

A Stability-Driven Hybrid MCDM Framework Based on Taxonomies of Decision-Making Process's Elements – an Empirical Case Study

Amany A. Slamaa^{1,*}, Hussein M. Elshafie², and Ahmed I. Sharaf³

¹ Department of Information System, Faculty of Computers and Information Sciences, Luxor University, Luxor, 85951 Egypt

² Department of Computer Science, Faculty of Computers and Information, Luxor University, Luxor 85951, Egypt

³ Deanship of Postgraduate Studies and Research, Umm Al-Qura University, Makkah, Saudi Arabia

Received: 2 Aug. 2026, Revised: 12 Oct. 2026, Accepted: 18 Oct. 2026.

Published online: 1 Nov. 2026.

Abstract: Quantifying decision-making approaches like Hybrid Multi Criteria Decision-making (MCDM) addresses the vagueness associated with the decision-making process by leveraging the integration of at least two MCDM methods. Unfortunately, there is no guidance mechanism for combining MCDM methods for real decision-making problems, where MCDM methods are the core of Hybrid-MCDM, as well as MCDMs or Hybrid-MCDM, not addressed from a practical perspective. The study aims to recommend a stability-driven Hybrid-MCDM framework that aids in designing a decision-model based on the taxonomy of decision-making process elements. The proposed methodology integrates PRISMA with Design Science Research and Extended Taxonomy Design Process to introduce a guidance stability-driven framework for MCDM as well as Hybrid-MCDM that aids in designing a decision-model based on the taxonomy of decision-making process elements. Practically, it helps decision makers to design robustness decision-models. As implementation, the proposed framework recommends Neutrosophic ELECTRE-VIKOR to prioritize beneficiaries for donation management systems that have 21 constraints and 16 alternatives. Average Spearman rank correlation and deviation across five scenarios are 0.998 and 0.03 respectively. Further, Decision Stability Intervals and Monte Carlo simulations are introduced to test robustness. The comparative benchmark for MCDM methods (TOPSIS, ANP, and VIKOR) and the proposed Hybrid-MCDM model are introduced as evidence of conflict-resilient hybrid decision models. This prioritization issue faces decision makers in various domains such as healthcare, education, civil development, project management, the software industry, etc. The stability of this decision model is proved by sensitivity tests. The proposed model contributes to ranking priorities in these critical domains.

Keywords: Decision-making; stability decision; multi-criteria decision-making (MCDM); Hybrid-MCDM (HMCDM); taxonomy; Neutrosophic ELECTRE-VIKOR.

1. Introduction

Mutli-Criteria Decision Analysis (MCDA) or Multi-Criteria Decision-making (MCDM) is one of the operations research disciplines concerned with economics, mathematics, and psychology for solving decision problems. They aim to reduce biases of decision makers [1], [2]. MCDM methods are transparent and structured processes that provide systematic decisions by modeling the decision matrix of stakeholders' preferences and solutions criteria and then implementing the trade-off subjectivity of weighting criteria, priorities of decision makers for evaluating alternatives under data uncertainty, conflicting objectives, and proposed alternative decisions [3]. Alternative selection is completely different depending on alternative prioritization although both rank alternatives. In alternative selection, the best is selected and the others are discarded. While alternatives are prioritized, they are ordered based on given factors without discarding any alternate [4].

MCDM methods do not handle data uncertainty well,

subjectivity weighting criteria and evaluating conflicted alternatives with complete neutrality in complex real scenarios. Where, traditional MCDM approaches facilitate reliability decision-making, enhance transparency under inconsistency issues by designing models combining objectives and stakeholders' perspectives with criteria. Under conflicting objectives and ambiguity data, uncertainty and vagrancy factors that are oriented to decisions, these MCDM methods are not enough and do not guarantee the stability of the decision and its reliability [5]. These methods sometimes lose the importance of distinctions between factors and criteria. Thereby, Hybrid-MCDM addresses this issue and is used for evaluating alternatives under conflict criteria [1], [6].

Quantitative decision models such as Hybrid-MCDM (HMCDM) are essential. Hybrid-MCDM provides its proficiency in decision-making for complex applications, because it handles the complex decisions efficiently [7]. HMCDM has many methods that address different real problems based on its advantages and drawbacks and affect various factors such as risks, cost, efficiency, and time. For

*Corresponding author e-mail: amani.slamaa@fci.luxor.edu.eg, ORID: 0000-0002-9698-2496

example, both VIKOR and TOPSIS produced the optimal solution after analyzing the distance of candidate alternatives from the ideal solution. Where TOPSIS proposed the most optimal solution, VIKOR balanced between the worst and the best-case scenario. Therefore, systematic evaluation, comparative analysis, and benchmarking of MCDM methods are the critical needs for solving complicated, dynamic, collaborative, and multi-concerns decision-making problems by Hybrid-MCDM [8].

1.1 motivation and problem statement

Through tracking the decision-making methods classifications in previous literature to deduce the most effective MCDM methods or Hybrid-MCDM approaches for ensuring a sound decision, unfortunately, *the provided classifications addressed by the previous researchers ignored classifications that are close to the nature of the real-life problem, the lack of degree of data or information, the difficulty of evaluating alternatives, or confused preferences that may overlap with goals. There is no framework for selecting MCDM to ensure stability results if the same MCDM method is reused for another decision-problem with the same conditions but in a different domain. Although there are guidance frameworks that help for combining MCDM and designing Hybrid-MCDM approaches [9], [10], they did not come close to the real problem's parameters.*

Taxonomy is a classification system that helps researchers conceptualizes phenomena based on their dimensions and characteristics. The taxonomy of MCDM classes that was introduced by Cinelli et al. used quantitative methods to provide recommendations about the usage of the MCDM class. *Unfortunately, it did not provide the gaudiness of which method of the class is more suitable for the problem. Therefore, Cinelli's taxonomy does not help decision makers who have less experience. Further, it did not address the new approach of problem solving decision-making or Hybrid-MCDM approaches [11].*

The most NonProfit Organizations (NPO) are oriented to apply one or both goals: "no poverty" or "zero hunger". Distributing donations fairly to the most eligible is a critical challenge for these NPOs. Beneficiaries' statuses are very confused. Besides, empathy increases complexity and causes confusion among institutions and donors. Beneficiaries' ranking and deserving priorities are one of the most complex real decision-making problems. *However, previous studies that addressed MCDM methods or Hybrid-MCDM approaches in real applications, didn't address it well. They cared about selecting one alternative (beneficiary), not ranking multi-alternatives under more controls and conditions. That shapes another challenge for this paper in the empirical case study. There are no previous papers studying the 'beneficiaries' selection and ranking' issue particularly by Hybrid-MCDM approaches, although the papers that addressed blood donors in medical cases exist under low controls and criteria.*

By tracking down previous publications and trusted academic databases, such as Web of Science (WOS) and Scopus, they were examined under the following queries without any timeline condition, just keyword position within the document as a constraint to ensure the relevancy of the retrieved document, as shown in the following figure 1. Further, by tracking different applications and usages of MCDM methods and browsing the review literatures that were issued from 2011 until May 2025, which addressed all published studies about MCDM methods from 1999 to 2025, like [12], [13], and [14], *unfortunately, there are no reports about donation management or beneficiaries' selection. Obviously, finding a solution for a decision-making problem for "managing donations and beneficiaries" by MCDM or HMCDM is significant nowadays under global concerns of sustainable development goals.*

The current research aims to provide a comprehensive decision-making framework involving information management and the MCDA on criteria and alternatives. This is based on the success of an end-to-end system in aiding complex multi-criteria decision problems.

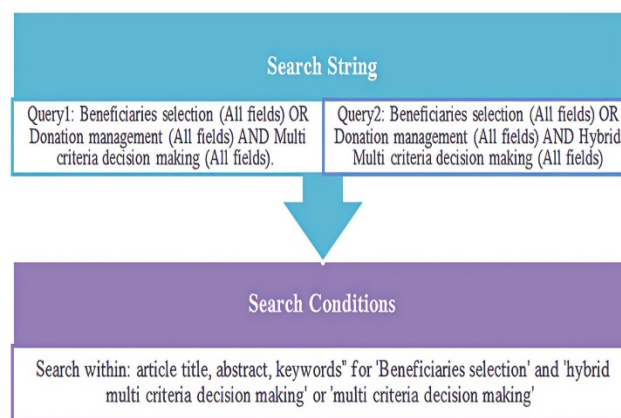


Fig. 1: the general search string is refined into detailed search conditions which are applied to identify relevant papers for empirical case study

1.2 research gap

Existing MCDM classification studies group methods by intrinsic membership rather than by their fitness for a given decision problem's real-world characteristics: how structured the problem is, how uncertain the criteria data is, and how much conflict exists among alternatives. Consequently, three practical gaps remain unresolved:

1. No problem-driven selection logic, where prior taxonomies describe what methods are, not which method (or hybrid) a practitioner should choose given a specific combination of structure, uncertainty, and conflict.
2. Individual MCDM and Hybrid-MCDM components are documented separately in the literature, but no

study provides a structured mapping that helps decision-model designers know which methods to combine and why for a given decision-problem profile.

3. Limited solution for management ranking beneficiaries, where there are no previous papers studying the “beneficiaries’ selection and ranking” issue, particularly by Hybrid-MCDM approaches, although the papers that addressed blood donors in medical cases exist under low controls and criteria.

1.3 study objectives

The aim of this study is to overcome inconsistency issues and to achieve reliability of alternative ratings, by guiding decision makers to select a suitable MCDM method and set theory to real decision problem’s elements, furthermore, designing a consistency Hybrid-MCDM model. Where selecting the wrong MCDM method or non-fit set theory for evaluation values of weighting or trade-off will lead to mis-ranking of alternatives; therefore, inconsistent decisions and subsequently hard losses upon this wrong decision applied for health, building, manufacturing, hiring, etc. Further there is a full research gap in MCDM taxonomies that ignore classifications that are close to the nature of the real-life problem, the lack of degree of data or information, the difficulty of evaluating alternatives, or confused preferences that may overlap with goals.

Where taxonomy is a key that is used in this study to provide a structured roadmap for selecting or combining MCDM methods correctly for decision-making problems with fewer biases, the study discusses the taxonomy based on elements of decision-making problems. This paper indexes MCDM methods and provides a taxonomy of decision-making process elements from different aspects. Previous studies that addressed MCDM classification are interested in classifying decision methods based on its membership rather than classifying based on MCDM’s feasibility of handling conflict or certainty levels of decision scenarios, elements of decision-making or the problem’s structure and nature. In brief, those pre-studies provided classifications, but they ignored the practical side of applying MCDM methods and the Hybrid-MCDM approach. Therefore, these previous classifications and taxonomies did not help decision makers in correctly choosing MCDM or combining MCDM methods together for real-world decision-making problems.

Furthermore, the study provides answers for the following Research Questions (RQ):

- **RQ1:** How does the decision maker select a suitable set theory for decision problems that can handle different issues of conflict or uncertainty?
- **QR2:** How does the decision maker select a suitable MCDM method or Hybrid-MCDM approach for decision problems that can handle different issues of conflict or uncertainty in criteria or alternatives?
- **RQ3:** How does the proposed framework perform

when applied to a real-world case study characterized by these complex parameters?

The stability and robustness of the proposed framework is introduced by the empirical side via charity organizations for beneficiary selection. This empirical case study cares about selecting multi-beneficiaries based on their priorities. Their priorities are regarded as high challenges because of conflict alternatives and complex criteria. Although this case study serves in sustainable development goals, “no poverty” and “zero hunger”, but this challenge exists in many domains. For example, in the healthcare domain, beneficiary selection helps in arranging the patients for organ donation or surgeries, or even in medical crises management in light of the limited capabilities like lack of biomedicine and the large number of critical cases. In education, beneficiary selection helps in selecting deserving students for fellowship, internship, or scholarship. In project management and business, priority selection helps in selecting the most profitable projects or suitable risk plan and so on. In the software industry, priority selection helps in selecting a more qualified team member for a high-profile project. These samples of applications in different domains require robust decision-making models and reflect the significance of this study via the proposed framework and MCDM taxonomy. Further, these applications support sustainable development goals that are adopted by the United Nations [15]; such as “no poverty”, “zero hunger”, “good health and well-being”, “quality education”, “and economic growth” etc.

The novelty is listed below:

- 1- Reduce the gap in the practical side of applying MCDM methods and Hybrid-MCDM approaches for real decision-making problems, by classifying MCDM methods based on real decision problem’s nature (uncertainty and conflicting levels) upon decision process elements (criteria, alternatives, and objectives).
- 2- A Hybrid-MCDM framework guides decision makers to design decision models by combining the most relevant approaches to the real-life decision-making problem’s nature instead of MCDM methods’ characteristics. There are individual components of MCDM classifications available in literature. But the contribution of this work is not only to extend the previous taxonomies but also to offer prescriptive mapping logic, as prior works reported numerous applications of MCDM dynamically and depending on real decision-making processes’ elements (problem’s structure levels, criteria’s certainty levels, and alternatives’ conflict levels), with no structured guidance on how to use a particular combination of these hybrid methods. The study introduces a very fine-grained selection matrix in the framework, using Problem Structure, Uncertainty Level of Criteria, and Conflict Level of Alternatives (Tables 4 and 5). For instance, it explicitly continues a user from AHP-

- TOPSIS (low conflict/crisp data) to Neutrosophic ANP-ELECTRE (high uncertainty and high conflict) or to the proposed Neutrosophic ELECTRE-VIKOR (high uncertainty and high conflict). This is a new theoretical framework for practitioners to follow.
- 3- Taxonomy for MCDM methods based on the problem's structure levels, criteria's certainty levels, and alternatives' conflict levels. This taxonomy supports the framework and further leads to stability and reliability-driven decisions in the context of decision problems.
 - 4- The integration of theoretical classification with practical decision-making needs, bridging the gap between academic models and real-world applications.
- Contributions of this paper are providing:**
- 1- A comprehensive MCDM framework guides decision model designers to select the most suitable MCDM method for real-life problems and consequently Hybrid-MCDM.
 - 2- Taxonomy for MCDM methods with set theory based on: problem's structure levels, criteria's certainty levels and alternatives' conflict levels. This taxonomy supports the framework further leads to stability and reliability-driven decision in context of decision problems
 - 3- Briefly comparative analysis for most utilized MCDM methods based on mathematical membership, strength, limitation, best suitability case, and cause most usage for domain or application
- 4- Decision on a sustainable Hybrid-MCDM model for Beneficiary selection for donation management information systems, which can apply in other domains for surgeries, scholarships, or hiring, etc.
 - 5- Practical implementation for the Neutrosophic-ELECTRE-VIKOR decision model for donation management and beneficiaries' selection. Application of the Neutrosophic ELECTRE-VIKOR combination to a problem class that has not been previously studied for the same purpose. Where ELECTRE and VIKOR are individually well-established, and Neutrosophic extensions of each have been reported separately in prior literature, as seen in section 2. The contribution is not a new mathematical operator or proof, but the specific combination and its application to a decision problem (beneficiaries' prioritization under high alternative conflict and extreme linguistic vagueness) that has not been addressed by existing Hybrid-MCDM studies. Neutrosophic logic is used to represent truth, indeterminacy, and falsity membership simultaneously; ELECTRE performs outranking-based filtering of conflicting alternatives, and VIKOR derives a compromise ranking. The applied methodological contribution (a justified method selection and case study validation) rather than a theoretical or algorithmic one.

Statement of Significance

Motivations of the study and who would benefit are tabulated in the following table1

Table 1 Statements of the study's significance

Problem or Issue	▪ The MCDM field suffers from lacking techniques, unified classification or selection guidance. ▪ Decision-makers often face difficulty in choosing the right MCDM method, practically, if they are unfamiliar with the theoretical underpinnings or computational requirements. ▪ There is a lack of how to evaluate and compare MCDM methods across various application domains.
What is Already Known	▪ Decision-making is Multi-Attribute Decision-making (MADM) and Multi-Objective Decision-making (MODM). ▪ Numerous methods exist (e.g., AHP, TOPSIS, ELECTRE, PROMETHEE, VIKOR), each with specific assumptions, strengths, and limitations. ▪ Most studies have attempted to compare or classify MCDM methods, but often lack a comprehensive or decision-oriented taxonomy.
What this Paper Adds	▪ A comprehensive taxonomy that reflects both theoretical foundations and practical considerations. ▪ A decision-support framework that maps decision contexts to suitable MCDM methods or Hybrid-MCDM approaches. ▪ A critical synthesis of the literature that identifies gaps, overlaps, and trends in MCDM research. ▪ a benchmarking framework for evaluating the performance of MCDM methods and Hybrid-MCDM approaches in different decision-making problems
Who Would Benefit	1. <u>Decision makers, CIO and decision consultants</u> who are involved in complex decision-making across sectors such as engineering, healthcare, public policy, and logistics. 2. <u>Information system engineers and Software developers</u> can easily design Decision-Support

	Systems (DSS), Management Information System (MIS) and tools.
3.	<u>Researchers</u> in operations research, decision sciences, and information systems who are interested in a structured overview of MCDM methods and Hybrid-MCDM approaches.
4.	<u>Different applications in various domains</u> like healthcare, education, software industry, project management and business.

The outline of this paper presents a review of related work in section 2. Section 3 covers the methodology that was applied to deduce the guidance frameworks – Hybrid-MCDM approaches and MCDM methods-, the phases of studying and classifying the nature of decision-making problems, and analyzing set theory upon the decision process, besides the results of a proposed methodology in section 4. Section 5 defines an empirical case study on Beneficiary selection for a donation management information system and its validation is audited in subsection 5.3. The discussion and final conclusion of this study are presented in sections 6 and 7, respectively.

2. Literature review

Methods of MCDM are classified according to data type or two groups: Multi-Purpose Decision-making (MPDM) and Multi-Quality Decision-making (MQDM) methods. Unfortunately, this is a complex explanation for non-expert [16]. Avoiding challenges of data mining [17], [18] is important to draw the whole map of different MCDM methods within different classes. The AHP method, for example, is based on the rationale of determining the priority weight of each decision criterion by comparing the alternatives according to the criteria and assessing the performance of all alternatives according to the criteria [19]. MCDM methods depend on a decision matrix to represent the decision issue with multiple criteria and alternatives. These alternatives are scored on each criterion, and criteria' weights that are evaluated by experts who vary on educational level and background. Quality of scoring depends on the expert's experience level, despite the MCDM assigned those experts are equal. This means the quality of MCDM results is questionable. Because of this criticism, consequently, studies proposed designing an AI model to influence the experience level of experts [20]. Although AI excels at processing vast amounts of data, it lacks the human centric and transparent framework necessary for complex decisions involving human values. Thus, Hybrid-MCDM approaches with its long mathematical steps are particularly suitable when decisions require balancing conflicting objectives, stakeholder involvement and Explainability [21], [22].

Values in natural language are vagueness and ambiguity and called linguistic variables. Expressions such as 'severe', 'moderate', 'very mild', 'mild', or 'low' are more realistic than Boolean values '0' or '1', and crisp values 'true' or 'false'. Thus, a fuzzy set of linguistic variables are easy to assign in numerical values. Fuzzy sets help in Fuzzy logic [23]. It provides a model for handling uncertainty; therefore it can describe linguistic vagueness precisely [4]. Fuzzy set theory serves this prognosis process. Because Fuzzy set

theory reflects degrees of membership and non-membership, intuitionistic fuzzy sets are proposed for this purpose. Where the sum of membership and non-membership degrees is always one and (hesitancy degree) uncertainty is stated as one minus this sum. Unfortunately, an intuitionistic fuzzy set cannot handle issues, where the sum of membership and non-membership exceeds one. Accordingly, a Pythagorean Fuzzy Set (PFS) is proposed in such a domain. Because the square sum of membership and non-membership is less than or equal to one, thus, PFS extends to intuitionistic fuzzy sets, handling uncertainty and vagueness in ambiguity situations such as healthcare domain and diagnosis specifically. However, The Neutrosophic set explicitly handles indeterminacy, inconsistent with data and flexibility, but it has complexity in interpretation [24], [25], and [26].

2.1 MCDM Steps and Classifications:

In general, MCDM method consists of three main steps: establishing evaluation criteria (whether subjective or objective), conducting methods, then calculating criterion weights, and prioritizing alternatives to rank them and conclude the decision. Decision-making is a critical problem seeking to be solved by many different methodologies. From the perspective of MCDM, this real-world decision problem involves structuring the decision problem by specifying appropriate problem's criteria, measuring alternatives' performance, choosing appropriate MCDM method to weight these criteria for scoring alternatives, finally providing MCDM's result embedded with sensitivity analysis for decision-makers to make a decision [27].

To frame decision problems, procedures of problem solving in [28] are followed as declared below. *The first step involves clearly identifying the decision problem and aims to structure a decision problem into two terms; alternatives and criteria. Objective is addressed in:*

- Identifying the alternatives under stakeholders' preferences and situation's consideration, then, stakeholders view and validate them.
- Specifying the criteria for the decision. Decision makers and stakeholders review it to guarantee its validity, reliability and relevance to decision (alternatives in decision matrix).

Criteria must be preferentially independent. If they are preferentially *dependent*, then these criteria are re-specified and re-identified. The preferentially independent feature does not contrast with being highly correlated. *The second step "applies analysis issues and gathering data".* It includes:

- Gathering quantitative or qualitative data depends on problem, relevant evidence, and practical factors.
- Checking the validity of related criteria and forming their final form.

Combining subjective judgments with traditional scientific evidence is allowed when addressing the decision issue, and considering stakeholders and experts' options.

"Design the proposed solution and assess the alternatives" is the third step of problem solving. When mapping it, we have:

- Creating a Data performance matrix consisting of the alternatives' performance for each criterion in consideration of expert opinions or systematic reviews
- Weighting criteria and Scoring alternatives in numerical values

Based on the applied MCDM method, this procedure is done simultaneously or iteratively.

Step of scoring alternatives based on the criteria and weighting these criteria has two classes of methods; *direct* and *choice-based* methods.

