array} \\ \begin{pmatrix} \langle 0.7,0.2,0.5\rangle & \langle 0.2,0.8,0.7\rangle & \langle 0.5,0.8,0.2\rangle & \langle 0.6,0.5,0.3\rangle \\ \langle 0.4,0.7,0.6\rangle & \langle 0.8,0.5,0.6\rangle & \langle 0.7,0.5,0.4\rangle & \langle 0.7,0.5,0.6\rangle \\ \langle 0.6,0.7,0.4\rangle & \langle 0.4,0.7,0.8\rangle & \langle 0.6,0.4,0.8\rangle & \langle 0.5,0.8,0.2\rangle \\ \langle 0.4,0.6,0.7\rangle & \langle 0.2,0.8,0.7\rangle & \langle 0.8,0.6,0.5\rangle & \langle 0.6,0.7,0.4\rangle \end{pmatrix} \end{array} \tag{16}$$

Step 2: The decision matrices are assembled in this step. Consequently, we obtain a resultant decision matrix displayed in the equation (17) below.

$$\widehat{DM} = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{cccc} \mathscr{C}_1 & \mathscr{C}_2 & \mathscr{C}_3 & \mathscr{C}_4 \\ \end{array}$$
$$\begin{pmatrix} \langle 0.6472, 0.3932, 0.5204\rangle & \langle 0.5349, 0.6202, 0.5519\rangle & \langle 0.4111, 0.7257, 0.4632\rangle & \langle 0.6000, 0.6265, 0.3638\rangle \\ \langle 0.5800, 0.6959, 0.5951\rangle & \langle 0.6412, 0.6852, 0.2873\rangle & \langle 0.6709, 0.5000, 0.3636\rangle & \langle 0.5663, 0.5843, 0.4993\rangle \\ \langle 0.7515, 0.5942, 0.4935\rangle & \langle 0.5938, 0.6529, 0.6943\rangle & \langle 0.5368, 0.5531, 0.5421\rangle & \langle 0.6487, 0.4280, 0.3927\rangle \\ \langle 0.4000, 0.6315, 0.7317\rangle & \langle 0.4466, 0.5750, 0.7324\rangle & \langle 0.6266, 0.5782, 0.6549\rangle & \langle 0.6711, 0.6246, 0.4941\rangle \end{pmatrix} \quad (17)$$

Step 3: Describe the "best criterion" and the "worst criterion" by each decision expert and obtain the "best-to-others" and "others-to-worst" vectors as follows.

The decision-maker $\widehat{DM}_1$, one group of automobile experts, have identified $\mathscr{C}_3$ and $\mathscr{C}_4$ as the "best" and "worst" criteria, respectively, and then used Table 1 to deliver the best-to-others vector $\widehat{G_B}^1$
Where, $\widehat{G_B}^1 = [(0.83, 0.02, 0.1), (0.7, 0.24, 0.4), (0.5, 0.5, 0.5), (0.9, 0.04, 0.01)]$ and others-to-worst vector $\widehat{G_W}^1$
Where, $\widehat{G_W}^1 = [(0.8, 0.2, 0.12), (0.75, 0.1, 0.16), (0.9, 0.04, 0.01), (0.5, 0.5, 0.5)]$.
The decision-maker $\widehat{DM}_2$, one group of environmentalists, have identified $\mathscr{C}_2$ and $\mathscr{C}_1$ as the "best" and "worst" criteria, respectively, and then used Table 1 to deliver the best-to-others vector $\widehat{G_B}^2$
where, $\widehat{G_B}^2 = [(0.83, 0.02, 0.1), (0.5, 0.5, 0.5), (0.6, 0.4, 0.18), (0.75, 0.1, 0.16)]$ and others-to-worst vector $\widehat{G_W}^2$
where, $\widehat{G_W}^2 = [(0.5, 0.5, 0.5), (0.83, 0.02, 0.1), (0.75, 0.33, 0.5), (0.7, 0.29, 0.35)]$.
The decision-maker $\widehat{DM}_3$, another group of ordinary people, have identified $\mathscr{C}_3$ and $\mathscr{C}_4$ as the "best" and "worst" criteria, respectively, and then used Table 1 to deliver the best-to-others vector $\widehat{G_B}^3$
where, $\widehat{G_B}^3 = [(0.75, 0.1, 0.16), (0.72, 0.02, 0.17), (0.5, 0.5, 0.5), (0.9, 0.2, 0.03)]$ and others-to-worst vector $\widehat{G_W}^3$
where, $\widehat{G_W}^3 = [(0.75, 0.1, 0.16), (0.7, 0.24, 0.4), (0.9, 0.2, 0.03), (0.5, 0.5, 0.5)]$.
Step 4: Determine the optimum weights of criteria by executing optimization model 10 for decision-maker $\widehat{DM}_q$ where $q = 1, 2, 3$.
The corresponding weights of criteria for $\widehat{DM}_1$ is $\widetilde{SC}(\widehat{W}_1) = 0.2648, \widetilde{SC}(\widehat{W}_2) = 0.2359$, $\widetilde{SC}(\widehat{W}_3) = 0.2652$ and $\widetilde{SC}(\widehat{W}_4) = 0.2341$. The corresponding weights of criteria for $\widehat{DM}_2$ is $\widetilde{SC}(\widehat{W}_1) = 0.2457, \widetilde{SC}(\widehat{W}_2) = 0.2521, \widetilde{SC}(\widehat{W}_3) = 0.2511$ and $\widetilde{SC}(\widehat{W}_4) = 0.2511$.
The corresponding weights of criteria for $\widehat{DM}_3$ is $\widetilde{SC}(\widehat{W}_1) = 0.2454$, $\widetilde{SC}(\widehat{W}_2) = 0.2445$, $\widetilde{SC}(\widehat{W}_3) = 0.2692$ and $\widetilde{SC}(\widehat{W}_4) = 0.2409$. Table 2 illustrates the combined weight of each criterion, which has been determined with the weights provided by the three decision specialists.
Step 5: Obtain the consistency index($\widetilde{CI_q}$) and consistency ratio ($\widetilde{CR_q}$) for decision-maker $\widehat{DM}_q$ where $q = 1, 2, 3$.
From equation 11, $\widetilde{CI_1}$ for decision-expert $\widehat{DM}_1$ is 3.8623; $\widetilde{CI_2} = 2.8699$ for decision-expert $\widehat{DM}_2$; $\widetilde{CI_3} = 3.6301$ for decision-expert $\widehat{DM}_3$.

Based on equation 12, $\widetilde{CR}_1$ for decision-expert $\widehat{DM}_1$ is 0.0128; $\widetilde{CR}_2 = 0.0131$ for decision-expert $\widehat{DM}_2$; $\widetilde{CR}_3 = 0.0131$ for decision-expert $\widehat{DM}_3$.

Step 6: Determine the optimal weights of decision-experts.

From equation 13, we obtain the optimal weight of $\widehat{DM}_1$ is 0.3388; the optimal weight of $\widehat{DM}_2 = 0.3316$; the optimal weight of $\widehat{DM}_3 = 0.3296$.

Step 7: This step signifies the calculation of the preference values of the alternative employing the aggregation methods MOORA([46]) and CODAS([43]), which is depicted by Table 3.

We have done the classification of choices by two methods namely, MOORA and CODAS using Matlab. Table 3 and Figure 2 shows that infrastructure advancement (S_1) is the best action.

Table 1: Rules for transforming linguistic variables adopted by decision-makers

Linguistic factors	Corresponding CNN
Equal importance (ei)	(0.5, 0.5, 0.5)
Slightly greater than ei	(0.75, 0.33, 0.5)
Moderate importance (mi)	(0.6, 0.4, 0.18)
Slightly greater than mi	(0.7, 0.29, 0.35)
Strong importance (si)	(0.7, 0.24, 0.4)
Slightly greater than si	(0.8, 0.2, 0.12)
Very strong importance (vsi)	(0.75, 0.1, 0.16)
Slightly greater than vsi	(0.72, 0.02, 0.17)
Extreme importance (exti)	(0.9, 0.2, 0.03)
Exceptional importance (exci)	(0.83, 0.02, 0.1)
Absolute importance (ai)	(0.9, 0.04, 0.01)