The scoring and weighting of alternatives and criteria is a comprehensive overview that includes pairwise ranking and pairwise comparisons of alternatives or criteria. Decision makers are directly expressing criteria relative to alternatives from their viewpoints and experience in the decision domain. These expressions are represented in terms of an interval scale. Unfortunately, the validity and reliability of this score and weight is questionable. As scoring preferences are cognitively difficult for most decision experts. Direct methods include: Analytic Hierarchy Process (AHP), SMART – an acronym for “Simple MultiAttributes Rating Technique”, “Bisection” and “difference” methods, SMARTER – for “Simple MultiAttributes Rating Technique Exploiting Ranks”, Direct rating and points allocation, and Swing weighting.

For the second class of scoring and weighting alternatives and criteria, Choice-based methods include regression-based or quantitative techniques. Decision experts answer relative questions based on choosing between two or more alternatives defined on some or all the criteria. This choice or ranking indirectly derives scores and weights for alternatives and criteria. This ranking resembles real-world decision expression and is observable and verifiable. The Choice-based or indirect method is more robust, reliable and easier than direct methods for decision makers. These indirect methods include:

- Conjoint analysis (or discrete choice experiments, DCE): the regression technique approximates each alternative's value (or utility) or probability of alternative's preferences by decision-makers.
- *Potentially All Pairwise RanKings of all possible*

Alternatives (PAPRIKA) (or choice-based) method: each score of alternatives upon the criteria are multiplied by the weights, and then these weighted scores are summed across the criteria to get each alternative's total score.

MCDM methods are not suitable for all decision-making problems. Level of availability and uncertainty of data, stakeholder preferences, equality of background for an expert's decision are oriented factors for selecting a suitable MCDM method that handles this decision-making issue. Selecting an unsuitable MCDM method leads to an unreliable decision therefore, consuming resources, time, costs, and risks at business level or life if this decision is related to health, human, environment and creature. Below classification provides help for selecting a suitable decision model for decision problem's type [5].

- Decision-making model for Uncertainty and risk decision problem: design decision model with MCDM method addresses uncertainty and robust and risk analysis by supporting fuzzy logic set, probability or stochastic optimization.
- Decision-making model for Complex optimization problems and multiple conflicting alternatives (objectives): combining MCDM methods with Pareto optimal solutions to design model support interactive decision. It is called Multi-objective evolutionary optimization.
- Decision-making model for dynamic environments problem: changing criteria, modified stakeholders' preferences, updated strategies considered features and constraints of dynamic decision environments. That requires a decision model that handles these frequently dynamic. The proposed model engaged real-time decision support systems, dynamic optimization algorithms and adaptive decision-making methods.
- Decision-making model for Cognitive biases and multidisciplinary human factor problem: this problem requires engagement decision model addresses human behavior, biases and emotions, and decision neuroscience, economics and psychology to form behavioral Decision-making model.
- Decision-making model-based sphere: that requires accurate decision model tailored criteria-based specific domain with alternatives constrained in context such as healthcare and sustainability.

The pre-mentioned classification is ignoring the problem's nature, structure and purpose. It also does not provide a clear aggregation of MCDM methods; unfortunately, it also may not be enough under uncertainty, vagueness, conflict, and ambiguity data, in addition to the other rest of decision-making process's elements. The following Classification of decision is in account into data structure and management levels [3].

- Structured decision for transitional management level: clear criteria, well defined objectives and alternatives. MCDM methods made reliable decisions by quantifiable criteria and informed performance. For example selecting suitable building location based on accessibility, facility, area, location etc.
- Semi-Structured Decision for middle management level: semi-defined objectives, alternative and criteria. There are moderate levels of uncertainties or ambiguities in data, imprecise preferences, incomplete information and unstructured subjective judgments. MCDM methods attempt to make systematic decisions by comparing alternatives and assessing subjective criteria. For example, evaluate job candidates' portfolio in count to their experiences, skills, and qualifications.
- Unstructured Decision for strategic management level: High level of uncertainty and lack of distinct objectives, alternatives and criteria are its properties, besides, limited information, conflicting preferences and alternatives. MCDM methods provide an organized model including relevant criteria and alternatives; this model helps stakeholders to consensus-building. For example, set a long-term strategy for organization [29].

There are some studies handled Decision taxonomy from specific-domains perspective like buying [30], orders [31], recommender system, behavioral supply management [32], strategic applications of information system [33], artificial inelegance aspect [34] and etc. although various studies for the taxonomy of decision support systems, but they are very old and are not updatable, for example Alter's taxonomy was since 1977 [35], Thrall's taxonomy in 1984 [36], and Arnott's taxonomy of decision biases since 1998 [37]. These studies categorized the decision-making in terms of methodological, organizational, behavioral and technological approaches, but they seldom combine the nature of decision problems with the selective engagement of MCDM or hybrid strategy, which can be viewed as a gap that the current research will fill.

Note that classification doesn't clearly exist in real-life decision-making problems. There is overlap. Obviously, MCDM methods provide a systematic, subjective and flexible framework to address uncertainty and guide decision makers to holistic-criteria-based-decision.

2.2 MCDM for Hybrid-MCDM Approaches

Decision-making for real problems is a significant issue and complicated because of uncertainty, vagueness, and incomplete data where MCDM method is a mathematical model that has qualitative and quantitative criteria to address conflicting criteria [27]. Simultaneously those are traded off by experts and supported with Expert Decision (ED) performance assessment, and studied alternatives to provide scores for proposed alternatives [38], [39]. MCDM methods classify into multiple groups working based on

mechanism, as in [16], [5], [3]. Unfortunately, this classification is listed below and is not helpful for selecting suitable MCDM methods for real decision scenarios.

- value-based methods: provide decision model by prioritizing criteria, ranking alternatives, and establishing preference relationships like AHP, TOPSIS, PROMETHEE
- Multi-objective methods: handle conflict objectives like WSM, WPM, TOPSIS
- fuzzy-based MCDM methods: address uncertainty decision-making problem by formulate preferences under imprecise information by expressing linguistic subjective judgments and quantifying vague information, like fuzzy-MCDM methods
- data-driven-integrated-MCDM methods: provide decision model combining Machine learning algorithms with MCDM methods to enhance effectiveness and efficiency results by adding valued information extracted from bid data analysis or prediction, like integrating TOPSIS and decision tree
- Hybrid method: it varies on the rest by providing a comprehensive and enhanced decision-making framework by addressing the drawbacks of each individual MCDM method. This addressing and enhancing achieved by combining MCDM method together, like ANP-TOPSIS
- Outranking methods: provide decision model upon criteria address preferences and alternatives pairwise to outrank alternatives each other, like ELECTRE, PROMETHEE
- Distance-based methods: provide optimum decision based on measuring the distance from ideal and worst solution, like TOPSIS, MTS
- Probabilistic MCDM methods: that explicitly incorporates uncertainty in form of probabilities to model imprecision in data or criteria weights, like Markov chain-based MCDM, Monte Carlo simulation in MCDM, Bayesian MCDM.

Decision makers, decision model designers and managers need a roadmap guiding them to select suitable MCDM for decision problems where this problem has multiple levels of complexity and sometimes ambiguity. Unfortunately, the wrong decision has high costs. Losing money is the least of the losses a company incurs. Reputation, time, and the loss or delays in winning a competition or go-to market are the real losses resulting from a wrong decision. This threatens managers, CIO, and sometimes lives, especially when implementing the decision in the healthcare sector for example. Therefore, making the right decision in record time is the goal of managers, decision makers, and companies in various fields. This highlights the importance of having a guide or directive map for the correct MCDM method appropriate for the

problem. The next sections address this issue and provide the solution in section 4 where its results are tested in section 5 through real case problems related to beneficiary selections which can be applied in various domains like healthcare, education, civil development, and etc.

3. The Methodology

3.1 Methodology Architecture

To develop a methodology for solving problem statements in the introduction section, and in accordance with the problem-solving steps, the proposed methodology combined PRISMA Steps for collecting the data, Design Science Research Method (DSRM) and Extended Taxonomy Design Process (ETDP) with scientific and structured problem-solving steps for concluding taxonomy and designing guidance frameworks for MCDM and Hybrid-MCDM. ETDP is a structured approach for developing and generating taxonomy. This approach incorporates evaluation guidelines while leveraging multiple information sources like literature reviews and expert interviews [40]. ETDP with six phases and 18 processes follows a systematic approach in developing taxonomy. The three frameworks are not parallel; they are nested:

1. DSRM is the outer shell governing the whole study, since the end product is the taxonomy and framework.
2. ETDP is nested inside DSRM's "Design and Development" phase. It is the specific procedure to build the decision method taxonomy.
3. PRISMA operates inside ETDP's data-gathering sub-stage which is the literature-identification-and-screening protocol that supplies the empirical material ETDP needs to build the taxonomy.

3.1.1 DSRM Phase Mapping

This phase is tied to and started from the motivation of the

study. This is reflected in the following figure 2. The first step is to identify the problem and motivate, during which the scholars define the problem that the taxonomy aims to solve and determine the intended users and the intended use of the taxonomy. The second stage, 'Define Objectives of a Solution', develops the meta-characteristics upon which the classification of the items of the taxonomy will be based, along with the objective terminal conditions and objective evaluation goals that will authorize the taxonomy's validity. 'Design and Development' is the third stage, during which a suitable taxonomy-construction methodology is chosen, that is, an empirical-to-conceptual or conceptual-to-empirical approach. In the empirical approach, the relevant objects are discovered and grouped based on similar attributes and dimensions whereas in the conceptual approach, characteristics and dimensions are codified first before applying them to analysis of objects. Regardless of the option taken, both methods end in the creation of the taxonomy. 'During the Demonstration' phase, the investigators verify that the objective terminal conditions have been achieved and then refine the taxonomy as necessary. Evaluation phase criticizes the taxonomy by examining subjectively defined terminal states, establishing an evaluation plan, and implementing the evaluation to determine whether or not the objectives that were set were met. Lastly, the 'Communication' stage spreads the taxonomy and its evolutionary path, providing a full description of the phenomenon that the taxonomy is meant to explain.

3.1.2 ETDP Execution Phase

This is the same approach followed in MCDM methods and Hybrid-MCDM approach. Within DSRM, the third step embedded ETDP's six phases were executed as follows in Table 2 which shows applied steps in the MCDM taxonomy development process aligned with DSRM and ETDP. The steps in table 2 follow a systematic approach in developing taxonomy, and they are:

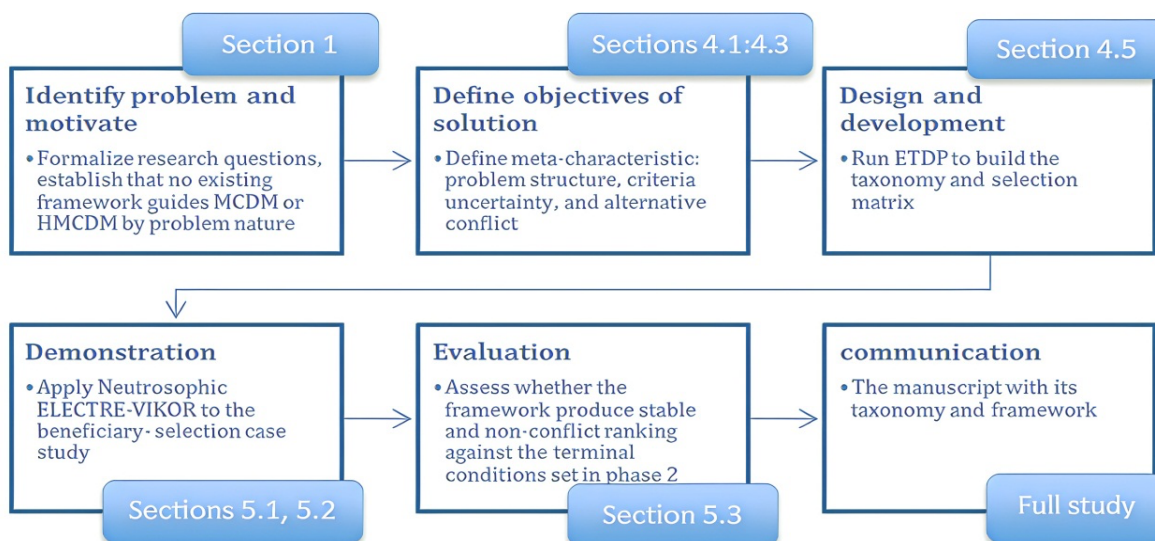


Fig. 2: DSRM steps that mapped study activity and output

Table 2: Taxonomy steps for stability- decision model that are aligned with Extended Taxonomy Design Process (EDTP) and Design Science Research Methodology (DSRM)

DSRM Phase	ETDP Step	Application for Stability-Driven MCDM Framework
I. Identify Problem and Motivate	(1) Specify the observed phenomenon	- Decision makers find it difficult to choose the most suitable method in the selection process for Multiple-Criteria Decision-making (MCDM) methods because of the large number of methods. - Most of the study is on ranking alternatives, and very few look at the stability of the end decision in the presence of changing circumstances like weight changes or uncertainty. - The absence of a structured framework connecting the elements of decision-making with stability evaluation in MCDM.
	(2) Specify target user group(s)	- Researchers developing new MCDM methods. - Application of proper MCDM techniques on decision-making problems in the real world. - Decision makers dealing with uncertainty and the robustness/stability of decisions.
	(3) Specify intended purpose(s)	- Build taxonomy of decision-making process elements used in MCDM methods. - Use the taxonomy to design a stability-driven MCDM framework. - Provide a systematic guideline for method selection and stability evaluation in decision analysis.
II. Define Objectives of a Solution	(4) Determine meta-characteristics	The taxonomy will classify MCDM methods based on decision-making process elements, including: Problem structure, Criteria characteristics, Data type (crisp, fuzzy, Neutrosophic), Preference modeling, Aggregation mechanism, Ranking procedure, Stability and sensitivity evaluation mechanisms
	(5) Determine ending conditions and evaluation goals	Objective ending conditions: - Each MCDM method can be uniquely classified. - All decision-making elements are represented. - Dimensions are mutually exclusive and collectively exhaustive. Evaluation goals: - Framework supports stability evaluation (e.g., sensitivity analysis, rank robustness). - Framework assists in selecting stable MCDM approaches.
III. Design and Development	(6) Choose building approach	Empirical-to-Conceptual approach based on a systematic literature review of MCDM methods.
	(7) Identify objects	Objects are MCDM methods, including: AHP, TOPSIS, ELECTRE, VIKOR, PROMETHEE, DEMATEL, WASPAS, MOORA, MARCOS, EDAS, and their fuzzy or Neutrosophic extensions.
	(8) Identify common characteristics	Extract shared methodological components such as Criteria weighting method, Normalization approach, Aggregation operator, Ranking procedure, Preference modeling, Handling uncertainty, Stability evaluation capability
	(9) Group characteristics into dimensions	The taxonomy organizes characteristics into decision-making elements, such as Problem formulation, Criteria representation, Data uncertainty modeling, Weight derivation, Aggregation mechanism, Ranking strategy, or Stability evaluation

		mechanism
	(10) Create taxonomy	The taxonomy of MCDM methods is constructed according to these dimensions and forms the foundation of the Stability-Driven MCDM Framework.
IV. Demos tration	(11) Check objective ending conditions	Verify that all selected MCDM methods can be classified within the taxonomy dimensions.
	(12) Decide whether ending conditions are met	If inconsistencies exist, refine taxonomy dimensions or method classifications until all methods are represented correctly.
V. Evaluati on	(13) Check subjective ending conditions	Evaluate clarity, usability, and completeness of taxonomy by domain experts.
	(14) Subjective ending conditions met?	If experts identify gaps, revise taxonomy dimensions or classification structure.
	(15) Configure evaluation	Apply the taxonomy in a case study using a stability-driven MCDM model, such as Neutrosophic ELECTRE-VIKOR with sensitivity analysis.
	(16) Perform evaluation	Evaluate the framework through Sensitivity analysis of criteria weights, Spearman rank correlation, Rank deviation analysis, Heatmap stability visualization
	(17) Evaluation goals met?	If results show stable rankings across scenarios, the framework is validated as supporting stable decision outcomes.
VI. Communi cation	(18) Report taxonomy	Publish the Stability-Driven MCDM Framework, including: The taxonomy of decision-making elements, Framework architecture, Case study validation, Guidelines for selecting stable MCDM methods.

3.1.3 PRISMA-Based Literature Search Phase

Further, reliable database sources such as Scopus and WOS are used to investigate the following:

- Classifying and dissecting the decision problem according to the principles of solving and the methodology of MCDM methods
- Define Characteristics, limitations, advantages, and suitability of each MCDM method to make selecting the most suitable method easier

The queries used across these databases for collecting the initial data were as follows:

1. TITLE-ABS-KEY (roadmap AND for AND selection AND mcdm AND method AND based AND on AND problem AND structure)
2. TITLE-ABS-KEY (taxonomy AND of AND decision-making AND process AND elements)
3. TITLE-ABS-KEY (how AND to AND select AND mcdm AND method AND for AND different AND decision AND problems)
4. TITLE-ABS-KEY (guidance AND framework AND for AND designing AND decision AND model AND by AND mcdm AND methods)

Unfortunately, there is no retrieved framework to help combine MCDM methods together to solve problems. Furthermore, there is no guidance decision tree or flowchart for selecting suitable MCDM methods to make this hybrid and combination. Wherefore, studying MCDM methods and decision process elements based on decision problem nature is critical. For the stability-driven Hybrid-MCDM framework and providing relevant taxonomy that matches with decision-making properties in the real world, this study adopts studying and classifying MCDM methods and decision-making process elements: criteria, alternatives, evaluation and analysis, pairwise and trade-offs, and objectives under different levels of constraints and difficulties: certainty and conflict. The search is more specific, as shown later.

Search Strategy

The approach, ETDP, was integrated with problem-solving procedures in a proposed methodology to report the taxonomy of decision-making process elements and conclude the guidance roadmap. The three main phases of providing these guidance frameworks are: (1) "gathering and assembling" then, (2) "reading and analysis", and (3) finally, "deduction and conclusion".

The first phase "gathering and assembling data" focuses on receiving materials that concern donation management, division supplies, prioritization, and beneficiary selection by MCDM methods or Hybrid-MCDM approach

specifically.

The second phase consists of three sub-stages; they are (2-1) the first sub-stage, as in a real decision problem and application domain at a practical perspective, index the decision problem, criteria and alternatives based on levels of structure, and certainty and conflict respectively (2-2) Second sub-stage, studying MCDM methods based on mathematical function, strength, limitation, best suitability, and usage domains those applied for. (2-3) Third sub-stage, providing taxonomy for set theory based on the same classes in the first sub-stage of the same phase.

The final phase, "deduction and conclusion," has two sub-stages (3-1) the first sub-stage, get a guidance framework for MCDM methods that guarantees reliable method selection based on real problem taxonomy and consequently reliable decision. That is done by combining MCDM method classes and the output of three previous sub-stages of phase two. (3-2) Second sub-stage is generating a stability-driven Hybrid-MCDM framework upon the same taxonomy to guarantee conflict-resilient decision models.

Keywords that are used for search strings are listed below. The timeline of research addresses the last 26 years before. The range time is 2011 until 2025 (1/1/2011 until 1/1/2026) where the released review literatures that are issued in this range handle all published studies about MCDM methods from 1999. The database that is used is Scopus and Web of Science to ensure wide trusted and retrieved documents, thereby ensuring the consistency and robustness of the study's results.

Keywords MCDM approaches, multi-criteria decision-making, Decision-making model, MCDM methods, value-based methods, AHP, TOPSIS, PROMETHEE, Multi-objective methods, WSM, WPM, TOPSIS, fuzzy-based MCDM methods, data-driven-integrated-MCDM methods, Hybrid method, Outranking methods, Distance-based methods, MTS, ELECTRE, Probabilistic MCDM methods, Spherical, Rough, VIKOR, ANP, criteria and alternatives, MCDM application, MCDM usages, taxonomy, decision-making, methods of decision-making without machine

learning algorithms, multi criteria decision-making, MCDM, MCDA, multi-attribute decision-making, multi-criteria decision analysis, method, technique, model, framework, approach, integrated MCDM, combined decision model, hybrid decision-making model, best worst method, BMW, DEMATEL, gray relational analysis.

Inclusion and Exclusion Criteria

English relevant peer-reviewed studies and conferences preceding are included in the results. While Grey literature like preprints and non-peer-reviewed sources are excluded. The article, review, conference paper, and conference review are included. The papers must have one or more keywords that are listed above in the title to include the screening and review. However, the results will be assessed by Quality Assessment (QA) statements written by authors. Only papers that have 5 or 4 as the quality Mark will be embedded in the study; otherwise, will be excluded. This scanning filter is done manually after excluding all duplicated documents.

- QA1: relevant to topic & keywords within (title & abstract & keywords), then Quality Paper (QP) = 5
- QA2: relevant to topic & keywords within (title || abstract || keywords), then QP = 4
- QA3: relevant to topic & keywords within abstract NOT (title || keywords), then QP = 3
- QA4: relevant to topic & keywords within keywords NOT (title & abstract), then QP = 2

Figure 3 declares Three-phase synthesis (sub-stages of ETDP Phase 3, not a separate methodology). Figure 4 shows the main key features for analyzing and classifying both MCDM methods and set theories and consequently Hybrid-MCDM approaches. The applying of these steps of figure 3 is listed in the next section 4. The subsections in section 4 are divided based on main phases and sub-steps of this proposed methodology in figures 2 and table 2.