Table 2: Weighted aggregate criteria of decision specialists

	$\widehat{DM}_1$	$\widehat{DM}_2$	$\widehat{DM}_3$	Combined weights
$\mathscr{C}_1$	0.2648	0.2457	0.2454	0.2521
$\mathscr{C}_2$	0.2359	0.2521	0.2445	0.2441
$\mathscr{C}_3$	0.2652	0.2511	0.2692	0.2618
$\mathscr{C}_4$	0.2341	0.2511	0.2409	0.2420

3.6. Sensitivity Analysis

Here, we scrutinize the preference order of the provided options by altering the criteria weights by 5%, -5%, 10%, -10% and analyze their order according to the group of three decision experts. The numerical computation is executed by MOORA and CODAS, represented in Table 3, Table 4 and Table 5. However, the variation does not have much effect on the preferred ranking of the actions. In both MOORA and CODAS methods, infrastructure advancement(S_1) appears to be the most effective alternative.

After the variation of the recommended weights in the methods by 5%, -5%, 10%, -10% the ranking order undergoes a change, infrastructure advancement(S_1) maintains its

Table 3: Ranking order of the alternatives applying MOORA and CODAS

Alternative	MOORA		CODAS	
	Value	Rank	Value	Rank
S_1	-18.6167	1	0.1814	1
S_2	-18.7890	2	-0.0358	3
S_3	-20.0362	3	0.0727	2
S_4	-20.4162	4	-0.1510	4
	MOORA Ranking:	$S_1 > S_2 > S_3 > S_4$	CODAS Ranking:	$S_1 > S_3 > S_2 > S_4$

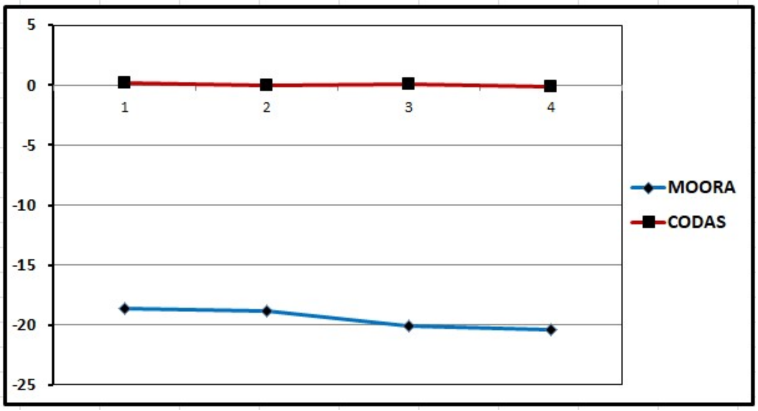

Figure 2: Ranking of the choices utilizing decision-making processes MOORA and CODAS

supremacy as the best option in both MOORA and CODAS method(See Figure 3, Figure 4, Figure 5 and Figure 6). Thus we may infer that the fluctuation does not have much impact on the preference order of the given attributes.

4. COMPARATIVE ANALYSIS

Our proposed approach's comparison with some concurrently existing research works has been presented in Table 6. In Table 6 we have listed different research works along with their embedded environment, associated operators/methodology, and model outcomes. our methodology has been developed in a cylindrical neutrosophic environment. Remarkably, our proposed model outcomes can be directly comparable with the models and strategies/techniques as suggested by [72] and [67], as all of the models deal with the same type of problem, MCGDM in a cylindrical neutrosophic arena. In addition, the cylindrical neutrosophic environment utilizes the operators "cylindrical neutrosophic weighted aggregation (CNWA)" and "cylindrical neutrosophic power averaging aggregation (CNPAA)" by [72] and [67], separately. Thereby, a direct comparison between these strategies and the one we have suggested is possible.

Table 4: Senstivity analysis by employing MOORA and CODAS methods with fluctuating 5% and -5% of weights

Process	Alternatives	5%	Ranking	-5%	Ranking
MOORA	S_1	-18.6025	$S_1 > S_2 > S_3 > S_4$	-18.6308	$S_1 > S_2 > S_3 > S_4$
	S_2	-18.7784		-18.7995	
	S_3	-20.023		-20.0493	
	S_4	-20.407		-20.4254	
CODAS	S_1	0.1917	$S_1 > S_3 > S_2 > S_4$	0.1713	$S_1 > S_3 > S_2 > S_4$
	S_2	-0.0370		-0.0345	
	S_3	0.0769		0.0685	
	S_4	-0.1572		-0.1446	

Table 5: Senstivity analysis by employing MOORA and CODAS methods with fluctuating -10% and 10% of weights

Process	Alternatives	-10%	Ranking	10%	Ranking
MOORA	S_1	-18.645	$S_1 > S_2 > S_3 > S_4$	-18.5884	$S_1 > S_2 > S_3 > S_4$
	S_2	-18.8101		-18.7679	
	S_3	-20.0625		-20.0098	
	S_4	-20.4346		-20.3979	
CODAS	S_1	0.1613	$S_1 > S_3 > S_2 > S_4$	0.2020	$S_1 > S_3 > S_2 > S_4$
	S_2	-0.0331		-0.0382	
	S_3	0.0644		0.0812	
	S_4	-0.1381		-0.1634	

4.1. Analysis related to the score value strategy ([72])

In this instance, the weighted summed decision matrix ($\widehat{DM}$) explained in subsection 3.5 consists of the remaining steps of [72] strategy. Here, the score values within the cylindrical neutrosophic environment are used to determine the ranking values.
Here, the alternative values are specified as: $S_1 = 0.5027, S_2 = 0.5312, S_3 = 0.5227, S_4 = 0.4364$. Hence, the ranking of the alternatives is displayed as, $S_2 > S_3 > S_1 > S_4$, giving S_2 the best possible decision.

4.2. Analysis related to the VIKOR strategy ([67])

[67] integrated the VIKOR methodology to the existing literature in the domain of *CNN*s. Here, the weighted summed decision matrix ($\widehat{DM}$) explained in subsection 3.5 includes the remainder of VIKOR procedure steps. Here, the alternative values are presented as: $S_1 = 0, S_2 = 0.8926, S_3 = 0.2162, S_4 = 0.9554$. The ranking of the alternatives is provided as $S_4 > S_2 > S_3 > S_1$, giving S_4 the best possible decision.

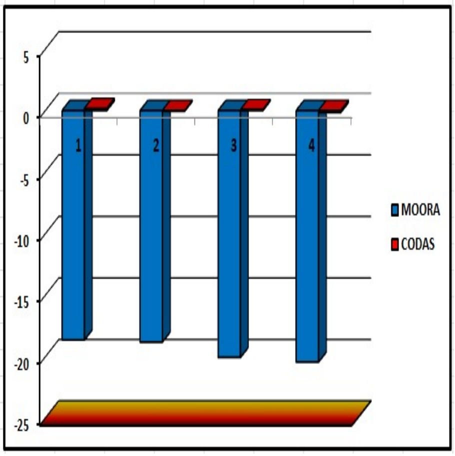

Figure 3: Ranking of the choices utilizing decision-making processes MOORA and CODAS at a variable level of -5%

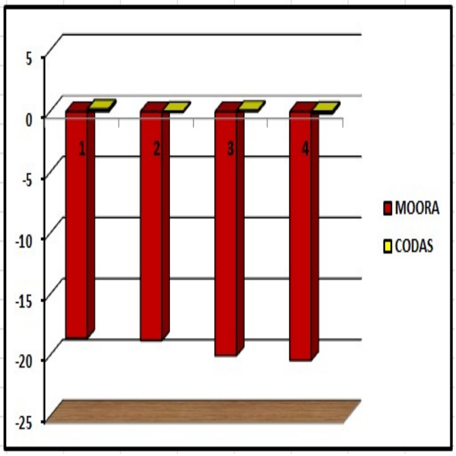

Figure 4: Ranking of the choices utilizing decision-making processes MOORA and CODAS at a variable level of +5%

4.3. Analysis related to the EDAS strategy ([67])

At this point, the weighted summed decision matrix ($\widehat{DM}$) explained in subsection 3.5 involves the remainder of EDAS procedure steps. Here, the alternative values are stated as: $S_1 = 0.9945, S_2 = 0.3646, S_3 = 0.8188, S_4 = 0.0645$.The ranking of the alternatives is exhibited as $S_1 > S_3 > S_2 > S_4$, giving S_1 the best possible decision.

4.4. Analysis related to the TOPSIS strategy ([67])

At this point, the weighted summed decision matrix ($\widehat{DM}$) explained in subsection 3.5 involves the remainder of TOPSIS procedure steps. Here, the alternative values are presented as: $S_1 = 0.7217, S_2 = 0.4285, S_3 = 0.6167, S_4 = 0.3141$. The ranking of the alternatives is exhibited as $S_1 > S_3 > S_2 > S_4$, giving S_1 the optimal one.