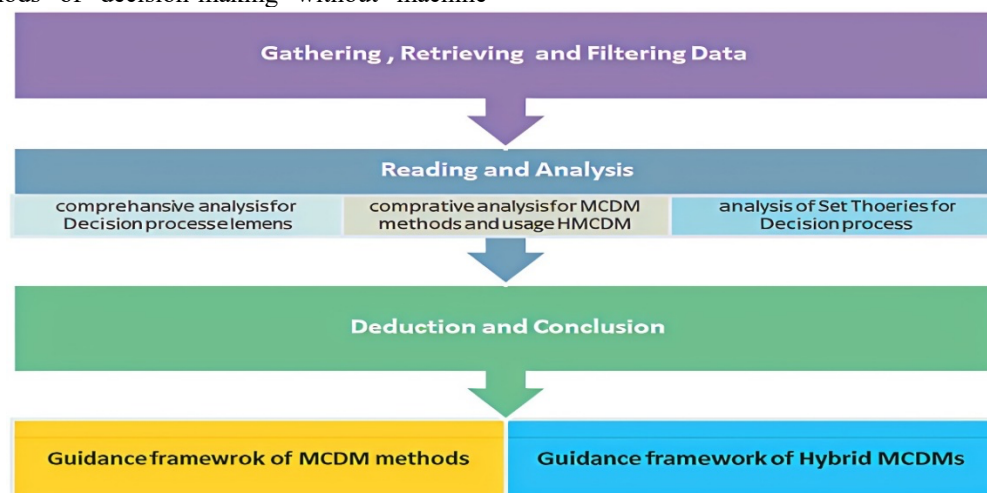


Fig. 3: Sub-Stages of ETDP (step 3), these sub-stages are not a separate methodology

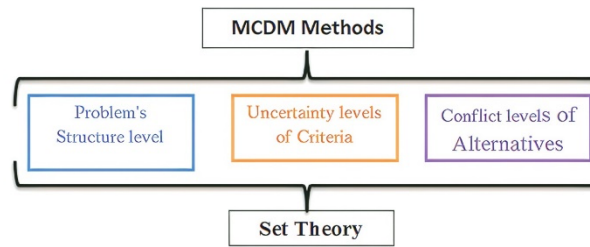


Fig. 4: Classification of MCDM methods and their set theories based on three categories

3.2 Data-Driven the Result

This section addresses the output of each stage of the proposed methodology that leads to final findings to generate two guidance frameworks for MCDM and Hybrid-MCDM.

3.2.1 Gathering Phase

Collecting and gathering highly relevant and trusted documents that are indexed in both Scopus and WOS for MCDM methods or Hybrid-MCDM approaches within titles, abstracts, and keywords is the output of this phase. To ensure inserting highly relevant papers, the applied search string is:

("Multi-criteria decision-making" OR "multi criteria decision-making" OR MCDC OR MCDA OR "multi-attribute decision-making" OR "multi-criteria decision analysis") AND (method * OR technique* OR model* OR framework* OR approach*) OR ("hybrid MCDM" OR "integrated MCDM" OR "combined decision model" OR "hybrid decision-making model") OR (AHP OR ANP OR ELECTRE OR PROMETHEE OR VIKOR OR TOPSIS OR "best worst method" OR BMW OR DEMATEL OR

"gray relational analysis")

Based on the results of PRISMA's steps, the total number of retrieved documents in the defined timeline is 12486. Applying document type filters (peer-reviewed journals and conferences), the included documents are 9842. The English documents are 9215. The documents after the duplication are 8763. Applying quality assessments that were defined in previous section 3, the distribution of documents per value of quality paper is 3214, 7942, 1826, and 821 with quality levels of QP being fifth, fourth, third, and second, respectively. The documents that have the highest quality values with five are only included in the study and prepared for the second analysis phase that is handled below.

3.2.2 Analysis Phase - Decision-Making Process Elements based on Real-Problem Nature

Based on the decision-making process and its elements that are discussed in section 2, the main elements and steps are visualized in the following figure 5. The different MCDM methods and their key features were analyzed upon that to get in final a roadmap for selecting suitable MCDM methods and set theory that fit the real decision problem.

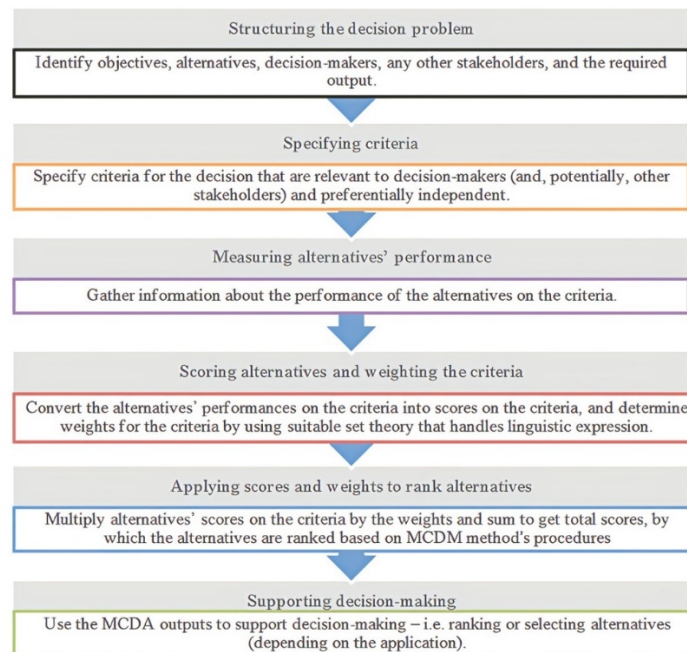


Fig. 5: steps of decision-making process and its elements

Criteria are *tools for evaluating and comparing alternatives from the viewpoint of the consequences of their selection* [41]. The main differences between MCDM methods are associated with the complexity level of their procedures, the criteria weighting, the method of representing preferences and criteria's evaluation, the uncertain level of the data, and data aggregation type. Because of that, the criteria classification and studying its effect on MCDM method classification and selection are significant. Furthermore, alternatives represent possible solutions that are difficult to choose between, and the criteria guide and decide this choice by evaluating trade-offs or pairwise based on need.

A proposed guided framework in selecting a suitable MCDM method based on the problem's nature, certainty levels of criteria, and conflict levels of alternatives, which are similar to realistic problems. It is a critical requirement. This guidance framework helps decision makers to easily design decision models and reduces bad side effects of using unsuitable MCDM methods to solve problems. In addition to increasing confidence and robustness of decisions as mentioned in section 2, the literature discussed the classification of MCDM methods academically rather than practically. The following tables and output of the third phase of this methodology solve this gap. It is one of this study's contributions. The following classification tables adopt practical perspectives by combining the problem's nature, certainty levels of criteria, and conflict levels of alternatives as in real-world problems. Table A in the appendix A tabularized comparative analysis based on properties of decision level, nature of decision-making problem's criteria (quantitative, qualitative), and alternatives' certainty levels.

MCDM methods can define its properties based on different criteria such as compensation level, preference modeling, decision rules, and problem structure. Listed in the following table B in appendix A. Compensation means the degree to which an alternative weakness in one criterion can be offset by strengths in another criterion. Preference modeling is how decision-makers address their judgments and weighting. Decision rules are how alternatives are ranked or selected. The final classifying factor is the structure of interdependencies and uncertainty and examples of which MCDM methods are effective in handling that.

3.2.3 Analysis Phase – MCDM Method Analysis:

Gathering and analyzing much literature such as [12], [42], [43], [5], [44], [45], [46], [25], [14], [47], [48], [49] and studies are important for this step. A sample comparative analysis for MCDM methods based on mathematical approaches, strengths, drawbacks, and suitability usage is discussed in table B in Appendix A. This step is very significant because it is an orientation for studying MCDM

methods' features within the decision-making process and decision-making elements— criteria, alternatives, assessment (pairwise, trade-off, etc.) - and set theories. This step is important to simply deduce a roadmap and a guidance framework for suitability MCDM methods for real-life problems in the following sections 4.6, and 4.7. Table C in Appendix A cares on samples of the most commonly used MCDM methods in different applications mentioned in the literature.

3.2.4 Analysis Phase - Set Theory Analysis based on Decision-Making Problem

Selecting suitable set theory to convert linguistic expressions to numerical values is missies. Another challenge faced by decision makers is to choose between Saaty set, classical fuzzy set, spherical fuzzy set, Pythagorean fuzzy set and Neutrosophic set based on the problem nature, uncertainty level of criteria, and handle conflict level of alternatives. Under set theory, to set numerical weights for criteria, decision problems are divided into the structured and unstructured problems. While well-defined, vague, or extremely uncertain, it expresses a certain level of criteria, and the conflict levels of alternatives are moderate or high trade-offs. Studies and literature address the set theory because of its significance and because it is used to formulate the real problem of mathematical values into decision matrixes. These studies [50], [51], [52], [53], [54], [55], [56], [57], [58], [59], [60], [61], [26], [62], [63], [24] are summarized and classified into decisions, as this study adopts a design guidance framework for selecting suitable MCDM methods based on real-life problem's properties. Tables D, E in Appendix A provide the main comparison between set theories based on their features.

4. The Results

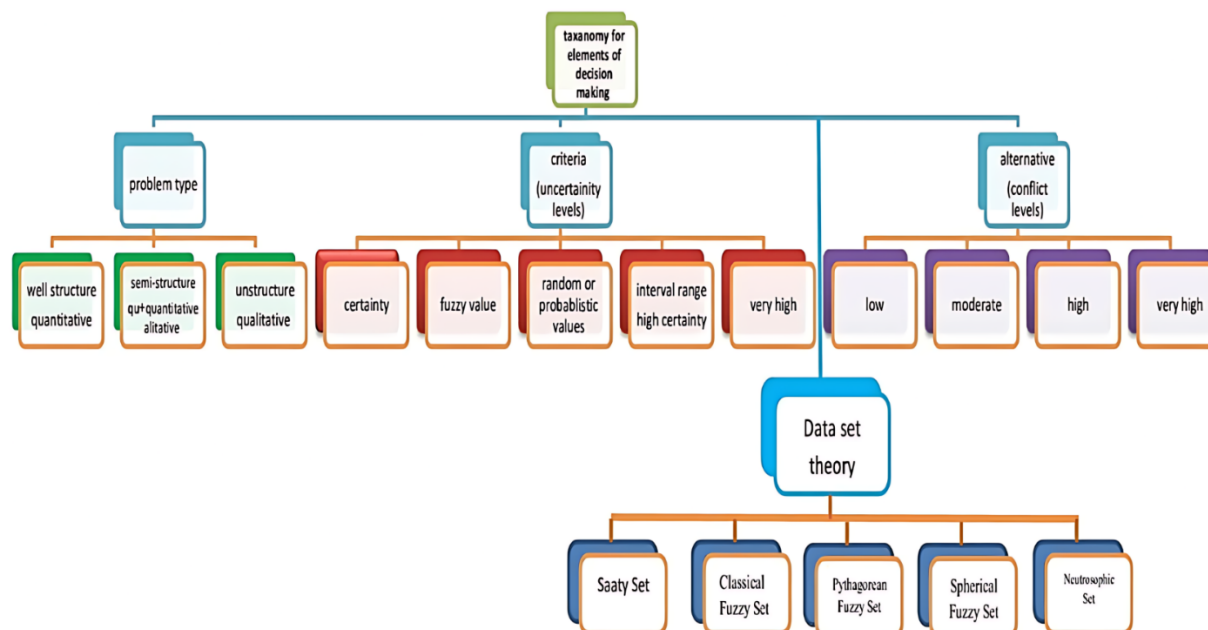
This section provides the results of all analysis steps and the insights of the used methodology to conclude the appropriate taxonomy is more helpful than the ordinary high uncertainty level of real-life decision-making problems. The taxonomy adopts Decision problem's structure, Uncertainty Level of Criteria, and Conflict Level of Alternatives in designing the guidance framework for MCDM method and HMCDM approach models as seen in the following subsections.

4.1 Conclusion and Deduction Phase – Taxonomy based Framework for Suitability Sets Theory based on Decision-Making Elements:

Figure 6 visualizes the taxonomy of decision-making elements further; table 3 provides the answer to the question – *RQ1: how does decision maker select a suitable set theory for decision problems that can handle different issues of conflict or uncertainty?*

Table 3: A framework for selecting set theory based on nature of decision-making elements

Set theory	Decision problem's structure	Uncertainty Level of Criteria	Conflict Level of Alternatives
Saaty Set	Well-structured	Moderate (Some Subjective Judgments)	Moderate (Some Trade-offs, Stakeholder's Mild-disagreement)
Classical Fuzzy Set		Low (Numerical Data Available)	Low (Minimal Trade-offs, Agreement Among Stakeholders)
Pythagorean Fuzzy Set	Semi-structured	High (Linguistic Variables with Some Missing Data)	Moderate (Some Trade-offs, Mild Stakeholder Disagreement)
Spherical Fuzzy Set			High (Severe Trade-offs, Conflicting Interests)
Neutrosophic Set	un-structured	Very High (Severe Data Gaps, Contradictions)	Very High (Contradictions, Ethical & Political Disputes)

**Fig. 6:** A taxonomy of decision- making elements

4.2 Conclusion and Deduction Phase: Taxonomy-based Framework for Suitability MCDM based on Decision-Making Elements

Figure 6 and Table 4 provide an answer to the question – *RQ2: How does decision maker select a suitable MCDM method or Hybrid-MCDM approach for decision problems that can handle different issues of conflict or uncertainty in criteria or alternatives?* By analyzing the classifications mentioned in sections 4.2 and 4.3 and tables

B, C, D in Appendix A, the next table 4 addresses characteristics of the most utilized MCDM methods. These attributes are concluded and tableted as a guidance to help decision makers to select suitable methods for decision-making problems based on methods' features, decision-making problem's properties (criteria's uncertainty and alternative's conflict). Table 4 regards as framework for selecting MCDM methods based on nature of decision-making's elements.

Table 4: A framework for selecting MCDM methods based on nature of decision-making's elements

MCDM class	assumption	Decision-making's elements	example		
			Method	description	application
Value-based	Decision-makers can trade off one criterion for another	all criteria contribute to a final score	AHP	Uses pairwise comparisons to assign weights and rank alternatives.	Supplier selection, project evaluation
			ANP	Extends AHP by considering	Healthcare prioritization,

				interdependencies between criteria.	strategic planning
			TOPSIS	Ranks alternatives based on closeness to an ideal solution.	Risk assessment, technology selection
			MAUT	Evaluate alternative under moderate uncertainty and conflict	Players assessment
			SAW	Weighted sum model	School evaluation
			VIKOR	Focuses on compromise solutions when trade-offs exist.	Disaster response planning, energy policy decisions
Outranking	No full trade-offs between criteria; instead, alternatives outrank each other	High-conflict situations where trade-offs are not acceptable	ELECTRE	Uses pairwise outranking to compare alternatives based on dominance.	Urban planning, environmental impact assessment
			PROMETHEE	Uses preference functions to rank alternatives.	Logistics optimization, investment decisions
Distance-based	Alternatives are ranked based on their distance from an ideal or worst solution	Decision-making under moderate uncertainty	TOPSIS	Identifies the best alternative by minimizing distance to the ideal solution.	Supply chain risk management, energy policy decisions
			VIKOR	- Evaluate alternatives based on their distance from an ideal solution	healthcare
			MTS	Uses statistical distance measures for ranking.	Fault detection, medical diagnosis
Multi-objective decision-making	Decision-making involves optimizing multiple conflicting objectives	Large-scale optimization problems	Goal programming	Minimizes deviations from predefined target values.	Budget allocation, financial planning
			Multi-Objective Linear Programming (MOLP)	Optimizes multiple conflicting linear objectives.	Production planning, energy distribution
			Pareto Optimization	Finds a set of optimal trade-offs rather than a single solution.	Economic policy formulation, environmental impact assessment
Fuzzy and Uncertainty-Based	Criteria and alternatives contain linguistic, vague, or imprecise information	Problems with moderate to high uncertainty	Fuzzy MCDM	Fuzzy-AHP: Extends AHP by using fuzzy numbers to model expert judgments.	Medical diagnosis, intelligent transportation systems
				Fuzzy-TOPSIS: Uses fuzzy numbers to evaluate alternatives under uncertainty.	Water resource management, supply chain risk
				Fuzzy-VIKOR: Adapts VIKOR to handle uncertain data in decision-making.	Healthcare prioritization, energy efficiency decisions
				Fuzzy-ELECTRE: Applies fuzzy set theory to outranking approaches.	Land-use planning, environmental sustainability
			Spherical	Extends fuzzy logic with	Hospital tanking,

			Fuzzy MCDM	three-dimensional uncertainty modeling.	disease diagnosis, e-learning
			Neutrosophic MCDM	Handles truth, indeterminacy, and falsity in uncertain environments.	Risk management, social decision-making
Probabilistic and Evidence-Based	Decision-making under risk and uncertainty with probability distributions	Problems where uncertainty and incomplete information exist	Bayesian MCDM	Uses Bayesian probability to update beliefs based on new evidence (for updating decision weights dynamically).	Medical treatment selection, cybersecurity risk assessment
			Dempster-Shafer Theory (DST)	Handles uncertainty by assigning belief functions to evidence.	Forensic decision-making, fault diagnosis
			Markov Decision Process (MDP)	Models sequential decision-making under uncertainty.	Autonomous vehicle navigation, AI-based decision support
			Stochastic MCDM	Uses probability distributions instead of fixed numerical comparisons.	Financial decision, transportation planning, emergency management
Hybrid and Data-driven (AI-Driven)	Combines multiple decision-making approaches for higher accuracy.	Complex decision problems requiring multiple evaluation perspectives	AHP-TOPSIS	Uses AHP for criteria weighting and TOPSIS for ranking alternatives.	Healthcare resource allocation, renewable energy site selection
			AHP-VIKOR	Uses AHP for weight assignment and VIKOR for compromise ranking.	Infrastructure planning, investment portfolio selection
			Neural Network-Based MCDM	Uses deep learning to identify decision patterns.	Fraud detection, predictive maintenance
			Genetic Algorithms for MCDM	Uses evolutionary optimization for complex decision problems.	Supply chain optimization, AI model selection
			Reinforcement Learning for MCDM	Models decision-making as a learning process.	Autonomous robotics, personalized medicine
			Neural Network-AHP	Uses deep learning to refine pairwise comparison consistency.	Health risk, medical prediction diagnosis, HR management
Network-based	Decisions comprising interrelated factors and cause-effect relationships.	Encapsulate complex interdependencies and relationships among decision elements	DEMATEL	Identifies causal relationships between criteria. Reveals direct and indirect relationships. Help in building influence-relation map (IRM)	Strategic decision-making urban planning
			Fuzzy DEMATEL	Extends DEMATEL with fuzzy logic for handling uncertain dependencies.	Crisis management and pandemic response

			ANP	Extends AHP to handle interdependent criteria.	Policy making, supply chain management, sustainability assessment
--	--	--	-----	--	---

4.3 Conclusion and Deduction Phase: Taxonomy-based Framework for Suitability Hybrid-MCDM based on Decision-Making Elements

The guidance framework for combining MCDM methods based on categories of problem, certainty criteria and

conflict alternatives is addressed in table 5. This framework of Hybrid-MCDM approaches the decision-making process. It delivers answers for the **RQ2**. Table 4 implicitly contributes in generating table 5 in different literatures of MCDM methods.

Table 5: A Framework for selecting suitable Hybrid-MCDM methods based on decision-problem's elements

Key feature	levels	Recommended HMCDM	Rational of combining
Problem type	Well-structured, quantitative	AHP - TOPSIS	AHP determines criteria weights, while TOPSIS ranks alternatives based on ideal solutions.
		MOORA - COPRAS	MOORA normalizes data efficiently, and COPRAS refines proportional ranking.
	Semi-structured (quantitative and qualitative)	ANP - VIKOR	ANP handles interdependencies, and VIKOR balances best and worst solutions.
		AHP - PROMETHEE	AHP assigns weights, while PROMETHEE handles ranking through outranking flows.
		ELECTRE - PROMETHEE	ELECTRE handle the initial filtering, while PROMETHEE provides detailed preference rankings
	Unstructured, qualitative	ELECTRE - Neutrosophic AHP	ELECTRE manages high-conflict choices, while Neutrosophic AHP handles uncertainty.
		Fuzzy AHP - PROMETHEE	Fuzzy AHP assigns uncertain weights, and PROMETHEE improves ranking in vague environments.
Uncertainty Level of Criteria	Crisp (Exact values)	WSM or WPM with SAW	for straightforward, additive models with enhanced consistency
		AHP - TOPSIS	AHP for weight determination, TOPSIS for ranking using ideal solutions.
	Fuzzy (Linguistic terms, imprecision)	Fuzzy AHP - Fuzzy TOPSIS	Fuzzy AHP handles uncertain criteria weights, and Fuzzy TOPSIS ranks alternatives.
		Fuzzy ANP - Fuzzy PROMETHEE	Fuzzy ANP for interdependence, Fuzzy PROMETHEE for handling preference functions in uncertainty.
	Probabilistic (Random variations, distributions)	Stochastic AHP - Stochastic VIKOR	Stochastic AHP for weighting with probabilities, Stochastic VIKOR for compromise ranking.
Conflict Level of Alternatives	Low Conflict	AHP - MAUT	AHP assigns weights, MAUT calculates utilities for ranking.
		MOORA - COPRAS	MOORA for quick normalization, COPRAS for proportional assessment.
		WSM or SAW with MOORA	to ensure simplicity and balance for alternatives with fewer conflicting aspects
	Moderate Conflict	TOPSIS - VIKOR	TOPSIS finds the closest solution, VIKOR identifies a compromise solution.

		AHP PROMETHEE	-	AHP provides consistent weights, PROMETHEE manages moderate conflicts through preference functions.
		AHP - VIKOR		AHP for weight criteria and VIKOR for handles ranking with an emphasis on conflict resolution
	High Conflict	ELECTRE or PROMETHEE with VIKOR		to resolve high-conflict scenarios while maintaining practical rankings and compromise solutions.
		ELECTRE - fuzzy PROMETHEE		ELECTRE handles strong outranking, PROMETHEE refines the ranking process.
		Neutrosophic ANP - ELECTRE		Neutrosophic ANP manages high uncertainty, ELECTRE ensures strong decision robustness.

4.5 Guidance Roadmap

To easily select MCDM methods, start from detecting the decision problem dimensions. Figure 7 for reading decision dimension, distribution of MCDM method to structured problem and three levels of criteria and alternatives, semi-structured and unstructured respectively. These figures are regarded as a small and visualized version of frameworks that are displayed via three tables 3, 4, and 5. They help decision makers to select and design stable-driven decision model combinations based on the problem's nature and its structure in addition to uncertainty levels of criteria and conflict level of alternatives without sympathy preferences biases.