Analyzing the ranking results, it has been seen that our proposed methodology is on par with other current strategies utilized to identify the best alternative. we noted that our proposed model outcomes are consistent with the outcomes of other various models as suggested by [72] and [67]. Our proposed methodology's results only differ for the [72] approach and VIKOR process ([67]). It is to be pointed out that even [67] cited many reasons for the less reliability of the result outcomes obtained by VIKOR technique. From the above discussion, it is clear that our *MCGDM* model with MOORA technique is good enough in terms of outcomes consistency and stability in capturing uncertainty in a robust way. Our research study highlighted several of the created strategy's advantages over the approaches of [67] and [72], as depicted below.

- [72] applied the CNWA operator for combining data information from several specialists and relied on the score function to decide on the most effective alternative,

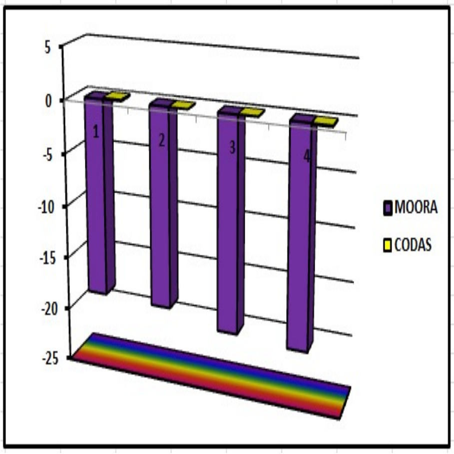

Figure 5: Ranking of the choices utilizing decision-making processes MOORA and CODAS at a variable level of -10%

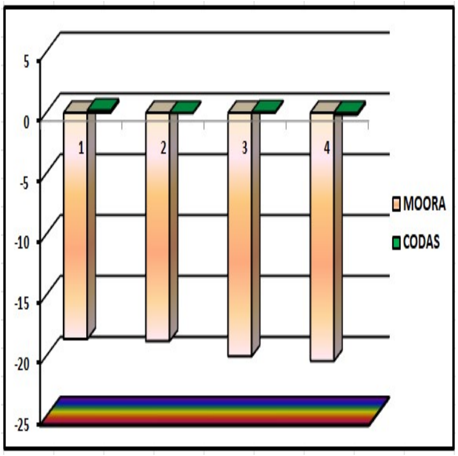

Figure 6: Ranking of the choices utilizing decision-making processes MOORA and CODAS at a variable level of +10%

whereas our suggested strategy has used the CNPA operator to integrate input from diverse specialists and leverages decision-making approaches, namely MOORA and CODAS. It should be mentioned that decision-making methods frequently have preference over the score function for ranking outcomes in *MCGDM* scenarios. The CNPA operator improves decision-making by successfully combining expert opinions with more flexibility and accuracy than the CNWA operator. Moreover, its combination with advanced methods such as MOORA and CODAS results in more precise rankings, which makes it more ideal for complicated *MCGDM* circumstances.

- The [72] and [67] used weights for attributes and decision-makers directly derived from survey data in the score value strategy, TOPSIS, EDAS, and VIKOR approaches, but did not individually analyze these weights. whereas our proposed methodology has employed the CNEBWM method to assess both attribute and decision-maker weights independently. This makes certain that our strategy is more rational, adaptable, and efficient.

- Furthermore, we have analyzed all the above-said model outcomes in terms of stability by changing the weights of decision experts. This stability analysis gives very interesting and supportive outcomes in favor of our proposed *MCGDM* model with MOORA technique, which is discussed in the next paragraph.

To evaluate and assess the model outcomes in a rigorous way, we have performed the stability analysis by changing the weights of decision experts. We have changed decision experts' weights from their original value both in negative and positive directions in a wide range, namely in the range of -70% to +70% and simulated the result in MATLAB. Here, we have adjusted the decision experts' weights in a dynamic way so that the restriction of the sum of weights is equal to one maintained always. The result of stability analysis of different methods, namely MOORA, CODAS, VIKOR, EDAS and TOPSIS has been shown in the Table 7. From the figures of the Table 7, we observed that MOORA method gives a huge stable range ([-70%,+70%]). On the other hand, CODAS method is very sensitive with regard to the changes in the weights of the decision experts. Thus, our MCGDM process with CODAS is not recommended when someone is not sure about the weights of decision makers although it shows consistent results with other outcomes in its stable position. Therefore, as a sum up, we can conclude that our suggested MCGDM model with the MOORA technique is simple, as well as reliable, and stable in comparison to others.

Table 6: Comparison between existing methods and our proposed approach

Author	Environment	MCGDM/MCDM	Aggregation Operator	Ranking Order
[72]	CNN	MCGDM	CNWA	$S_2 > S_3 > S_1 > S_4$
[67]	CNN	MCGDM with VIKOR method		$S_4 > S_2 > S_3 > S_1$
		MCGDM with EDAS method	CNPAA	$S_1 > S_3 > S_2 > S_4$
		MCGDM with TOPSIS method		$S_1 > S_3 > S_2 > S_4$
Our proposed method	CNN	MCGDM with MOORA method	CNPAA	$S_1 > S_2 > S_3 > S_4$
		MCGDM with CODAS method		$S_1 > S_3 > S_2 > S_4$

Table 7: Stability Analysis for changing the weights of decision makers

Method	Ranking	Stability Range w.r.t. decision makers weights	Corresponding range of decision makers weights
MOORA	$S_1 > S_2 > S_3 > S_4$	[-70%, +70%]	([0.105, 0.483, 0.412], [0.595, 0.238, 0.167])
CODAS	$S_1 > S_3 > S_2 > S_4$	[-1%, +3%]	([0.347, 0.322, 0.331], [0.361, 0.316, 0.323])
VIKOR	$S_4 > S_2 > S_3 > S_1$	[-11%, +56%]	([0.312, 0.346, 0.342], [0.546, 0.255, 0.199])
EDAS	$S_1 > S_3 > S_2 > S_4$	[-70%, +16%]	([0.105, 0.483, 0.412], [0.41, 0.30, 0.29])
TOPSIS	$S_1 > S_3 > S_2 > S_4$	[-70%, +24%]	([0.105, 0.483, 0.412], [0.434, 0.292, 0.274])

5. CONCLUSION AND FUTURE SCOPE

We have built up an *MCGDM* process under the cylindrical neutrosophic arena, which has been applied to identify the best action plan to promote BEVs in West Bengal. Here, a power averaging arithmetic operator is presented so as to compute the quantitative values for determining the best option with two techniques, namely, MOORA and CODAS. For precise decision, we have taken opinions from three distinct groups of decision-makers, namely, automobile experts, environmentalists, and the general public. We have conducted our proposed Cylindrical Neutrosophic enhanced Best-Worst (CNEBWM) method in order to deduce the values to be assigned as weights of the different attributes and decision-makers for our specified *MCGDM* problem. We have performed sensitivity analysis by varying the attributes' weights to check the accuracy, credibility and consistency of our suggested approach. Here, we have presented a detailed comparison analysis with existing research works to ensure the efficiency of our suggested MCGDM methodology. We have also tested the stability of our model outcomes along with the outcomes of other above-mentioned research works by varying the weights of decision experts. The range of stability of different methods has been presented in table 7. It is observed that MCGDM problem, along with MOORA technique, is robust enough in comparison to other techniques. Here, we have observed that MCGDM model with MOORA technique is stable when decision-experts weights are changed in the range of -70% to $+70\%$, whereas our proposed MCGDM model with CODAS technique is stable when decision-experts weights are changed only in the range of -1% to $+3\%$. As a result, it could be suggested that our proposed model is beneficial for effective action selection to unlock the potential of battery electric vehicles in West Bengal as well as for acceptable rankings purposes in some dynamic real-life scenarios with unreliable, inadequate, and irreconcilable information.

Future research may focus on new, favorable aggregation operators and creative approaches for selecting options in various uncertain circumstances. This study may eventually emphasize mathematical optimization approaches for determining the most suitable weight vector for several kinds of problematic real-world problem-solving scenarios in areas including intelligent machines, uncertainty demonstrating, and the analysis of decisions and evaluating its efficacy in combination with other strategies for optimization, extending its influence to realms beyond its current use.

Funding: This research received no external funding.

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