In attempt to bridge proposed framework into practical applications in real life, and to test the consistency of MCDM or Hybrid-MCDM model that is selected based on proposed taxonomy, consequently, using this guidance framework for ethical and transparent decision for beneficiaries and donation management regards as a critical and robust test. Because this case study has various challenges like conflicted alternatives, preferences, and sympathy that may negatively lead decision makers. Designing a decision model with wrong set theory – interpreting vagueness and ambiguity in decision maker's linguistic variables – or wrong MCDM method whether in single or hybrid model will lead to unreliable decision therefore, consuming resources, time, costs, and unfair distribution of dues. Furthermore, the donors will be reluctant later to provide support and donations to the foundation because of loss of trust. Losing the reputation of the foundation that manages donations. Designing conflict-resilient and reliable decision models is the only solution for this issue. Particularly, this case study -beneficiaries' selection and donation management- is not limited to this limited dimension of food resources or financial support or in humanitarian aid, disaster relief, or social welfare and government assistance. But also it is applied in determining the beneficiaries and the highest priority of free treatment, critical operations or organ transplantation in the healthcare field for example. It is also applied in the field of recruiting a qualified employee. It is also applied to determine the scholarship of students and grant allocation in the education domain. In banking industry and finance, it is also applied

for microfinance, microloans or financial empowerment programs or poverty alleviation programs. The next section 5 addresses the beneficiaries and donation management as an empirical case study for the study's findings in the nonprofit and charity resource allocation domain.

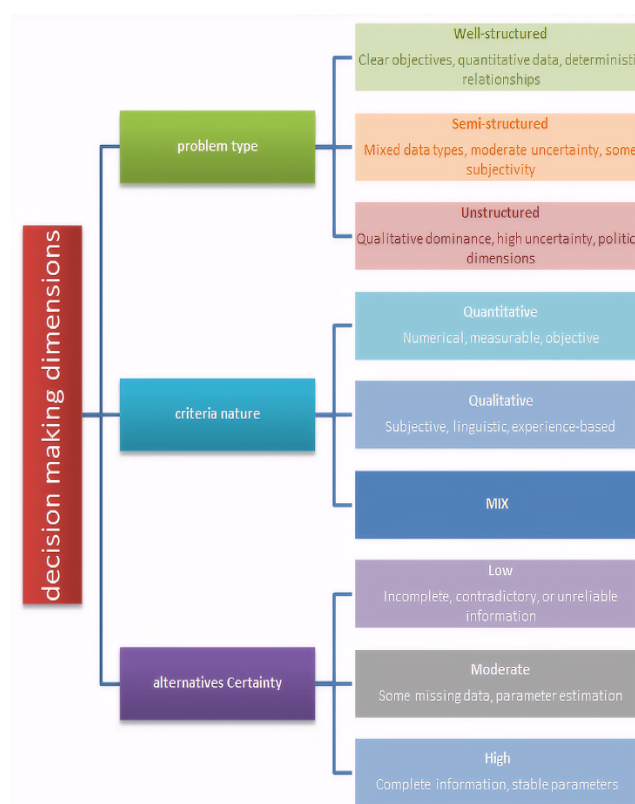


Fig. 7: A decision-making dimension – step 1 of selection suitable MCDM methods or hybrid-MCDM, then step2, follow the frameworks that illustrated in tables 9 or 10 based on the designed model Hybrid-MCDM or MCDM methods

5. Implementation:

This section addresses a real case study, checking the stability of the combined decision model that is proposed by the framework in section 4. The mathematical procedures of the decision model are also handled with its stability test.

5.1 The Case Study:

NPO depends on effective donation management to ensure that resources (foods, medicines, cloth, school/educational supplies, etc.) are allocated to those in need. A common main challenge all over the world in this domain is transparent and fair selection for beneficiaries from the long list. In Egypt, AL-ATEYAT nonprofit organization adopts "Zero Hunger" and "No Poverty" goals of sustainable development. It received financial aid and food (meals and hard ingredients like rice, meats etc.). The aid distribution is a complex mission. It has a long list full of the elderly, the sick, and various families with different categories (Families supported by women - families of orphans, widows, or both). These aids are also distributed to shelters whether for children or for animals. Managing food and financial aid in a Muslim country such as Egypt requires more effort and greater care than in other countries of non-Islamic charity. There are various types of donations like charity, Zakat, and expiation, besides distribution and grant constraints. Each charity type has its own rules; in acceptance, values and determining who deserves it according to Islamic law. For example, charity can be given to any person in need, whether Muslim or non-Muslim, but zakat must be given to the poor, the needy, debtors, or travelers Muslims and limited cases for non-Muslims. Zakat has specific timings that cannot be exceeded. Expiation, on the other hand, is only distributed to the

needy and has rules in its application. In some cases, money can be received as expiation to facilitate donors, but it must be given to the beneficiary as meals. Therefore, selecting those who are eligible is difficult and burdensome by nature. This complexity increases because of the type of donated money or food, the timing, and the category to whom it is donated. This is an additional challenge to the ordinary challenge in non-Islamic charity; beneficiary selection Figure 8 visualizes the complexity of handling a donation management system for only two resource types (food and money). This figure simply reflects the tracking path of money or food donations-grants in donation systems in Arabic countries and Islamic donation organizations as well like "Zakat and charities fund" [64], "Resala Charity Organization" [65], "HayaKarima Nonprofit Organization" [66]. An AL-ATEYAT has no automated system handling beneficiaries' selection and distributing donations. There is a director who is responsible for a group of beneficiaries in the same category: orphans, elderly and so on. The number of directors; who supervise beneficiaries' groups, depends on the number of members in each group. Those directors rank members in groups for each available grant. That is the reason for biases, sympathy-based preference thereby unfair and unethical dilemma. Some members may take several grants and others not once. An AL-ATEYAT decides to adopt an information system handling donation management issues, specifically beneficiary selection.

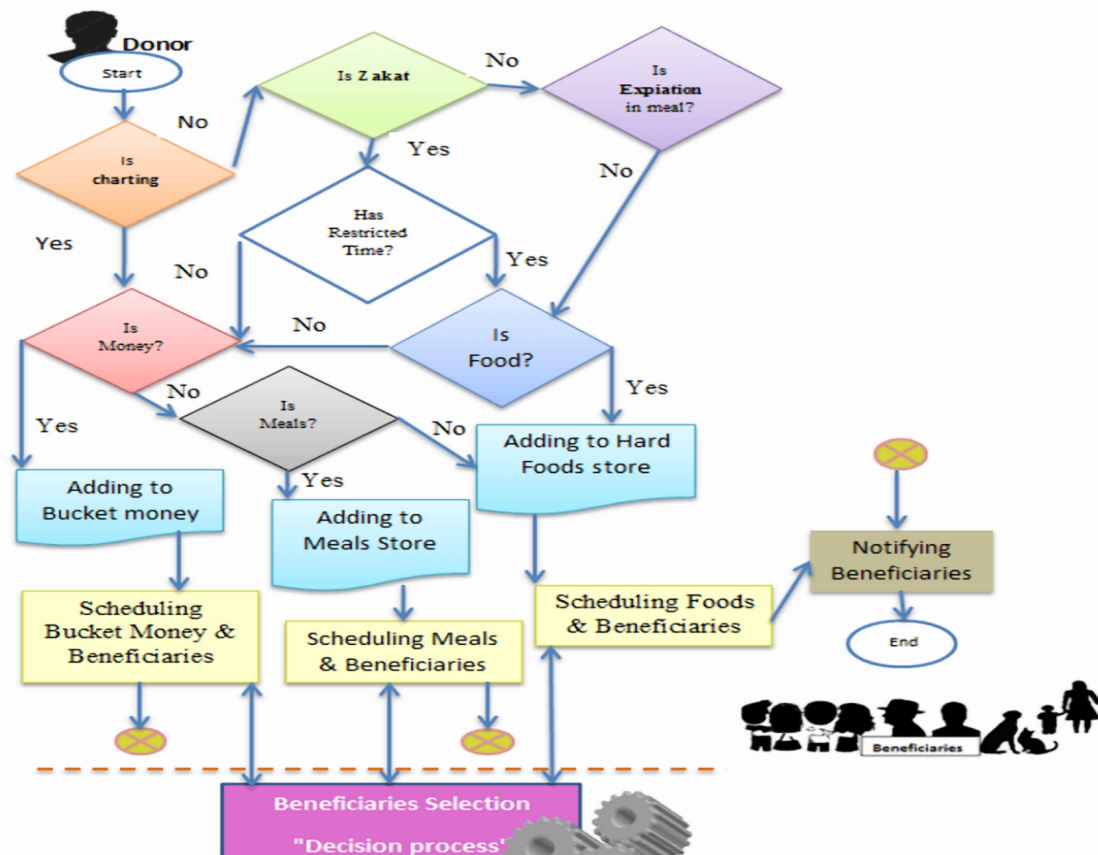


Fig. 8: Flow chart of tracking donations from donors to beneficiaries

The Bridge from Taxonomy to the Proposed Neutrosophic ELECTRE-VIKOR Method:

The broader taxonomy that is developed in this work and guidance frameworks (Tables 4 and 5) provide the direct theoretical basis for the selection and engineering of the proposed method. The decision problems are organized along three hard axes: Problem Type, Uncertainty Level and Conflict Level. The traditional MCDM method such as ANP, TOPSIS or VIKOR or the traditional set theory; Saaty set; are proven in next section 5.3. They fall into the boundaries of mathematical limits when an empirical problem is mapped in the “Unstructured/Qualitative” and “Neutrosophic/Extreme Linguistic Vagueness” uncertainty and “High Conflict” alternatives. Indeterminacy (information that is not definitely true and not definitely false) is not possible to be mapped using because: (1) the standard fuzzy approaches cannot map indeterminacy (information that is neither fully true nor fully false). (2) Standard distance based techniques are not able to handle structural outranking conflicts at severe level in a smooth way. Thereby, a deep uncertainty or high conflict boundary needs to be handled by a combination of Neutrosophic logic (to capture truth, indeterminacy, and falsity simultaneously) and ELECTRE (for robust filtering of high conflict outranking options) and VIKOR (to extract an optimized compromise solution). So, it is not a random integration but a direct mathematically justified output of the selection framework of the proposed Neutrosophic ELECTRE-VIKOR method.

5.2 Neutrosophic ELECTRE-VIKOR Hybrid Decision Model

Human engagement of the Donation management information system is visualized by sequence diagram in figure 9. It declares the start point of applying the proposed decision model to get fair, transparent and explained decisions based on different inputs; donation type, beneficiaries' data and workers on it (distributors). Donation management information system is an application of digital transformation for automating the main processes of applying applicants, donation and donors' management, beneficiaries' selection. 'Eligibility Form' and 'Identification Form' are the main sources for applicant's data and how well he deserves. 'Identification Form' is filled by the applicant who is detected his deserve later by 'Eligibility Form' and then is added to the beneficiary list. 'Eligibility Form' is filled by volunteers who are working in an AL-ATEYAT after they check content validation by field visit. Figure B in Appendix B is 'Eligibility Form' for all beneficiaries' categories; Adults, Families, Orphans, and Elderly. There are many factors that reflect society's reality, economic status and health conditions as in developing countries that have different regions; urban, rural and slums. Figure A in Appendix B is 'Identification Form'. Eligibility and identification forms are designed as a first

visualized step to analyze use cases and define problem statements. Figure B in Appendix B declares the complexity of accepting 'eligibility of applicants' thereby, all eligible applicants in an AL-ATEYAT database after this assessment and reviewing are urgent needs (beneficiaries).

1- Structuring the decision problem

By applying steps of the decision-making process that mentioned before. Firstly, it requires anatomy of the working cycle and steps of managing donation and grant-request by beneficiary and NOP. That is required to automate donation management and insert it into the information system. Eligibility and identification forms are designed as a first visualized step to analyze use cases and define problem statements. Figures A and B in Appendix B declare the complexity of accepting 'eligibility of applicants'. Therefore, all eligible applicants in an AL-ATEYAT's database after the field assessment and reviewing are urgent needs (beneficiaries). Distributing donations by ordering at group type or totally is a complex prioritization problem. It is a hard decision-making problem.

2- Specifying criteria and alternatives

As declaration, the form in figure A in Appendix B reflects the complexity of beneficiary's selection with incorporated and involved factors like infrastructure limitations as clear water, health condition, informal employment and corruption risks. The conflicting alternatives, sympathy biases, and ethical dilemmas create harder decision scenarios. It is another reason for the complexity of beneficiary selection that an AL-ATEYAT faces. The criteria and alternatives for this issue are listed in next figure C in Appendix B.

Criteria (factors) can be classified into quantifiable (objective) and qualitative (subjective). Based on defining the problem, it has both criteria. Objective criteria can be measured numerically like age and number of dependents, while subjective criteria depend on linguistic terms. They cannot be directly measured but are evaluated by an expert's judgment like health conditions. To ensure a unified measure for linguistic expression, there is a scale in table 6. This scale is used by volunteers and applicants to assess items in figures A and B in appendix B. Certainty means all factors influencing a decision have complete and reliable data. Where there are some subjective criteria like health condition and other criteria that have multiple values. Thereby, there is a level of uncertainty for criteria. For alternatives, orphans and disabilities have priorities. Also elders and families have priorities. Further, there are some families having orphans or elders and others have disabilities and orphan children. Alternatives are conflict and may be intertwined. The following table 7 declares the properties of 'beneficiaries' selection' decision problem.

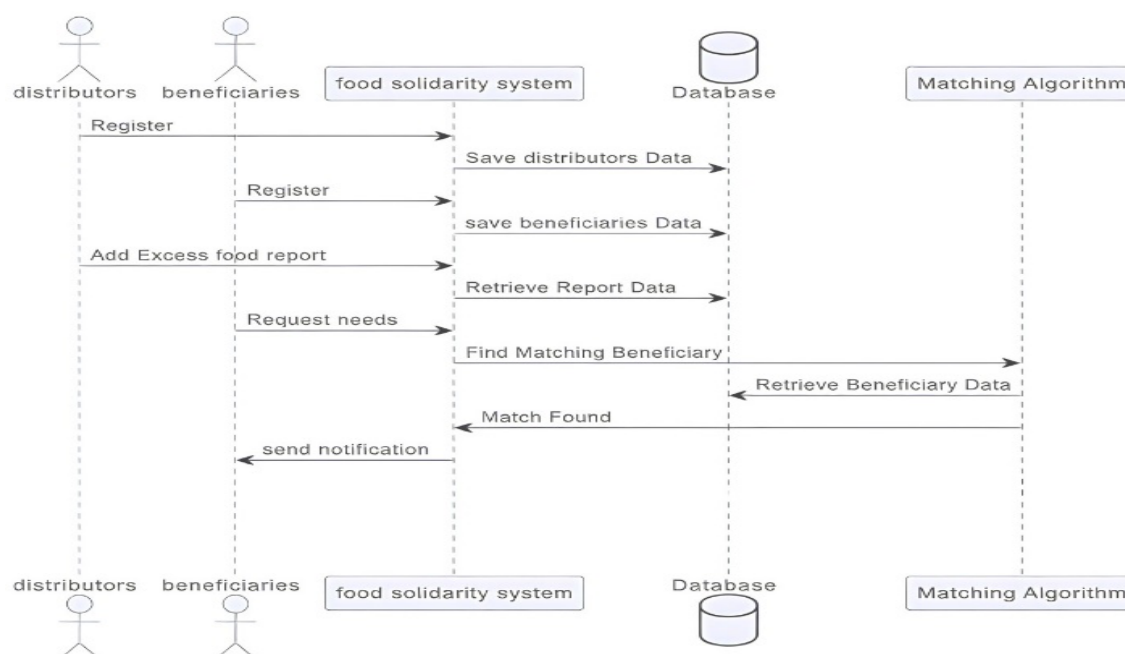


Fig. 9: A sequence diagram that shows how human-decision model-donation management system engagement

Table 6: A measure scale for linguistics expression for some subjective criteria in eligibility and identification forms

Income level	Low if <2000	moderate if [2000:5000]	High if >5000
Health condition	Good if Rare examination	Moderate if continuous examination per 3 months	Weak otherwise
Family income level	Low if <4000	Moderate if [4000:7000]	High if >7000
Not overcrowded house = at least parent in room, and different gender children (and grandparents if exist) in two separate rooms			
High number of dependent	if healthy wife/parent without children is stabile otherwise is high		

Table 7: The properties of 'beneficiaries' selection' decision-making problem taxonomy

Aspect	Level	Explanation
Uncertainty of Criteria	high	Subjectivity Measurement like Economic conditions, Social vulnerability (family hardship). Ethical and Political Sensitivity like Trade-offs between fairness and impact, Dynamic Context like Economic and health conditions change rapidly
Conflict Between Alternatives	High / very high	Different Prioritization by Decision-Makers. Contradictory Needs like families need more support but may be less vulnerable than a single disabled person. Prioritizing displaced refugees may conflict with local low income families. Support small business conflicts with providing elderly care Allocating funds for families with imprisoned parents rather than addicted parents. Elderly sick people in their homes may conflict with elderly in shelters
Problem Structure Complexity	Semi-Structured to Unstructured	Including both quantifiable and qualitative factors makes it complex.

Table 8: A Scale Set for Neutrosophic [47].

Saaty Scale	Explanation	Fuzzy triangular scale	Neutrosophic triangular scale
1	Equally significant	(1, 1, 1)	<<1,1,1>; 0.50, 0.50, 0.50>
3	slightly significant	(2, 3, 4)	<<2, 3, 4>; 0.30, 0.75, 0.70>
5	Strong significant	(4, 5, 6)	<<4, 5, 6>; 0.80, 0.15, 0.20>

7	Very strong significant	(6, 7, 8)	$\langle\langle 6, 7, 8 \rangle; 0.90, 0.10, 0.10 \rangle$
9	absolutely significant	(9, 9, 0)	$\langle\langle 9, 9, 0 \rangle; 1.00, 0.00, 0.00 \rangle$
2	Close scale = intermediate between equally and slightly significant	(1, 2, 3)	$\langle\langle 1, 2, 3 \rangle; 0.40, 0.60, 0.65 \rangle$
4	Close scale = intermediate between slightly and strong significant	(3, 4, 5)	$\langle\langle 3, 4, 5 \rangle; 0.35, 0.60, 0.40 \rangle$
6	Sporadic values between two	(5, 6, 7)	$\langle\langle 5, 6, 7 \rangle; 0.70, 0.25, 0.30 \rangle$
8	Close scale = intermediate between very strong and absolute significant	(7, 8, 9)	$\langle\langle 7, 8, 9 \rangle; 0.85, 0.10, 0.15 \rangle$

Table 9: A part of the random consistency index that listed [47].

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI (random index)	0.0	0.0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.52	1.54	1.56	1.58	1.59

3- Selecting MCDM method

Decision-makers must balance immediate relief with long-term sustainability under resource constraints. Alternatives (beneficiary groups) have many perspectives for prioritizing them, besides, limited resources, leading to

strong conflicts. Trade-off is necessary between different beneficiary groups. Based on this study, table 5, conclusion phase on proposed methodology, the decision model is selected to solve high conflict in alternatives by using a compromise and outranking method by:

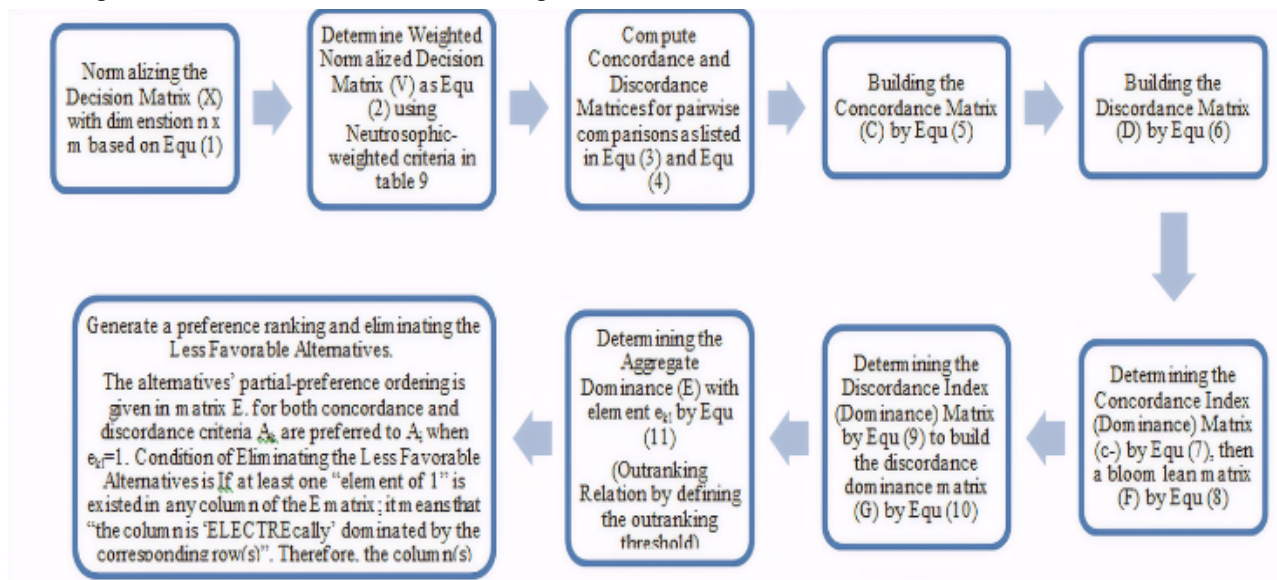


Fig. 10: flow steps of ELECTRE methods

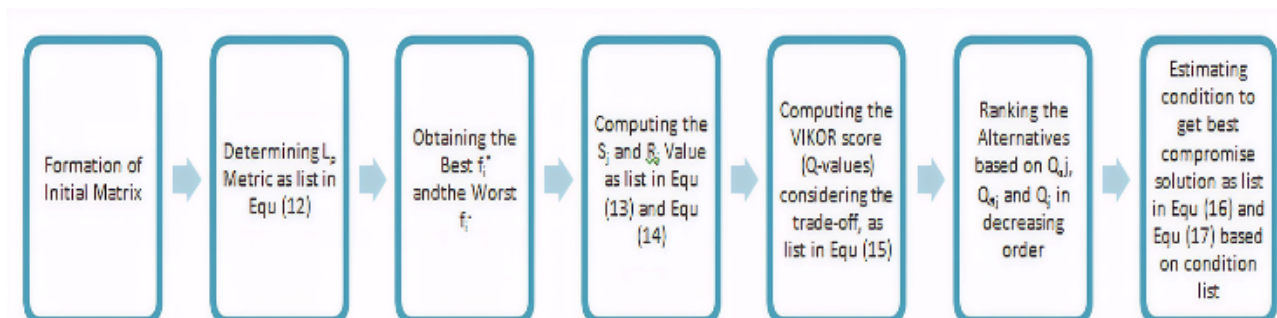


Fig. 11: flow steps of VIKOR methods

- Hybrid-MCDM approach handles problem structure complexity, multi-criteria trade-offs and pairwise preference analysis
- Neutrosophic sets handle uncertainty of criteria, capturing truth, indeterminacy, and falsity in criteria assessment by judgments.
- ELECTRE-VIKOR is selected to ensure the most justifiable and well-balanced decision. Where ELCTREE provides filtering and elimination and VIKOR provides final ranking and selection.

4-applying Hybrid decision model

Criteria per assessment alternatives shown in figure C in Appendix B score by using Neutrosophic set to express linguistic answers in forms figures A and B in Appendix B, then applying methods steps. Scale sets that are declared in table 8 and table 9 provide random consistency indexes that are used in consistency calculation. These approaches structure the decision problem into objective, alternatives and criteria

The Neutrosophic Steps of Apply Neutrosophic ELECTRE for outranking that are listed in figure 10 and equations 1:10 that are cited in the figure of method's flow steps [67].

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^m x_{ij}^2}} \quad \text{To normalize } X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \quad (1)$$

$$V = (V_{ij})_{n \times m} \quad \text{Where } v_{ij} = w_j * r_{ij} \quad (2)$$

$$C_{kl} = \{j | v_{lj} \geq v_{lj}\} \quad \text{where } C_{kl} \text{ is concordance set, } l \neq k \quad (3)$$

$$D_{kl} = \{j | v_{kj} < v_{lj}\} \quad \text{where } D_{kl} \text{ is discordance set, } l \neq k \quad (4)$$

$$C = \begin{bmatrix} - & c_{12} & \cdots & c_{1n} \\ c_{21} & - & \cdots & c_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{m(m-1)} & - \end{bmatrix} \quad \text{where } C_{kl} = \sum_{j \in C_{kl}} w_j \quad (5)$$

$$D = \begin{bmatrix} - & d_{12} & \cdots & d_{1n} \\ d_{21} & - & \cdots & d_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ d_{m1} & \cdots & d_{m(m-1)} & - \end{bmatrix} \quad \text{where } d_{kl} = \frac{\max_{j \in D_{kl}} |v_{kj} - v_{lj}|}{\max_{j \in J} |v_{kj} - v_{lj}|} \quad (6)$$

$$c^- = \sum_{k=1}^m \sum_{l=1}^m \frac{C_{kl}}{m(m-1)} \quad \text{where } k \neq l \text{ and } c^- \text{ can be assumed } 0.7 \text{ usually} \quad (7)$$

Note, a threshold value (c^-) is considered for the

concordance index if $C_{kl} \geq c^-$, otherwise equation 7 is applied to estimate c^- .

$$f_{kl} = 1 \text{ if } C_{kl} \geq c^- \text{ otherwise } f_{kl} = 0 \text{ if } C_{kl} < c^- \quad (8)$$

$$d^- = \sum_{k=1}^m \sum_{l=1}^m \frac{d_{kl}}{m(m-1)} \quad \text{where } k \neq l \text{ and } d^- \text{ can be assumed } 0.3 \text{ usually} \quad (9)$$

$$g_{kl} = 1 \text{ if } d_{kl} \leq d^- \text{ otherwise } g_{kl} = 0 \text{ if } d_{kl} > d^- \quad (10)$$

$$e_{kl} = f_{kl} \times g_{kl} \quad (11)$$

Steps of Apply Neutrosophic VIKOR for Compromise ranking that are listed in figure 11 and equations 12:17 that are cited in the figure of method's flow steps [68].

$$L_p = \left\{ \sum_{i=1}^n \left[W_i \frac{(f_i^* - f_{ij})}{f_i^* - f_i^-} \right]^p \right\}^{1/p} \quad (12)$$

Where $1 \leq p \leq \infty$ and $j = 1, 2, \dots, J$, f_i is the criterion $i = 1, 2, \dots, n$ and n is the number of criteria, f_{ij} is the value of i^{th} criterion function for the alternative a_{ij} , w_i is the weights of the i criterion expressing the relative importance of the criteria. Equation (1) is to evaluate each alternative based on each criterion and use a compromise ranking comparing closeness to the ideal alternative. Further, $f_i^* = \max_j f_{ij}$ and $f_i^- = \min_j f_{ij}$ Where values of f_i^* and f_i^- for all criterion

$$S_j = \sum_{i=1}^n \left[W_i \frac{(f_i^* - f_{ij})}{f_i^* - f_i^-} \right] \quad (13)$$

$$R_j = \max_i \left[W_i \frac{(f_i^* - f_{ij})}{f_i^* - f_i^-} \right] \quad (14)$$

$$Q_j = \vartheta Q_{sj} + (1 - \vartheta) Q_{Rj} \quad (15)$$

Where $Q_{sj} = \frac{S_j - S^*}{S^- - S^*}$, $Q_{Rj} = \frac{R_j - R^*}{R^- - R^*}$, $S^* = \min_j S_j$, $S^- = \max_j S_j$, $R^* = \min_j R_j$ and $R^- = \max_j R_j$. ϑ is the weight of satisfying most criteria based on the weight of strategy of the majority of criteria or the maximum group utility, $(1 - \vartheta)$ is the weight of the individual loss of opportunity. Further, Q_{sj} is the measure of deviation which expresses the demand for maximum group benefit, Q_{Rj} is the measure of deviation which expresses the demand for minimization of maximum distance between some alternative from the ideal point, Q_j is the establishing of compromise ranking list which unifies units Q_{sj} and Q_{Rj} .

$$Q(a'') - Q(a') \geq \frac{1}{J - 1} \quad (16)$$

Where a'' is the second alternative in the list of ranking. To select alternative a' which has minimum Q , it must fulfill the following conditions or not. The Condition 1 is an "acceptable advantage" that defined by equation (5), a' and a'' are in the final compromise set.

$$Q(a^h) - Q(a) < \frac{1}{j-1} \quad (17)$$

Where this equation (6) defines the Condition 2 “the acceptable stability in decision-making” that achieved when alternative a' is ranked first in the Q and first in the S or/and R ranking list, $a', a'', \dots, a^h$ is the alternative set where h is a position number in the ranking list.

Note that, sometimes NPO needs to select one beneficiary and sometimes needs to select multiple beneficiaries with ranking. To handle that, ELECTRE addresses acceptable Threshold Filtering, and VIKOR addresses top k-selection. Where, ELECTRE provides a concordance and discordance matrix. So update steps 3 and 4 with the following: instead of selecting just one alternative, set a minimum concordance threshold such as 0.6, then select all alternatives above the threshold (at least 5 – if need 5 beneficiaries). For VIKOR, step 3 is updated to VIKOR ranks alternatives based on their Q -values, so instead of selecting only the best (Rank 1), select the top 5 ranked alternatives.

5- Scoring criteria and ranking alternatives

Alternatives' ranks are influenced by charity rules, ethics and humanitarian. The goal is selecting the best beneficiaries' cases (16 alternatives) based on 21 criteria considering uncertainty which is addressed in Neutrosophic logic and outranking then compromise ranking by ELECTRE and VIKOR in respective.

Each case has three officials responsible for its assessment

in order to make a decision regarding its adoption and the type of support it requires. To use the actual assessment of these officials in the proposed decision model, the assessment form was presented in Figure C in Appendix B with the corresponding language expression in Table 8 are used. The language expression that was approved by at least two of the officials responsible for the case was adopted. These evaluations are expressed in Saaty set values in (to make it easier for official evaluators) figures A and B in Appendix C. This language expression was converted to its corresponding value in Neutrosophic using the same table (last column), and a weighting matrix was created, which was subsequently used in applying the steps of ELECTRE-VIKOR.

Neutrosophic logic handles uncertainty. It models judgment values in triple format: truth (T), indeterminacy (I) and falsity (F) to be as (T, I, F) with meaning (T: degree of satisfaction of criterion, I: level of uncertainty, F: not satisfying the criterion). (T) Values taken from the normalized matrix that are generated, and (I) is fixed value equals to 0.05, while (F) is calculated by $F=1-T-I$.

Table 10 contains the base weights by experts of criteria and alternatives' rank based on rules of AL-ATEYAT. For example, weights for each criterion category are unified such as c_1, c_2, c_3, c_4, c_5 , and c_6 . They have the same value of weight 0.04 and 0.24 as a total value for "Need category". Alternatives are listed in order in the table from the largest rank to the smallest.

Table 10: The weights for criteria and alternatives

For criteria				For Alternatives					
Group	Criteria	Weight	Total	Alt.	Weight	Alt.	Weight	Alt.	Weight
General Needs	C1 : C6	0.04	0.24	A3	0.95	A6	0.81	A1	0.74
Vulnerability	C7 : C12	0.045	0.27	A4	0.92	A8	0.80	A16	0.72
Economic Potential	C13: C17	0.045	0.225	A13	0.85	A12	0.79	A7	0.70
Ethical Considerations	C18 : C21	0.065	0.26	A9	0.84	A10	0.78	A2	0.68
Total weight			1	A15	0.83	A14	0.77		
				A11	0.82	A5	0.76		

	S	R	Q
A1	0.7639	0.0504	0.7657
A2	0.9956	0.0653	1
A3	0.0023	0.0019	0
A4	0.1039	0.0103	0.1176
A5	0.7125	0.0504	0.7402
A6	0.5069	0.0357	0.5202
A7	0.9102	0.0653	0.957
A8	0.5485	0.0368	0.5499
A9	0.3962	0.0282	0.4058
A10	0.6217	0.0475	0.6716
A11	0.4763	0.0405	0.543
A12	0.5785	0.0402	0.5916
A13	0.3468	0.0269	0.3703
A14	0.6552	0.0468	0.6814
A15	0.4328	0.0298	0.4368
A16	0.8572	0.0563	0.8588

final rank in ascending	
A3	0
A4	0.1176
A13	0.3703
A9	0.4058
A15	0.4308
A6	0.5202
A11	0.543
A8	0.5499
A12	0.5916
A10	0.6716
A14	0.6814
A5	0.7402
A1	0.7657
A16	0.8588
A7	0.957
A2	1

Fig. 12: A VIKOR matrix on the left and final alternatives' rank in ascending order on the right

The initial weights in figure A in Appendix C were in the Saaty set. It converts to Neutrosophic value as cleared in table 10, and then can be normalized. The raw normalized decision matrix is shown in figure C in appendix C 12, this matrix analyses pairwise criteria for each alternative. Then, generate a score function matrix which will be the input data for ELECTRE and VIKOR. The score function is calculated as $(S) = T - F = 2T - 1 + I$ where T is truth, I is indeterminacy and F is falsity. This function is used because it balances risk and addresses uncertainty instead of a simple score function that ignores indeterminacy. This function restores a genuine mathematical role for indeterminacy. The score function is in figure D in Appendix C 13.

For concordance matrices from ELECTRE summarize pairwise dominance between alternatives. It compares each pair of alternatives. Concordance index $C(A_i, A_k)$ for example $C(A_1, A_3) = 0.10$ means A_1 dominates A_3 only on 10% of the criteria. The discordance matrix shows the alternative which is much worth rather than others. The dominance outranking matrix is to detect no dominated values. The concordance matrix is in figure E in Appendix C 14, while the discordance matrix is in figure F in Appendix C 15.

VIKOR is applied to determine the close ideal compromise solution. Its values are displayed in figure 12 where S refers to utility measure, R refers to regret measure and Q is final score. After ascending order (Best to Worst), finally, select Top 5 Alternatives are: A_3, A_4, A_{13}, A_9 , and A_{15} .

6- Check stability test for Hybrid model:

Check the stability of decision by checking statistical analysis – sensitivity table for Spearman rank correlation and deviation further visualization for five scenarios. Furthermore, Decision Stability Intervals (DSI) and Monte Carlo simulation are advanced techniques used to test the robustness of decision-making models, particularly those built with Hybrid-MCDM approaches [10]. MCDM may use Spearman rank correlation, rank deviation analysis and visualization as a measure of stability analysis of decision results across various conditions. The level of agreement between two rankings is given by the Spearman rank correlation which is best suited in MCDM as the results are not usually given in absolute values but in ordinal rankings. A large correlation coefficient means that the ranking of alternatives would not change as model parameters including criteria weights vary thus indicating the stability of decisions. Rank deviation analysis is an extension that measures the extent of positional changes of alternatives in different scenarios, which gives a researcher insight into the alternatives that are responsive to variations in the parameters. Lastly, visualization offers a graphical representation of rank change of alternatives and scenarios, which allows one to quickly identify patterns of stability and inconsistencies. Combining these methods, it is possible to obtain statistical and visual confirmation of the soundness of the MCDM findings. Spearman rank

correlation and rank deviation are widely used in MCDM stability analysis to examine the robustness of ranking results under different scenarios [69].

Suppose setting four extra case scenarios as defined below table 11. For each scenario, all previous steps of Neutrosophic-ELECTRE-VIKOR are applied. Visualization represents the pairwise relationships between scenarios thereby; it assesses stability of the decision model via deviation values. It is an effective way to display these square matrices and make patterns visually clear, where colors indicate correlation or deviation. Consistency level of decision refers to specific colors where green means correlation (consistency) while red means deviation (inconsistency).

Table 11: The scenario description for sensitivity test

Scenario	Description
S0	base case that solved before and decision made by model is identical with real case
S1	Increase top-3 criteria weights by +10%, normalize others (C_1, C_2, C_3)
S2	Decrease bottom-3 criteria weights by -10%, normalize others (C_{19}, C_{20}, C_{21})
S3	Random noise $\pm 5\%$ added to weights
S4	Equal weights for all criteria, suppose $1/n$ where n is number of criteria

The Spearman correlation (r_s) and deviations (D_s) matrix for each scenario are illustrated in table 12. Equation 18 for spearman correlation and equation 19 for deviation matrix - which represents the average absolute difference between ranks - are applied [43]. Green color indicates stable decision (no deviation on base), yellow indicates inconsistent decision and requires investigation, while red color indicates un-robust decision that needs immediate attention. These colors depend on deviation values, where stability is achieved when deviation values close to 0 and spearman rank correlation close to 1.

$$r_s = 1 - \frac{6 \sum d_i^2}{m \times (m^2 - 1)} \quad \text{Eq. (18)}$$

$$D_s = \frac{1}{m} \sum_{i=1}^m ||d_i| \quad \text{Eq. (19)}$$

Where d_i is the difference in ranking of the alternative by the two scenarios and m is the number of alternatives.

Table 12: The spearman and deviation matrices for five scenarios and visualizing in colors – the Green Color indicates stable decision (no deviation on base), the Yellow Color indicates inconsistent decision and requires investigation, while Red Color indicates un-robust decision that needs immediate attention

Scenario	Spearman Matrix					Deviation Matrix				
	S0	S1	S2	S3	S4	S0	S1	S2	S3	S4
S0	1	1	1	1	0.997	0	0	0	0	0.125
S1	1	1	1	1	0.997	0	0	0	0	0.125
S2	1	1	1	1	0.997	0	0	0	0	0.125
S3	1	1	1	1	0.997	0	0	0	0	0.125
S4	0.997	0.997	0.997	0.997	1	0.125	0.125	0.125	0.125	0
Average	0.999	0.999	0.999	0.999	0.998	0.02	0.02	0.02	0.02	0.10

```
Optimising weights for maximum stability...

Computing ensemble consensus top-5 (Borda count)...
Ensemble Borda: 100%|██████████| 2000/2000 [00:22<00:00, 87.25it/s]
Final robust top-5: ['A3', 'A4', 'A13', 'A9', 'A15']

Running final Monte Carlo stability test (5000 simulations, noise=0.05)...
Final stability test: 100%|██████████| 5000/5000 [00:57<00:00, 86.98it/s]

*** FINAL EXACT TOP-5 STABILITY: 98.44% ***
✓ Target stability (≥98%) achieved.

Decision Stability Intervals (width ≥ 0.8 indicates good robustness)
✓ Criterion 0: interval [0.000, 1.000] depth = 1.000
✓ Criterion 1: interval [0.000, 1.000] depth = 1.000
✓ Criterion 2: interval [0.000, 1.000] depth = 1.000
✓ Criterion 3: interval [0.000, 1.000] depth = 1.000
✓ Criterion 4: interval [0.000, 1.000] depth = 1.000
```

Fig. 13: snapshot of council output python program that estimate Monte Carlo stability test for 5000 simulation and for DSI test

While DSI is largely conceptual as a robust test principle, Monte Carlo is actively engineered by the generation of thousands of possible input weight scenarios. The confidence in the model is high if the final ranking is still the same in most scenarios. The results of both tests are illustrated in the following figure 13.

5.3 Empirical Validation and Systemic Auditing

This section addresses evidence-based Conflict-resilient Hybrid-MCDM framework through comparative analysis for four decision models; one Hybrid-MCDM model and three MCDM models. This section is divided into two evidence studies. The first one, the test unifies the set theory between the models while the second test studies the ordinary model against the proposed hybrid model.

a- sensitivity analysis for Neutrosophic MCDM and HMCDM models

This section benchmarks the proposed hybrid model ‘Neutrosophic ELECTRE-VIKOR’ against three standalone MCDM models; TOPSIS, VIKOR and ANP under two conditions; stable test (which exhibits low inherent alternative conflict) and a stress test (which constructed high conflict dataset) for different scenario that is defined in previous table 11. All four models share an identical corrected Neutrosophic score function and normalization procedure, so that differences in outcome are attributable to the aggregation logic of each method, not to inconsistent inputs. Robustness is assessed through deterministic sensitivity scenarios, spearman correlation (r_s). Table 13 shows four models comparison. The raw weight data or initial scenario (S0) for both tests; low and high conflict weight is defined in figures A and B Appendix C in sequent. These raw data are used later as a base for the four scenarios and changed based on each simulation. All computations are compiled in python 3.9.7.

Table 13: A stability benchmark for Neutrosophic MCDM and Hybrid-MCDM model in low conflict case and high conflict case supported with sensitivity analysis for four simulation scenarios

Model	Neutrosophic ELECTRE- VIKOR	Neutrosophic TOPSIS	Neutrosophic VIKOR	Neutrosophic ANP
type	Hybrid-MCDM approaches	MCDM method	MCDM method	MCDM method

Ranking logic			ELECTRE: concordance/discordance outranking defines a kernel of non-dominated alternatives. VIKOR: compromise ranking orders alternative within outside that kernel	Distance-to-ideal or distance-to-anti-ideal ratio	Compromise ranking aggregation of group utility and individual regret	Cluster level interdependency (super matrix) adjusts criteria weights before a weighted sum ranking
Top ranking alternatives	5	Stable case test (S0)	A3, A4, A13, A9, A15	A3, A4, A13, A9,A15	A13, A4, A3, A9,A15	A4, A3, A13, A9,A15
		Stress case test (S0)	A1, A6, A7, A8, A14	A7,A6,A1, A14, A8	A14, A8, A1, A6, A7	A6, A7, A1, A14, A8
Robustness testing for low conflict weights – stable case test						
Spearman correlation (Stability) - S0			0.93	0.88	0.91	0.93
Stability for four scenarios in table 11	S1	r _s	0.91	0.84	0.92	0.87
		Rank	A3, A4, A13, A9, A15	A3, A4, A13, A15, A9	A13, A4, A3, A9, A15	A4, A3, A13, A9, A15
	S2	r _s	0.96	0.91	0.95	0.79
		Rank	A3, A4, A13, A9, A15	A3, A4, A13, A9, A15	A13, A4, A3, A9, A15	A4, A3, A13, A9, A15
	S3	r _s	0.98	0.95	0.98	0.86
		Rank	A3, A4, A13, A9, A15	A3, A4, A13, A9, A15	A13, A4, A3, A9, A15	A4, A3, A13, A9, A15
	S4	r _s	0.97	0.79	0.87	0.84
		Rank	A3, A4, A13, A9, A15	A3, A4, A13, A9, A15	A13, A3, A4, A9, A15	A4, A13, A3, A9, A15
r _s Average			0.95	0.87	0.93	0.86
Robustness testing for high conflict weights – stress case test						
Spearman correlation (Stability) – S0			0.96	0.85	0.94	0.93
Stability for four scenarios in table 11	S1	r _s	0.92	0.85	0.93	0.90
		Rank	A1, A6, A7, A8, A 14	A7,A6,A1, A14, A8	A14,A8,A1, A6, A7	A6,A7,A1, A14, A8
	S2	r _s	0.96	0.90	0.95	0.93
		Rank	A1, A6, A7, A8, A 14	A7,A6,A1, A14, A8	A14,A8,A1, A6, A7	A6,A7,A1, A14, A8
	S3	r _s	0.98	0.95	0.97	0.97
		Rank	A1, A6, A7, A8, A 14	A7,A6,A1, A14, A8	A14,A8,A1, A6, A7	A6,A7,A1, A14, A8
	S4	r _s	0.88	0.80	0.87	0.85
		Rank	A1, A6, A7, A8, A 14	A7,A6,A1, A14, A8	A14,A8,A1, A6, A7	A6,A7,A1, A14, A8
r _s Average			0.94	0.87	0.93	0.91

b- sensitivity analysis for ordinary MCDM and Neutrosophic Hybrid model

this analysis study the proposed hybrid model ‘Neutrosophic ELECTRE-VIKOR’ against three standalone MCDM models with Saaty set theory; TOPSIS, VIKOR and ANP under same two conditions in subsection(a); stable test (which exhibits low inherent alternative conflict) and a stress test (which constructed high conflict dataset) for four different scenarios. The

results are visualized in below table 14.

Table 14: Stability benchmark for Neutrosophic MCDM and Hybrid-MCDM model in low conflict case and high conflict case supported with sensitivity analysis for four simulation scenarios

Model			Neutrosophic ELECTRE-VIKOR	TOPSIS	VIKOR	ANP
type			Hybrid-MCDM approaches	MCDM method	MCDM method	MCDM method
Top 5 ranking alternatives	Stable case test (S0)	A3, A4, A13, A9, A 15		A4, A3, A13, A9, A 15	A13, A4, A3, A9, A 15	A4, A3, A13, A9, A 15
	Stress case test (S0)	A14, A5, A6, A3, A13		A13, A11, A2, A6, A12	A11, A13, A2, A6, A12	A11, A2, A13, A6, A7
Robustness testing for low conflict weights – stable case test						
Spearman correlation (Stability) - S0			0.93	0.88	0.94	0.92
Stability for four scenarios in table 11	S1	r _s	0.91	0.86	0.93	0.90
		Rank	A3, A4, A13, A9, A 15	A4, A3, A13, A15, A 9	A13, A4, A3, A9, A 15	A4, A3, A13, A9, A 15
	S2	r _s	0.96	0.92	0.96	0.94
		Rank	A3, A4, A13, A9, A 15	A4, A3, A13, A9, A 15	A13, A4, A3, A9, A 15	A4, A3, A13, A9, A 15
	S3	r _s	0.98	0.96	0.98	0.97
		Rank	A3, A4, A13, A9, A 15	A4, A3, A13, A9, A 15	A13, A4, A3, A9, A 15	A4, A3, A13, A9, A 15
	S4	r _s	0.97	0.82	0.87	0.85
		Rank	A3, A4, A13, A9, A15	A4, A3, A13, A9, A 15	A13, A4, A3, A9, A 15	A4, A13, A3, A9, A 15
r _s Average			0.95	0.89	0.94	0.92
Robustness testing for high conflict weights – stress case test						
Spearman correlation (Stability) – S0			1	1	0.96	0.96
Stability for four scenarios in table 11	S1	r _s	0.92	0.88	0.94	0.93
		Rank	A1, A6, A7, A8, A 14	A13, A2, A11, A6, A5	A11, A13, A2, A6, A12	A11, A2, A13, A6, A7
	S2	r _s	0.98	0.91	0.95	0.96
		Rank	A1, A6, A7, A8, A 14	A13, A11, A6, A2, A12	A11, A13, A6, A2, A12	A11, A2, A13, A7, A6
	S3	r _s	0.98	0.95	0.97	0.98
		Rank	A1, A6, A7, A8, A 14	A13, A11, A2, A6, A12	A11, A13, A2, A6, A12	A11, A2, A13, A6, A12
	S4	r _s	0.88	0.73	0.86	0.85
		Rank	A1, A6, A7, A8, A 14	A2, A13, A6, A11, A5	A11, A2, A13, A6, A5	A11, A2, A13, A6, A7
r _s Average			0.95	0.89	0.93	0.93

6 Discussion

The finding of this study illustrated in the guidance of the Hybrid-MCDM framework and MCDM frameworks based on a proposed taxonomy of decision-making's elements is visualized in figure 6. The figure 7 and table 5 offer suggestions for Hybrid-MCDM models considering the type of problem, levels of uncertainty, and degrees of conflict. The previous tables 4 and 5 engaged to deduce this

framework. In Hybrid-MCDM, previous analysis for each MCDM is useful in designing hybrid decision models. These frameworks are significant where the wrong designing decision model leads to the wrong decision, therefore high damages in money and resources, and may be human loss. The evidence of stability of the proposed Hybrid-MCDM is displayed through the case study and audited by the stability tests in tables 13 and 14, which are visualized in figures 14 and 15. Validation of the MCDM framework is achieved through the validation of the

Hybrid-MCDM framework because Hybrid-MCDM is a combination of MCDM methods.

This study focuses on addressing a major challenge faced by decision makers in designing decision models to solve critical problems specifically that require semi- or unstructured decisions at middle- and top management levels. This key challenge is "How to combine the suitable MCDM methods to design Hybrid-MCDM models that fit problem vagueness in real business under the MCDM model's limitation?" In the attempt to solve this challenge, it breaks down to many questions. Their answers lead to solving this challenge. Where the decision-making process is a trade-offs and comparison of different alternatives under constraints and criteria. Certainty is also involved in structuring types of problems and furthermore alternatives that may conflict with each other. Thereby, certainty levels of criteria and conflict levels of alternatives are correlated factors to decision-making. Thus, studying MCDM methods' features and properties must be close to the criteria, alternative, and problem's nature and domain. Because solving decision-making problems is done under mathematical calculation, studying the relation between mathematical functions and the MCDM method is significant too in handling incomplete data and vagueness of criteria. These mathematical functions– that reflect an expert's linguistic expression to numerical values in precision- are Saaty set theory (classical, spherical, and Pythagorean) fuzzy theory, and Neutrosophic set theory.

Based on key features of MCDM methods and their usages in different domains, table B in Appendix A listed MCDM methods by their main features and how well they fit different decision-making situations. The classification of criteria for MCDM methods depends on compensation level (compensatory, non-compensatory), preference modeling (pairwise, distance, outranking, and rule-based), decision rules (aggregation, ranking, and filtering), problem structure (independence, interdependence, and uncertainty). The classification of set theories based on certainty and conflict levels is Moderate uncertainty and low conflict, classical fuzzy, or Saaty set is sufficient. While, if uncertainty is high and there are conflicting preferences, Pythagorean fuzzy or spherical fuzzy is preferred. A Neutrosophic set is the best option with extreme uncertainty, missing data, and contradictions. Thereby, the second group of tables A: E in Appendix A is classified MCDM methods into groups basing on what kind of decision needs to be made, how unclear the criteria are, and how much the options/alternatives conflict. For problems that are moderate in structure and in uncertainty, fuzzy or chance-based models are better. When decisions are confused, options (alternatives) are correlated and conflict together, criteria (constraints) are interdependent or uncertain and there's a lot of disagreement, then the usage of Neutrosophic and spherical fuzzy sets is recommended. The tables also classify MCDM methods by how they work- some look at value, some compare options, some measure distance, and some mix these approaches-

depending on how the decision needs to be made. These classifications and features are the bases that are used in Taxonomy MCDM and therefore building the framework of MCDM and Hybrid-MCDM Decision model.

A case study– that is a trigger to this study- is the "donation management information system," which handles making decisions for "beneficiaries' selection". What makes matters more complicated are multi-constraints, ethical dilemmas, and sympathy-based biases because of eligibility and conflicting judgments of multiple perspectives of beneficiaries.

By applying the framework of Hybrid-MCDM approach that was concluded by the proposed methodology, and for the case study, Neutrosophic ELECTRE-VIKOR is a suggested solution. Neutrosophic ELECTRE handles uncertainty and subjectivity criteria and uses outranking relations. Neutrosophic VIKOR finds the compromise solution for ranking alternatives based on closeness to the ideal solution. Statistical analysis proved the stability and robustness of the proposed hybrid decision model. Furthermore, it ensures the most justifiable and well-balanced decision.

The decision maker has confidence in using the system outputs for final selection, as the consistency of decision is proved by Spearman analysis and deviation square matrices, and the results are visualized by a Heatmap. The sensitivity test is applied at five tests with different scenarios and supposes the solved case in section 5.1 is a base case for the test. For each trial the Spearman rank correlation is calculated between first trial ranking and each trial's ranking. Average Spearman rank correlation for five scenarios is 0.999, 0.999, 0.999, 0.999, and 0.998, respectively. The average Spearman rank correlation across trials equals 0.998. Based on the correlation scale meaning, if all correlations are close to 1, which means the decision model is stable, and the rankings (alternatives' order) do not change significantly upon weights. Average deviation values for five scenarios are 0.02, 0.02, 0.02, 0.02, and 0.10, respectively, and the average value for the totally sensitive test is 0.03. Based on the deviation scale meaning, if all deviations are close to 0, which means the decision model is stable, and the rankings (alternatives' order) do not change significantly upon weights.

The case study that is addressed in this study is very critical and significant, where unreliable decisions, therefore, consume resources, time, costs, and unfair distribution of dues. Furthermore, the donors will be reluctant later to provide support and donations to the foundation because of loss of trust. Losing the reputation of the foundation that manages donations.

6.1 statistical discussions

Tables 14 and 15 provide robustness tests for the Hybrid-MCDM model versus the MCDM model in high-uncertainty cases. It can be seen that this benchmark is

based on unifying set theory (Neutrosophic) for the four different decision models (VIKOR, ANP, TOPSIS) and hybrid (ELECTRE-VIKOR) to check the stability and study the model's effect fairly, as in table 14, and check the stability of the proposed hybrid model with the ordinary MCDM model (with Saaty set) for ranking. Both benchmarks in two tables were used to check the conflict resistance of the proposed HMCDM framework in table 5. Therefore, these tables prove the confidence of the proposed guidance MCDM framework in table 4 and the set theory in table 3, which they used in designing the guidance framework of Hybrid-MCDM. The sensitivity results reported in tables 13:15 point to a conclusion that "the robustness of the hybrid model framework" is high in conflict states.

Table 13's color-coded Spearman and deviation matrix shows the ranking is entirely insensitive to three of the four perturbation types (S0, S1, S2, and S3 all correlate at 1.000, and deviation 0.000) and only meaningfully affected by the equal-weighting distortion, S4 ($r = 0.997$, deviation = 0.125). These results declared that the decision is essentially invariant to realistic weight adjustments; it regards a reassuring result.

Table 14 extends the comparison to three standalone Neutrosophic models under both conflict weights. Two patterns are consistent enough to be worth stating as findings rather than incidental numbers. First, average stability declines only modestly and, for some models improves, moving from the low-conflict to the high-conflict

condition. Neutrosophic ELECTRE-VIKOR moves from 0.95 to 0.94, and ANP also transforms from 0.86 to 0.91, while TOPSIS keeps on 0.87 and VIKOR with 0.93. It is a genuinely interesting result, since the intuitive expectation is that conflict-rich data should be harder for every method, as shown in table 15. That refers to using Neutrosophic set theory to provide this enhancement in the model's performance. Second, S4 (equal weighting) is the weak point for every model in both conditions. TOPSIS drops to 0.79 (in low conflict) and 0.80 (in high conflict), notably below the hybrid's 0.97 and 0.88 in the same scenario. Thus, the following figures 14 and 15 visualize that this is the strongest evidence for the hybrid model. The hybrid model is stable with different specific scopes and performance under extreme and unrealistic weight flattening.

The decision of four distinct Neutrosophic decision models- Hybrid-MCDM (ELECTRE-VIKOR)- and the other three MCDM models- TOPSIS, ANP, and VIKOR- with high conflict weights reveals an agreement on the top five alternatives but a meaningful deviation in their ranking. This emphasizes the significance of MCDM method adoption. Because it reflects the decision maker's viewpoint towards risks, ideal decision preferences, or perception of complex interrelated relationships between criteria. The divergence in ranking provides a nuanced view of the alternatives' performance profiles. By this comparative analysis in tables 13 and 14, the best practice is to use a hybrid model approach to gain a comprehensive understanding and make a well-informed final selection.

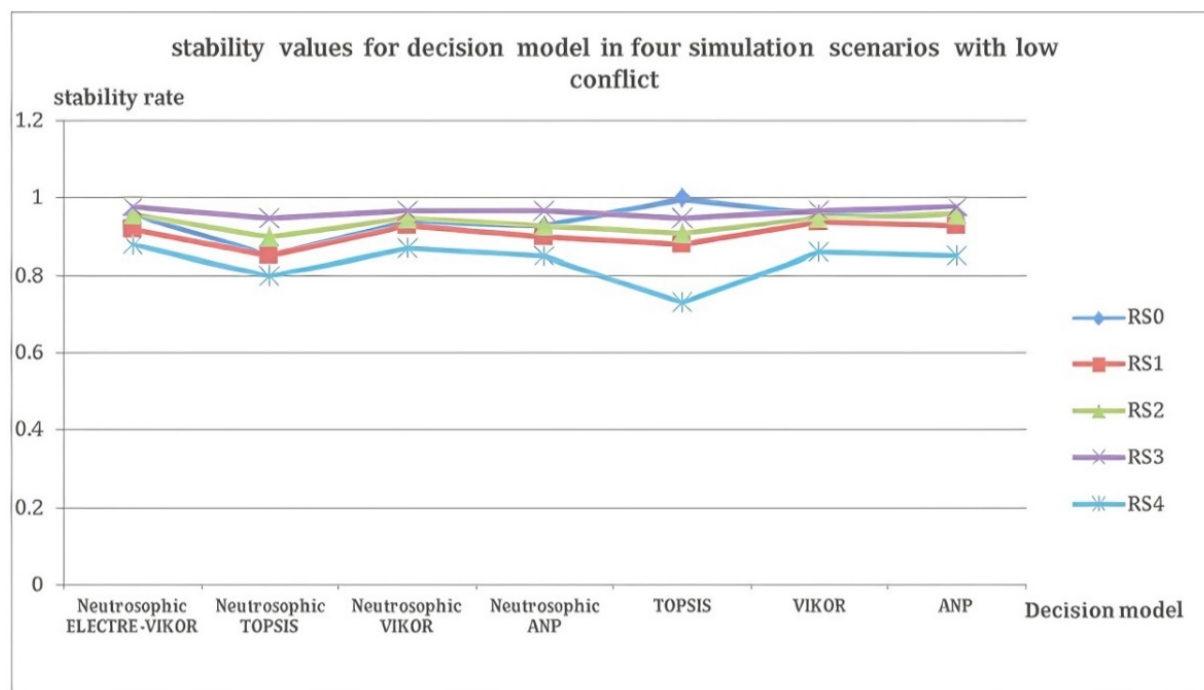


Fig. 14: A spearman correlations for MCDM models and Hybrid-MCDM model in different simulation scenario with low conflict weights

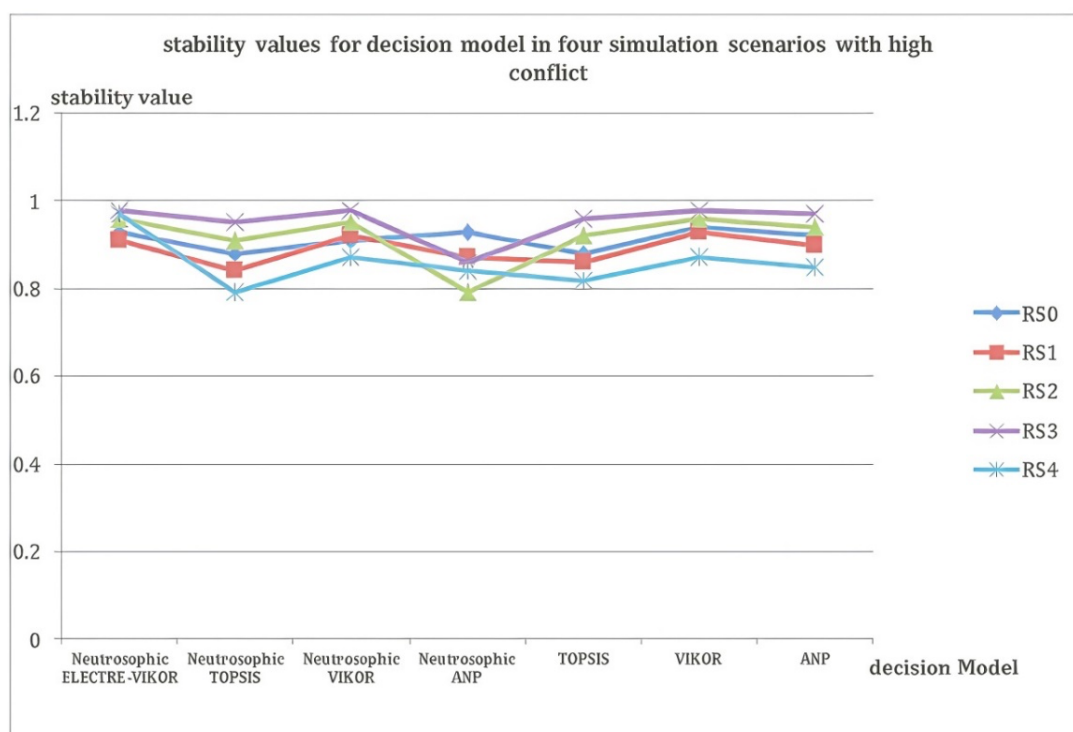


Fig. 15: A spearman correlations for MCDM models and Hybrid-MCDM model in different simulation scenario with high conflict weights

In table 13 for low conflict, the top 5 alternatives are invariant across all models and all four scenarios, but based on Spearman correlation, the hybrid model and VIKOR are the most robust, TOPSIS is the most sensitive, and ANP provides moderate stability. For high conflict and inconsistency, the hybrid model and VIKOR are the safest option. Their ranking changes when weights are altered. TOPSIS is useful, but ranking is more sensitive to weights. The TOPSIS model should be used only when weights have high confidence. Although ANP is a balanced model and is used when the network between criteria is dependent, there is what is known with a correct model. Thereby, a decision maker who accepts some risk to achieve the best possible outcome would favor the TOPSIS model, while those who prefer robustness would align with the hybrid model. A decision maker who understands the strategic effect of criteria and wants to leverage their interconnections would prefer the ANP. VIKOR is the choice for who avoids risk and any significant failure.

Table 14 repeats the exercise against Saaty-weighted (non-Neutrosophic) standalone baselines and shows a similar shape: r_s averages cluster tightly across all four models (0.89 and 0.95 in low-conflict cases; 0.89 and 0.95 in high-conflict cases). The hybrid model's advantage is concentrated in the S4 scenario, where TOPSIS falls to 0.82 and 0.73 while the hybrid holds at 0.97 and 0.88. Otherwise, S1, S2, and S3, the four models, are difficult to distinguish statistically. Further, in table 14, in the second part of the stability test for high conflict (stress test), the ranks of alternatives in the MCDM models are similar to

the ranks in low conflict states. That means that these models can't recognize the differences in weights and are not sensitive.

Two general statistical points apply across all three tables. First, every r_s value reported is a point estimate from what appears to be a single computed ranking per scenario, not a distribution, with the partial exception of S3, which is described elsewhere in this project as amenable to repeated random-noise trials. Second, the practically meaningful result across all three tables is not the overall stability ranking of the four methods, which are close enough to overlap once uncertainty is accounted for, but the specific, reproducible finding that every model's weakest point is the equal-weighting scenario and that the hybrid's margin over the standalone alternatives is real and largest exactly there. That refers to the inability of these models to work efficiently, and these MCDM models are not robust in high conflict.

6.2 Socio-technical contributions

Socio-technical aspects explore the interaction between human decision-makers, information technology systems, and organizational processes. In other words, how human, organizational, or institutional actors interact with the system in practical contexts. Human aspects of decision-making as dependent variables are perceived fairness trust in decision support systems, user satisfaction, and confidence in outcome relevance. Technology supports, enhances, or transforms decision behavior in organizational settings by providing structured guidance, reducing

subjective bias, enabling transparent evaluation of decisions, and integrating uncertainty into decision models with respect to conflict issues too. Key socio-technical dimensions such as user engagement, system usability, adoption, or institutional decision processes are addressed by aligning the decision model with domain-specific criteria with supporting multiple stakeholder inputs, then offering interpretable ranking outputs (alternatives or different beneficiaries in the case study), and embedding the framework into institutional workflows (donation management information system for charity organizations as in the case study). The theoretical framework supports the role of information technology, and decision systems from a behavioral, managerial, and organizational perspective. The case study that is handled in this study considers proof and evidence to leverage the theoretical frameworks of building decision models.

The proposed decision model is implemented and used in a real information system environment via a modular decision support platform that integrates Neutrosophic data, ELECTRE outranking, and VIKOR compromise ranking with an interactive user interface for input donation data, type, amount, donors, and also beneficiaries' data and their needs. The system provides monitoring, tracing donations, marking the idea, and feedback.

Users interact with a graphical interface where they input uncertain data using linguistic terms; the system then guides them through method selection based on the decision taxonomy, ranks beneficiaries, and visualizes justifications through eligible criteria and assessment that is blind applied. Transparency is enhanced through explainable scoring and traceable decisions, as in section 5.1. The decision model of this system proposes who benefits as an output of this model.

That is an impact on decision workflows and a clear articulation of how human and organizational decision-makers interact with the system under usability, acceptance, and transparency factors. The contribution of the work beyond computational accuracy, particularly in terms of supporting decision processes in real-world environments, is its ability to bridge the technical field with human-centric uncertainty and to offer a reusable taxonomy for selecting suitable MCDM techniques and support ethical, fair, and explainable decisions in sensitive domains such as humanitarian aid and other civilized aid for different applications.

6.3 Research Questions' Answers

This section provides answers for the research questions that are mentioned in section 1; they are:

- **RQ1: How does the decision maker select a suitable set theory for decision problems that can handle different issues of conflict or uncertainty?**

Information about the type, degree, and representation of uncertainty in the decision problem is the key determinant

in the selection of an adequate set theory. The classical crisp sets can be used in situations where the information of the evaluation is quite precise and deterministic, and the fuzzy set theory can be applied in the situations where vagueness and linguistic judgments prevail. In the case of uncertainty that involves both membership and non-membership information; intuitionistic fuzzy sets offer more detailed information. Information for decisions is both truthful and false at the same time and indeterminate, as with conflicting expert opinions or incomplete expert opinions. Neutrosophic sets provide more flexible frameworks. Thus, the selection of set theory must be informed by the character of uncertainty, availability of information, and context of a decision to ensure that the model of representations is a sufficient measure of ambiguity, inconsistency, and incompleteness in the decision variables. Table 3 provides this answer by collecting all set theories that are applied in different literature for many cases. These set theories are alignment values in natural languages in numerical values mapped to vagueness and ambiguity of alternatives under stakeholders' criteria or conditions. Failure in mapping linguistic variables, loss of many values in the natural language of decision makers and stakeholders, and therefore, wrong decisions. Tables D and E enhance the results that were concluded in table 3. Table D delivers features of set theories based on problem nature, and table E defines features of usage set theories for decision-making.

- **QR2: How does the decision maker select a suitable MCDM method or Hybrid-MCDM approach for decision problems that can handle different issues of conflict or uncertainty in criteria or alternatives?**

In order to find a proper MCDM approach, the nature of the decision problem needs to be analyzed in terms of criteria dependencies, type of evaluation data, the number of alternatives, and the preference structure of a decision maker. An example of this is that distance-based approaches such as TOPSIS can be used when the decision problem is to find alternatives nearest to the ideal solution, whereas outranking-based approaches such as ELECTRE or PROMETHEE can be used when the decision problem is characterized by conflicting criteria and pairwise dominance relationships. VIKOR, along with other methods is useful when the compromise solutions are needed for conflicting purposes. As a result, the process of method selection must determine the correspondence between the decision problem features and the methodological opportunities of the MCDM technique. Table A provides this answer after studying the characteristics of MCDM under different elements of the decision-making process. Figure 5 and previous tables B and C participated in conclusions in table 3 and figure 5. Table 3 defines structures and levels of certainty and conflict for criteria and alternatives of decision-making problems, while table C shows a comparative analysis for

the most used MCDM methods.

The Hybrid-MCDM methods are chosen in case one method is not sufficient to cover all issues of a decision issue. Hybridization usually combines the merits of several approaches that are complementary, for example, the use of weighting methods such as AHP, ANP, DEMATEL with ranking methods such as VIKOR, ELECTRE, or TOPSIS. Even more, a hybrid model can be applied to identify interdependent criteria weights with ANP and the final ranking with ELECTRE or VIKOR. A hybrid model is thus selected based on the decision structure, the relationship that exists between the criteria, the uncertainty representation and the requirements of soundness in the ranking of the outcomes. Table 5 provides the answer for this question after well studying the MCDM methods and concluding in the final taxonomy in table 4. Table 4, figure 5 and table 3 together contributed to the final result table 5. The core of the Hybrid-MCDM approach is the MCDM method. Further, the hybrid decision model is combining two or more of these MCDM methods based on the decision problem nature and characteristics of MCDMs.

The taxonomy includes criteria such as (1) data type (crisp, fuzzy, or probabilistic), (2) interdependencies among criteria, (3) uncertainty level, (4) presence of conflict among alternatives, and (5) nature of stakeholder preferences. The taxonomy is useful to the decision makers, as it offers a systematic mapping of decision problem characteristics and the suitable MCDM method. Decision makers can examine the properties of their problems, including uncertainty type, interactions of criteria, or evaluation data, and locate methods that are specifically tailored to deal with those situations instead of arbitrarily choosing methods. This systematic process enhances the level of methodological transparency, consistency, and justification in the process of methodology choice, thus increasing the level of credibility and reliability of the process of decision-making.

▪ **RQ3: How does the proposed framework perform when applied to a real-world case study characterized by these complex parameters?**

The framework provides a structured, transparent guide for selecting appropriate methods based on the taxonomy of decision elements, reducing subjectivity and enhancing consistency across sustainability-driven applications. The suggested framework enables the proposed methodology to select the tools of the method and evaluate the uncertainty and stability, integrating them into a common framework. Contrary to traditional methods, which commonly consider the selection of appropriate methods as a subjective task, the framework is based on the systematic matching of characteristics of the decision problems with the suitable set theories and methods of the MCDM. In addition, it has strong robustness and stability analysis features, and decision makers can use them to prove the soundness of the rankings that are arrived at in various situations. The framework consequently enhances the accuracy of method

selection, transparency of decisions, and the strength of results, which makes it especially appropriate to complex decision settings with uncertainty and conflicting criteria. Besides that, the next section 5 addresses a real case study and shows real application for this proposed framework.

6.4 Implications of the study

The findings and results of this study can apply in many applications, such as

1. Theoretical impact:

This study advances the theoretical foundations of MCDM and decision sciences by introducing a taxonomy-driven paradigm for MCDM, or Hybrid-MCDM selection. It shifts to problem-based alignment, rather than treating MCDM methods as interchangeable tools. The proposed framework explicitly decides problem characteristics such as uncertainty, criteria interdependency, and conflict intensity to method suitability.

2. Methodological and approach impact:

The proposed framework provides a systematic and reproducible roadmap for selecting and combining MCDM methods. The taxonomy reduces reliance and arbitrariness in MCDM choice, mitigates methodological bias, and enhances the comparability of empirical studies. The framework contributes more robust, stable, and context-sensitive decision modeling practices.

3. Practical impact:

The framework directs practical relevance for complex and sustainability-oriented decision contexts characterized by uncertainty, trade-offs, and heterogeneous stakeholder interest or conflicting objectives and enables justifiable decisions under uncertainty. By aligning problem structure with appropriate decision methods, the study improves decision reliability and interpretability. That is valuable in real-world applications such as policy evaluation, resource allocation and strategic planning because transparent and defensible decisions are essential.

4. Socio-technical impact:

This study contributes to the socio-technical decision support research by interdependence between human judgment and computational decision models. Further, the framework promotes Explainability, trust and ethical reasoning and awareness in decision support systems, thereby improving user acceptance in decision-making environments. Thus, the framework supports a decision environment in which human preferences, uncertainty, and value-based considerations are systematically embedded within formal analytical processes.

5. Organization and managerial impact

The proposed taxonomy assists managers and decision makers in aligning analytical decision tools with organizational sustainability strategies, governance requirements, and standardized decision design

mechanisms that can be embedded into organizational workflows. The taxonomy facilitates standardization of decision-making within organizations, enabling consistent method selection across projects and departments as an example and auditable decision processes. Further, it enhances knowledge transfer between technical and managerial stakeholders and supports strategic alignment between decision processes and sustainability objectives.

6. Research and Academic impact

The study provides a foundational reference framework for future MCDM and Hybrid-MCDM research and advanced decision analysis. The study also promotes further empirical validation, comparative analysis, and domain-specific extensions of taxonomy-based decision modeling and hybrid model design. Further, the framework enables advanced studies in decision-making for cross-domain applications and theoretical extension of taxonomy-driven decision support systems.

6.5 Limitation

However, the significance conclusion of the results is that, there are some limitations requiring to be addressed, they are:

1. The study excluded emerging or Hybrid-MCDM techniques that have not yet been widely adopted or documented.
2. The dynamic evolution of MCDM tools and software platforms may frequently improve and has no static nature of the taxonomy, thereby requiring periodic updates to maintain relevance.

6.6 Future Work and Recommendations

The future work for this study's findings is checking the relationship between the problem in specific domains and the combination MCDM (Hybrid-MCDM) approaches. There are different applications in each domain that require high-stable decisions, whatever the management level. Furthermore, it is highly recommended to provide a comparative analysis and benchmark in studying the performance for decisions that are made by Hybrid-MCDM model and artificial intelligence algorithms.

7 Conclusion

Quantifying decision-making approaches like Hybrid-MCDM help address the vagueness associated with the decision-making process. Unfortunately, there is no guidance mechanism for combining MCDM methods for real decision-making problems. Where core Hybrid-MCDM is MCDM methods which are not addressed from a practical perspective involving different levels of uncertainty, conflict, vagueness, and incompleteness in criteria, alternatives, and preferences. The study proposes a structured taxonomy of MCDM methods. That offers a clear classification based on criteria such as problem type, data nature, decision environment, and computational

complexity. The taxonomy introduces new dimensions or criteria for classifying MCDM methods, such as robustness, transparency, or stakeholder involvement. Thereby, this study contributes to the standardization of terminology and classification in the MCDM field, which is often fragmented across disciplines. The study supports selection guidance for researchers and decision makers by aligning decision problems with suitable MCDM methods. Further, it proposes a decision-support framework or roadmap to assist decision makers in selecting the most appropriate MCDM method based on problem characteristics. The novelty of this study lies in the integration of theoretical classification with practical decision-making needs, bridging the gap between academic models and real-world applications. The proposed frameworks of decision model, whenever for MCDM methods or Hybrid-MCDM approaches, bridge human-centric social challenges with computational methods in real-time. Its integration into an information system not only proves its feasibility but also ensures reusability, scalability, and institutional credibility. The stability and robustness of this framework is proved by real case study by sensitivity test at five scenarios and its deviation and spearman correlation values are close to 0 and 1 by 0.03 and 0.998 respectively.

To solve the real decision-making problem for Beneficiaries selection, the flowchart in figure 8, and legality criteria and in figures A and B in Appendix B are one of this study outputs that designing to visualize and simulate the main procedures in *real charity environment apply special rules –Islam's rules - of acceptance donation types (Zakah, charity, Kafarah) and rules of distributions and beneficiaries' classifications*. These rules make variables and multiple alternatives in all decision-making cases besides conflicting. They can be used in general for many other charity organizations all over the world which have the same or common constraints *which are completely different from other charity organizations*. The importance of case study is shown via another dimension of this case study. Where this case study has a wide effect and applied in multiple domains. In the healthcare domain, it will apply in determining the beneficiaries and the highest priority for free treatment, critical operations or organ transplantation. It is also applied in the field of recruiting a qualified employee. It is also applied to determine the scholarship students and grant allocation in the education domain. In banking industry and finance, it is also applied for microfinance, microloans or financial empowerment programs or poverty alleviation programs. Even in the software engineering and software development industry, it is applied for forming functional team-members or selecting suitable approaches to project management methodology, etc. It means that this study is helpful for decision makers in multi-domains at the empirical and practical side, beside at the theoretical side via taxonomy-based decision-making's elements and guidance frameworks for MCDM methods and Hybrid-MCDM approaches.

Acknowledgement:

The authors extend their appreciation to Umm Al-Qura University, Saudi Arabia for funding this research work through grant number 26UQU4330113GSSR03.

The author is grateful to the anonymous referee for a careful checking of the details and for helpful comments that improved this paper.

Declaration**Compliance with Ethical Standards:**

- **Funding:** This research work was funded by Umm Al-Qura University, Saudi Arabia under grant number: 26UQU4330113GSSR03.
- **Informed consent:** This article does not contain any studies with human participants
- **Ethical approval:** No studies are done on animals. This manuscript doesn't submit to any journal now, or is under review by any journal.
- **Authors' contribution:** the first author's contributions are conceptualization, methodology, investigation, formal analysis, writing original draft and writing, reviewing and editing the final version. The second author's contributions are resources and reviewing. The third author's contributions are project administration, resources, reviewing, and funding acquisition. All the three authors approved the final version of the research.
- **Data Availability Statement:** The article don't used any published dataset before from any data store
- **The author has no competing interests to declare that are relevant to the content of this article.**
- **Conflict of Interest:** author has no conflict of interest.

References

- [1] Tran Van Dua, "PSI-SAW and PSI-MARCOS Hybrid-MCDM Methods," engineering technology and applied science research, vol. 14, no. 4, pp. 15963-15968, doi: 10.48084/etasr.7992, 2024.
- [2] Richard Hodgett, Barbara Summers, Sajid Siraj Aritad Choicharoon, "Hit or miss: A decision support system framework for signing new musical talent," European Journal of Operational Research, vol. 312, no. 1, pp. 324-337, doi: 10.1016/j.ejor.2023.06.014, 2024.
- [3] Edwin Frank, "Overview of Multi-Criteria Decision-Making (MCDM) Methods," 2024.
- [4] Muhammad Umer, Uzma Hassan, Umer Asgher, Fabián Silva-Aravena, Nadeem Ehsan Hassan S. Rana, "Application of fuzzy TOPSIS for prioritization of patients on elective surgeries waiting list - A novel multi-criteria decision-making approach," Decision-making: Applications in Management and Engineering, vol. 6, no. 1, pp. 603-630, doi: 10.31181/dmame060127022023r, 2023.
- [5] Shankha Shubhra Goswami Sushil Kumar Sahoo, "A Comprehensive Review of Multiple Criteria Decision-Making (MCDM) Methods: Advancements, Applications, and Future Directions," Decision-making Advances, vol. 1, no. 1, pp. 25-48, doi: 10.31181/dma1120237, 2023.
- [6] Fatih Topaloğlu, "Development of a new hybrid method for multi-criteria decision-making (MCDM) approach: a case study for facility location selection," operational research, vol. 24, no. 60, pp. doi: 10.1007/s12351-024-00871-4, 2024.
- [7] Akula Siva Bhaskar and Akhtar Khan, "Comparative analysis of Hybrid-MCDM methods in material selection for dental applications," Expert Systems with Applications, vol. 209, no. 118268, pp. doi: 10.1016/j.eswa.2022.118268, 2022.
- [8] Chalila Ichwania, Rizki A. Mangkuto, Justin Pradipta, M. Donny Koerniawan, Joko Sarwono Arinda P. Rachman, "Comparison of multi-criteria decision-making methods for selection of optimum passive design strategy," Energy and Buildings, vol. 314, no. 114285, pp. doi: 10.1016/j.enbuild.2024.114285, 2024.
- [9] Yu-Min Wei, "A Hybrid Multi-Criteria Decision-Making Framework for the Strategic Evaluation of Business Development Models," information, vol. 16, no. 6, pp. 454, DOI:10.3390/info16060454, 2025.
- [10] Mehmet Özçalici, Dragan Pamucar, Hasan Emin Gurler, Nazan Güngör Karyağdı, and Ahmet Kaya, "A robust Hybrid-MCDM framework with emphasis on decision stability intervals: Performance evaluation of global insurance brokers using fuzzy LBWA and modified ARTASI," Applied Soft Computing, vol. 190, pp. 114557, DOI:10.1016/j.asoc.2026.114557, 2026.
- [11] Marco, Miłosz Kadziński, Michael Gonzalez, Roman Słowiński Cinelli, "How to support the application of multiple criteria decision analysis? Let us start with a comprehensive taxonomy," Omega, vol. 96, pp. 102261, doi: 10.1016/j.omega.2020.102261, 2020.
- [12] Mahdi Homayonfar Abbas Toloie-Eshlaghy, "MCDM Methodologies and Applications: A Literature Review from 1999 to 2009," Research Journal of International Studies, no. 21, pp. 86-137, 2011.
- [13] Zenonas Turskisa, Simona Kildienė Edmundas Kazimieras Zavadskasa, "State of art surveys of overviews on MCDM/MADM methods," Technological and Economic Development of Economy, vol. 20, no. 1, pp. 165-179, doi: 10.3846/20294913.2014.892037, 2014.

- [14] Rahul Kumar, "A Comprehensive Review of MCDM Methods, Applications, and Emerging Trends," *Decision-making Advances*, vol. 3, no. 1, pp. 185-199, doi: 10.31181/dma31202569, 2025.
- [15] (2015) Sustainable development goals. [Online]. <https://www.un.org/sustainabledevelopment/in-equality>
- [16] Hakan Murat Arslan, "current classification of multi criteria decision analysis methods and public sector implementations," *Current Debates in Public Finance Public Administration and Environmental Studies*, vol. 13, no. 13, pp. 242, doi:10.5281/ZENODO.1291836, 2018.
- [17] Zhiyuan wang and gade pandu rangaiyah, "multi-criteria decision-making principles, methods and programs," *CRC Press*, pp. 296, doi: 10.1201/9781003530435, 2026.
- [18] Serkan Eti, Hasan Dinçer Yasar Gokalp and Serhat Yuksel, "A novel approach to prioritizing health technology investments using integrated AI-based ranking model," *journal of health organization and management*, vol. 39, no. 4, pp. doi: 10.1108/JHOM-05-2024-0190, 2025.
- [19] Yewande Ojo, Olasumbo Ayodeji Makinde, Oluwabukunmi Victor Babatunde, Gbotemi Babatunde, and Subomi Okeowo, "Evaluating AI-Driven Mental Health Solutions: A Hybrid Fuzzy Multi-Criteria Decision-Making Approach," *AI*, pp. DOI:10.3390/ai6010014, 2025.
- [20] Ahmad Abdulla and George Baryannis, "A Hybrid Multi-Criteria Decision-Making and Machine Learning Approach for Explainable Supplier Selection," *Supply Chain Analytics*, vol. 7, no. 94, pp. DOI:10.1016/j.sca.2024.100074, 2024.
- [21] Juthika Mahanta Naveen Kumar, "a hybrid decision-making framework with Pythagorean fuzzy information for childhood cancer prognosis," *Sahand Communications in Mathematical Analysis (SCMA)*, pp. doi: 10.22130/scma.2024.2038238.1851, 2025.
- [22] Sondes Hammami, Hafedh Fessi, Abdellatif Achour Safa Chabouh, "Towards sustainable dialysis modality selection:a multi-expert fuzzy analytical hierarchy process based approach for guided decision-making," *Annals of Operations Research*, pp. doi: 10.1007/s10479-024-06026-0, 2024.
- [23] Rishikesh, divya jain chaurasiya, "Hybrid-MCDM method on pythagorean fuzzy set and its application," *decision-making: applications in management and engineering*, vol. 6, no. 1, pp. 379-398, doi: 10.31181/dmame0306102022c, 2023.
- [24] Natalia Jaramillo-Rueda, Muhammet Gul, Melih Yucesan, Genett Jiménez-Delgado, Juan-José Alfaro-Saíz Miguel Ortíz-Barrios, "A Fuzzy Hybrid-MCDM Approach for Assessing the Emergency Department Performance during the COVID-19 Outbreak," *international journal of environmental research and public health*, vol. 20, no. 4591, pp. 1-39, doi: 10.3390/ijerph20054591, 2023.
- [25] Dunbar kevin, "problem solving," a companion to cognitive science, pp. 289-298, doi: 10.1002/9781405164535.ch20, 2017.
- [26] Manjari Mehta and Rudy Hirschheim, "Strategic Alignment In Mergers And Acquisitions: Theorizing IS Integration Decision-making," *Journal of the Association for Information Systems*, vol. 8, no. 3, pp. doi:10.17705/1jais.00118, 2007.
- [27] Michele D. Bunn, "Taxonomy of buying decision approaches," *Journal of marketing*, vol. 57, no. 1, pp. 38-56, doi: 10.1177/002224299305700103, 1993.
- [28] Christopher M. Scherpereel, "Decision orders: a decision taxonomy," *Management Decision*, vol. 44, no. 1, pp. 123-136, doi: 10.1108/00251740610641508, 2006.
- [29] Craig R., Lutz Kaufmann, and Alex Michel Carter, "Behavioral supply management: a taxonomy of judgment and decision-making biases," *International Journal of Physical Distribution & Logistics Management*, vol. 37, no. 8, pp. 631-669, doi: 10.1108/09600030710825694, 2007.
- [30] Rajiv, and William R. King Sabherwal, "An empirical taxonomy of the decision-making processes concerning strategic applications of information systems," *Journal of Management Information Systems*, vol. 11, no. 4, pp. 177-214, doi: 10.1080/07421222.1995.11518064, 1995.
- [31] Caesar, Rui Zhang, Ramamohanarao Kotagiri, and Pascal Bouvry Wu, "Strategic decisions: survey, taxonomy, and future directions from artificial intelligence perspective," *ACM Computing Surveys*, vol. 55, no. 12, pp. 1-30, doi: 10.1145/3571807, 2023.
- [32] Steven Alter, ""A taxonomy of decision support systems," *Sloan Management Review (pre-1986)* , vol. 19, p. 39, 1977.
- [33] Robert M. Thrall, "A taxonomy for decision models," *Annals of Operations Research*, vol. 2, no. 1, pp. 23-27, doi: 10.1007/BF01874730, 1984.
- [34] David. Arnott, "A taxonomy of decision biases," *Monash University, School of Information Management and Systems*, Caulfield, 1998.
- [35] Ziyu Chen, Naijie chai, Jianqiang wang, and Xiaokang wang, "Restaurant recommendations under multimodal online reviews: A novel method based on image captioning and text analysis with multi-criteria

- decision-making," *Information Processing & Management*, vol. 63, no. 1, pp. DOI: 10.1016/j.ipm.2025.104308, 2026.
- [36] Dennis Kundisch et al., "An Update for Taxonomy Designers - Methodological Guidance from Information Systems Research," *Business & Information Systems Engineering*, vol. 64, no. 3, pp. DOI: 10.1007/s12599-021-00723-x, 2021.
- [37] Hamed Taherdoost and Mitra Madanchian, "Multi-Criteria Decision-making (MCDM) Methods and Concepts," *Encyclopedia*, vol. 3, no. 1, pp. 77-87, doi: 10.3390/encyclopedia3010006, 2023.
- [38] Daji ergy thomas I. saaty, "when a decision-making method trustworthy? criteria for evaluating multi-criteria decision-making methods," *international journal of information technology & decision-making*, vol. 14, 2015.
- [39] Varvara Mytilinou, Estivaliz Lozano-Minguez, Konstantinos Salonitis Athanasios Kolios, "A Comparative Study of Multiple-Criteria Decision-Making Methods under Stochastic Inputs," *enginers*, vol. 9, no. 566, pp. 1-21, doi: 10.3390/en9070566, 2016.
- [40] Jakub Wieckowska et al., "Recent advances in multi-criteria decision analysis: A comprehensive review of applications and trends," *International Journal of Knowledge-based and Intelligent Engineering Systems*, vol. 27, pp. 367-393, doi: 10.3233/kes-230487, 2023.
- [41] Hamed Taherdoost and Mitra Madanchian, "Multi-Criteria Decision-making (MCDM) Methods and Concepts," *Encyclopedia*, vol. 3, no. 1, pp. 77-87, 2023.
- [42] Hamed Taherdoost, "A Comprehensive Survey and Literature Review on TOPSIS," *International Journal of Service Science, Management, Engineering, and Technology*, vol. 15, no. 1, pp. doi:10.4018/IJSSMET.347947, 2024.
- [43] Haitham A. El-Ghareeb, Ahmed Aboelfetouh Amany A.Slamaa, "Comparative analysis of AHP, FAHP and Neutrosophic AHP based on multi-criteria for adopting ERPS," *Neutrosophic Sets and Systems*, vol. 4, pp. 64-89, 2021.
- [44] Wejciech, jaroslaw watrobski, andril shekhovtsov salabun, "are MCDM methods benchmarkable? a comparative study of topsis, vikor, cropras and promethee ii methods," *symmetry*, vol. 12, no. 9, pp. 15-49, doi: 10.3390/sym12091549, 2020.
- [45] Simamora im, allagan h manurung sv, "comparison of moora, waspas and saw methods in decision support systems," *jurnal mantik*, vol. 5, no. 2, pp. 485-493, doi: 10.1063/5.0094437, 2021.
- [46] Azadeh, and Adem Kılıçman Zahedi Khameneh, "Multi-attribute decision-making based on soft set theory: A systematic review," *Soft Computing*, vol. 23, pp. 6899-6920, 2019.
- [47] Henri Prade Didier Dubois, "Gradualness, uncertainty and bipolarity: Making sense of fuzzy sets," *Fuzzy Sets and Systems*, vol. 192, pp. 3-24, doi: 10.1016/j.fss.2010.11.007, 2012.
- [48] Bikash Koli Roy, Mohuya B. Kar, Samarjit Kar & Dragan Pamučar Sujit Das, "Neutrosophic fuzzy set and its application in decision-making," *Ambient Intelligence and Humanized Computing*, vol. 11, pp. 5017-5029, doi: 10.1007/s12652-020-01808-3, 2020.
- [49] T. Oner, T. Katican, F. Smarandache, N. Gandotra Rezaei, "A short history of fuzzy, intuitionistic fuzzy, neutrosophic and plithogenic sets," *international journal of neutrosophic science (IJNS)*, vol. 18, no. 1, pp. 99-116, doi: 10.54216/IJNS.180109, 2022.
- [50] Jingguo Dai Xindong Peng, "A bibliometric analysis of neutrosophic set: two decades review from 1998 to 2017," *artificial intelligence review*, vol. 53, no. https://doi.org/10.1007/s10462-018-9652-0, pp. 199-255, doi: 10.1007/s10462-018-9652-0, 2020.
- [51] Gündoğdu FK Kahraman C, "Decision-making with spherical fuzzy sets," *Studies in fuzziness and soft computing*, vol. 392, pp. 3-25, 2021.
- [52] Gaurikant Kumar Amal Kumar Adak, "Spherical distance measurement method for solving MCDM problems under Pythagorean fuzzy environment," *journal of fuzzy extension and applications*, vol. 4, no. 1, pp. 28-39, doi: 10.22105/jfea.2022.351677.1224, 2023.
- [53] Florentin Smarandache, "Neutrosophic Set is a Generalization of Intuitionistic Fuzzy Set, Inconsistent Intuitionistic Fuzzy Set (Picture Fuzzy Set, Ternary Fuzzy Set), Pythagorean Fuzzy Set, Spherical Fuzzy Set, and q-Rung Orthopair Fuzzy Set, while Neutrosophication is a Genera," *Journal of New Theory*, vol. 29, pp. 1-31, 2019.
- [54] Naresh kumar nageani Rama Ranjan Panda, "IPSFS: Intuitionistic, pythagorean, and spherical fuzzy similarity computation package in R," *software impacts*, vol. 14, pp. doi: 10.1016/j.simpa.2022.100424, 2022.
- [55] Fatmaa, Kahraman, Cengiza Kutlu Gündoğdu, "Spherical fuzzy sets and spherical fuzzy TOPSIS method," pp. 337-352, doi: 10.3233/JIFS-181401, 2019.
- [56] Biswajit Sarkar and Animesh Biswas, "A multi-criteria decision-making approach for strategy formulation using Pythagorean fuzzy logic," *expert systems*, vol. 39, no. 1, pp. doi: 10.1111/exsy.12802, 2021.

- [57] Muhammad Riaz, Masooma Raza Hashmi, Dragan Pamucar, and Yu-Ming Chu, "Spherical Linear Diophantine Fuzzy Sets with Modeling Uncertainties in MCDM," *Computer Modeling in Engineering & Sciences*, vol. 126, no. 3, pp. 1125-1164, doi: 10.32604/cmescs.2021.013699, 2021.
- [58] Palvinder, Bartosz Paradowski, Neeraj Gandotra, Parul Thakur, Namita Saini, and Wojciech Sałabun Thakur, "A Study and Application Analysis Exploring Pythagorean Fuzzy Set Distance Metrics in Decision-making," *information* 15, vol. 1, no. 28, pp. doi: 10.3390/info15010028, 2024.
- [59] Serhat Aydın, "A Fuzzy MCDM Method Based on New Fermatean Fuzzy Theories," *International Journal of Information Technology & Decision-making*, vol. 20, no. 3, pp. 881-902, doi: 10.1142/S021962202150019X, 2021.
- [60] AlAzharAlSharif. Zakat and Charities Fund. [Online]. <https://baitzakat.org.eg/en/>
- [61] Resala organization. Resala organization. [Online]. <https://resala.org/>
- [62] Haya Karima. Haya Karima Donation. [Online]. <https://www.hayakarima.com/>
- [63] Hamed Taherdoost and Mitra Madanchian, "A Comprehensive Overview of the ELECTRE Method in MultiCriteria Decision-Making," *Journal of Management Science & Engineering Research*, vol. 6, no. 2, pp. 5-16, doi: 10.30564/JMSER.V6I2.5637, 2023.
- [64] Hamed Taherdoost and Mitra Madanchian, "VIKOR method—an effective compromising ranking technique for decision-making," *Macro Management & Public Policies*, vol. 5, no. 2, pp. doi: 10.30564/mmpp.v5i2.5578, 2023.
- [65] Sema Kayapinar Kaya, "A novel two-phase group decision-making model for circular supplier selection under picture fuzzy environment," *Environmental Science and Pollution Research*, vol. 30, no. 2, pp. 1-23, doi:10.1007/s11356-022-24486-4, 2022.
- [66] K. Mansouri, and M. Qbadou, A. Daghour, "Information System Evaluation Based on Multi-Criteria Decision-making: A comparison of two sectors," *International Journal Advanced Computer Science Applications*. IJACSA, vol. 6, no. 9, pp. 291–297, 2018.
- [67] Ibrahim Sabry, Ahmed El-Assal Ahmed El-Araby, "A COMPARATIVE STUDY OF USING MCDM METHODS INTEGRATED WITH ENTROPY WEIGHT METHOD FOR EVALUATING FACILITY LOCATION PROBLEM," *Operational Research in Engineering Sciences: Theory and Applications*, pp. 121-138, 2022.
- [68] Shyi-Ming Chen, Deng-Cyun Chen, "A new multi attribute decision-making method based on interval-valued intuitionistic fuzzy values", *Knowledge and Information Systems*, pp. 3769–3787 76, doi: 10.1007/s10115-024-02328-8, 2025.
- [69] Ghous Ali, Muhammad Nabeel, Adeel Farooq "Extended ELECTRE method for multi-criteria group decision-making with spherical cubic fuzzy sets", *Knowledge and Information Systems*, pp. 6269–6306 66, doi: 10.1007/s10115-024-02132-4, 2024
- [70] QIANG YANG, Xindong Wu, 10 CHALLENGING PROBLEMS IN DATA MINING RESEARCH, "International Journal of Information Technology & Decision-making", pp. 597–604, 5(4), 2006.
- [71] Jeannette M. Wing, Data for Good, "KDD '18: Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining", pp.4, doi: 10.1145/3219819.32199, 2018.



Amany A. Slamaa is an Assistant Professor at faculty of Computers and Information Sciences. She received the BS, Master and Ph.D. degrees in Information Systems from faculty of Computers and Information Sciences, Mansoura University, Egypt. She is a *Fulbright Alumni*; she was a visiting professor at *North Carolina State University, USA* and *Honor Alumni* at *Zhejiang Normal University, China*. Her current research interests are information system, software engineering, and AI-augmented software engineering. She has contributed to the research community through research collaborations and scientific publications in leading journals in software engineering and information systems. She is peer review for international journals and conferences, besides a keynote speaker in international conferences.



Hussein M. Elshafie is an academic and researcher in Computer Science and Artificial Intelligence at the Faculty of Computers and Information, Luxor University. His academic and research interests encompass Computer Security, Artificial Intelligence, Machine Learning, Intelligent Systems, Internet of Things (IoT), Embedded Systems, Computer Vision, Data Science, and Sustainable Digital Technologies.

His research focuses on the design and development of intelligent, secure, and data-driven systems that integrate IoT sensing, machine learning, deep learning, and automated decision-making to address real-world challenges.



Ahmed I. Sharaf received the Ph.D. degree in Artificial Intelligence and is a Senior Member of the IEEE. He is actively engaged in academic research and teaching, with research interests that include, but are not limited to, artificial intelligence, machine learning, Generative AI, medical image analysis, intelligent systems, sensor networks, Internet of Things (IoT), and optimization. His research expertise encompasses deep learning, supervised and unsupervised learning, time-series analysis, and image processing, with recent work focusing on Generative AI, intelligent AI applications, and sensor-based intelligent systems. He has contributed to the research community through scientific publications, research collaborations, and peer review for international journals and conferences.

Appendix A

Table A: The properties of decision level, nature of criteria (quantitative, qualitative), and alternatives' certainty level

Key feature	levels	Recommended method
Problem type	Well-structured, quantitative	TOPSIS, MOORA, MAUT
	Semi-structured, both qualitative and quantitative	AHP, ANP, PROMETHEE, VIKOR
	Unstructured, qualitative	ELECTRE, Neutrosophic MCDM, ANP
Uncertainty Level of Criteria	Crisp (Exact values)	AHP, TOPSIS, MOORA, MAUT
	Fuzzy (Linguistic terms)	Fuzzy MCDM like Fuzzy AHP, Fuzzy TOPSIS,
	Probabilistic (Random variations)	Stochastic AHP, Stochastic MAUT
	Interval-based (Range of values)	Interval-based TOPSIS, Interval ELECTRE
	High Indeterminacy (Ambiguity, incomplete information)	Neutrosophic MCDM
Conflict Level of Alternatives	Low Conflict	AHP, MAUT, MOORA
	Moderate Conflict	TOPSIS, VIKOR, COPRAS
	High Conflict	ELECTRE, PROMETHEE, Neutrosophic MCDM

Table B: The detailed structures and levels of certainty, conflict for criteria and alternative of decision-making problem

key	Type	Description	Example Methods
Compensation level	Compensatory Methods	Allow trade-offs between criteria (e.g., a poor score in one criterion can be compensated by a high score in another).	AHP, ANP, TOPSIS, MAUT, SAW
	Partially Compensatory Methods	Allow limited compensation based on thresholds or preference structures.	VIKOR, PROMETHEE, COPRAS, MOORA
	Non-Compensatory Methods	Do not allow trade-offs; an alternative must meet all essential criteria to be selected.	ELECTRE, Outranking Methods, Decision Rules, Neutrosophic MCDM
Preferences model	Pairwise Comparison-Based Methods	Criteria and alternatives are compared in pairs, often using matrices.	AHP, ANP, Fuzzy AHP, Neutrosophic ANP
	Distance-Based	Rank alternatives based on their	TOPSIS, VIKOR, CP-TOPSIS,

	Methods	distance to an ideal or anti-ideal solution.	GRA (Grey Relational Analysis)
	Utility-Based Methods	Assign numerical utilities to alternatives based on predefined preference functions.	MAUT (Multi-Attribute Utility Theory), MAVT (Value Theory), SMART
	Outranking Methods	Compare alternatives by pairwise dominance rather than numerical ranking.	ELECTRE, PROMETHEE, REGIME, QUALIFLEX
	Rule-Based Methods	Use logical conditions to classify alternatives.	Dominance-Based Rough Set Approach (DRSA), Fuzzy Rule-Based Systems
Decision rule	Single-Criterion Aggregation	Converts multiple criteria into a single score.	SAW (Simple Additive Weighting), MAUT, MOORA
	Multi-Criterion Ranking	Ranks alternatives based on dominance relationships.	TOPSIS, VIKOR, PROMETHEE, ELECTRE
	Threshold-Based Selection	Filters out alternatives based on constraints.	ELECTRE, Fuzzy MCDM, Rough Set Approaches
	Consensus-Based Methods	Use group decision-making approaches to find an agreed-upon ranking.	Delphi Method, Neutrosophic MCDM, Group AHP
Interdependency structure	Independent Criteria Methods	Assume criteria are independent.	AHP, TOPSIS, VIKOR, ELECTRE, SAW
	Interdependent Criteria Methods	Consider interactions between criteria.	ANP, DEMATEL, BWM (Best-Worst Method)
uncertainty structure	Deterministic MCDM	Assumes precise data is available.	AHP, SAW, TOPSIS, PROMETHEE
	Fuzzy-Based MCDM	Uses linguistic variables or fuzzy sets for uncertainty.	Fuzzy AHP, Fuzzy TOPSIS, Fuzzy PROMETHEE, Fuzzy VIKOR
	Stochastic MCDM	Uses probability distributions to model uncertainty.	Stochastic AHP, Stochastic VIKOR
	Neutrosophic-Based MCDM	Handles extreme uncertainty and indeterminacy.	Neutrosophic ANP, Neutrosophic TOPSIS, Neutrosophic ELECTRE
	Grey-Based MCDM	Deals with incomplete or imprecise data.	Grey TOPSIS, Grey ELECTRE, Grey PROMETHEE

Table C: A comparative analysis for the most used MCDM methods

MCDM Method	Mathematical Approach	Key Feature	Advantage	Limitation	Best Use
AHP	Pairwise comparisons and eigenvector calculation	Hierarchical structure, subjective weights	Handles qualitative and quantitative criteria. good for moderate conflict levels	Inconsistent judgments affect results. Difficult for large criteria sets. It may struggle with high uncertainty	Structured problems with low to medium uncertainty and moderate conflict
ANP	Pairwise comparisons with interdependence	Captures interdependencies between criteria and alternatives	Suitable for complex, interrelated decisions, more realistic than AHP. Works well with quantitative data.	Computationally intensive. less effective for high uncertainty	Suitable for problems with conflicting criteria

TOPSIS	Distance-based evaluation	Ranks alternatives based on closeness to ideal and negative-ideal solutions (proximity to ideal solution)	Easy to implement, considers both best and worst solutions, Intuitive and computationally efficient.	Assumes linear relationships, sensitive to scale differences. Does not handle uncertain or qualitative data well.	Quantitative problems with conflicting criteria and lower uncertainty.
VIKOR	Distance-based evaluation with regret measure	Focuses on compromise solutions, Finds compromise solutions by minimizing maximum regret	Balances best and worst alternatives, effective for ranking under trade-offs. Handles uncertainty in weights and preferences effectively.	Sensitive to normalization techniques, requires subjective parameters	High-conflict decisions that emphasize balance and closeness to the ideal solution.
PROMETHEE	Outranking method	Uses pairwise comparisons and preference functions. Provides preference ranking based on outranking	Handles conflicting criteria well, no need for weight normalization. Handles moderate uncertainty effectively	Requires preference function selection	Moderate to high-conflict decisions requiring detailed rankings.
ELECTRE	Outranking method	Uses concordance-discordance analysis	Suitable for high-conflict decisions. Handles uncertainty better than AHP and TOPSIS. Designed for high conflict levels; uses concordance and discordance indices.	Computationally complex, sensitive to threshold parameters	Strategic problems with high uncertainty and strong conflicts
MAUT	Utility function-based optimization	Converts criteria into a common utility scale	Provides a strong theoretical foundation. - Balances trade-offs comprehensively	Requires precise utility functions. Can be complex for non-experts	Problems needing detailed utility-based evaluations under moderate uncertainty/conflict
MOORA	Ratio-based evaluation	Simple, computationally efficient. Focuses on multi-objective problems.	Suitable for quantitative criteria. Handles low conflicting criteria using ratio analysis	Limited for qualitative decisions. Less effective with high uncertainty. Relies on clear data structures	Moderate-conflict problems with clear conflicting criteria
WSM	Weighted linear combination	Straightforward and computationally simple	Effective for problems with additive criteria.	Assumes independence of criteria. Limited handling of uncertain or conflicting data	Simple problems with clear, independent criteria and minimal uncertainty.
WPM	Multiplication exponent weighting method	Avoids scaling issues by multiplying weights where uses a multiplicative approach instead of additive to compare alternatives.	Suitable for proportional criteria. Works best in low-conflict, independent criteria scenarios	Restricted to low complexity problems. less suitable for uncertain environments. Similar limitations as WSM	Scenarios with independent criteria and low uncertainty

SAW	Simple addition weighting	Straightforward, like WSM; easy to apply	Assumes criteria independence	Poor at handling uncertainty	Basic problems with additive criteria and low levels of uncertainty or conflict.
------------	---------------------------	--	-------------------------------	------------------------------	--

Table D: The features of usage set theories for decision-making

Set theory	aspect	feature
Saaty Set and Absolute Assessment Theory	Strengths	Helps reduce subjectivity in expert-based evaluations, Balances subjectivity and objectivity, improves decision reliability
	Weaknesses	Requires expert opinions, sensitive to expert bias. Less effective for highly uncertain or contradictory data
	Advantages	Ideal for group decision-making, balances subjectivity and objectivity.
	Disadvantages	Less effective for highly uncertain or contradictory data
	Best Used For	Moderate uncertainty and conflict, expert-driven decisions
	Application Example	Faculty performance assessment(Converting peer reviews into quantitative scores), ranking universities, HR recruitment, Project Feasibility Analysis evaluation
Classical Fuzzy Set	Strengths	Easy to implement, well-established, suitable for simple decision problems
	Weaknesses	Cannot handle higher degrees of uncertainty or conflict (contradictions) criteria
	Advantages	Good for structured problems with well-defined linguistic terms
	Disadvantages	Fails when uncertainty is high, does not support independent degrees of hesitation or contradiction
	Best Used For	Problems with low uncertainty and low conflict
	Application Example	Supplier selection, Customer satisfaction analysis, Quality control in Manufacturing, Selecting a new marketing strategy, Evaluating software performance
Pythagorean Fuzzy Set	Strengths	Handles higher uncertainty than Classical Fuzzy, provides better flexibility
	Weaknesses	Does not explicitly hesitation model or contradictions degree
	Advantages	Useful for multi-criteria decision-making with some trade-offs
	Disadvantages	Not ideal for highly indeterminate problems
	Best Used For	Problems with high uncertainty but moderate conflict
	Application Example	Healthcare prioritization (Medical diagnosis, Surgeon & Patient Waiting List) , Financial risk assessment (credit risks, stock investments), and insurance claims, Smart city development, Environmental Risk Management
Spherical Fuzzy Set	Strengths	Models hesitancy, uncertainty, and contradiction simultaneously
	Weaknesses	More complex, requires computational effort and expert knowledge
	Advantages	Suitable for high-conflict and uncertain environments, handles partial missing data well
	Disadvantages	Complex mathematical computations, requires more expert input
	Best Used For	Problems with high uncertainty and high conflict
	Application Example	Disaster response planning (floods, earthquakes, or pandemics), Healthcare Resource Allocation (beds, vaccines, or emergency response units) Military and Defense Strategy (like Decision-making in national security under uncertain and conflicting intelligence data), AI decision ethics
Neutrosophic Set	Strengths	Handles extreme uncertainty, contradictions, and missing data better than any other set. Captures hesitancy and uncertainty better than Pythagorean Fuzzy.
	Weaknesses	Computationally intensive, complex interpretation
	Advantages	Best for decision problems with extreme vagueness, contradictions, or ethical dilemmas

	Disadvantages	Requires advanced modeling, difficult to explain to non-experts
	Best Used For	Highly uncertain, contradictory, missing data, and ethical decision problems
	Application Example	Legal and Political risk assessment (by Handling conflicting testimonies, misinformation, and missing data in judicial systems), Unethical and AI ethics model detection, Geopolitical risk assessment,

Table E: The features of set theories based on problem nature

Set Theory	Mathematical Representation	Uncertainty Level	Conflict Level	Use and cause
Saaty Set	Nonlinear transformation of subjective ratings into objective numbers	Moderate	Moderate	Expert-based evaluations in group decision-making, where expert bias needs correction (e.g., peer reviews, HR assessments)
Classical Fuzzy Set	Membership function $\mu(x) \in [0,1]$	Moderate (Handles vagueness but lacks flexibility)	Low to Moderate	Simple problems with moderate uncertainty (e.g., supplier selection, service quality assessment)
Pythagorean Fuzzy Set	Membership & non-membership degree: $\mu^2(x) + \nu^2(x) \leq 1$	High (Allows better flexibility than classical fuzzy)	Moderate to High	Complex decision-making with high trade-offs (e.g., healthcare, financial risk analysis)
Spherical Fuzzy Set	Membership, non-membership, and hesitancy degree: $\mu^2(x) + \nu^2(x) + \pi^2(x) \leq 1$	Very High (Handles greater uncertainty than Pythagorean Fuzzy)	High	Problems with highly conflicting criteria & missing information (e.g., disaster management, critical safety assessments)
Neutrosophic Set	Truth and falsity membership, and indeterminacy degree: $T(x), I(x), F(x) \in [0,1]$ and $T + I + F \leq 3$	Extreme (Handles indeterminate, contradictory, and missing data)	Very High	Problems with extreme vagueness & conflicting opinions (e.g., ethics-based AI decision-making, geopolitical risk assessment)

Appendix B**Beneficiary Selection Criteria Form****General Information for Individual Applicants (Adults, orphan and Elderly)**

1. Name of Applicant: _____
2. Age: ☐ (21 - 30) , ☐ (31 - 40), ☐ (41 – 50), ☐ (51 – 60), ☐ 60+
3. Gender: ☐ Male ☐ Female
4. Social status: ☐ single, ☐ married, ☐ divorced, ☐ widowed
5. Contact Information: _____
6. Address: _____
7. National ID/Registration Number (for Refugees): _____
8. Income type: ☐ salary, ☐ pension, ☐ Solidarity aid, value: _____
9. Income Level: ☐ Low ☐ Medium ☐ High (measure by kilo of meat's price)
10. Has Health Insurance: ☐ yes, ☐ No

11. Has Social Security: ☐ Yes, ☐ No
12. Health condition: ☐ good, ☐ moderate, ☐ weak, ☐ disability
13. Has Treatment: ☐ No, ☐ monthly medical treatment, ☐ several chronic disease
14. Disability: ☐ No, ☐ yes (birth), ☐ by accident, ☐ by disease, list: _____
15. Employment Status: ☐ Unemployed ☐ Employed ☐ Self-employed ☐ Informal Sector Worker ☐ Other, List: _____
16. Education Level: ☐ No formal education ☐ Primary ☐ Secondary ☐ Higher education
17. Access to Basic Services: ☐ No access to clean water ☐ Limited access to healthcare ☐ No access to electricity ☐ No access to formal banking services ☐ Limited access to education
18. Responsible for : ☐ self, ☐ parent(s), ☐ orphan, ☐ children, List: _____, Number : _____
19. Desired assistance: ☐ money ☐ meals ☐ hard foods ☐ medical resources ☐ medicine ☐ educational supplies ☐ rent and bills, timing: ☐ daily ☐ monthly
20. (for Orphans) Birth year ____ live in shelter: ☐ yes ☐ No, both parents are dead: ☐ yes ☐ No

Note: In case she/he has family, fill the next section _____

General Information for Families (has Orphans, children, disabled, sick) and refugees family

1. Number of family Members has income (rather that applicant): _____
2. Number of Dependents (Children, Elderly, Disabled): _____, _____, _____
3. Family Income Level: ☐ Low ☐ Medium ☐ High, value: _____
4. Living Conditions: ☐ Overcrowded housing ☐ No permanent shelter ☐ Rural/slum dwelling ☐ Refugee/displaced status- list number of rooms: _____
5. Special Considerations: ☐ Single-parent household ☐ Orphaned children (number: _____) ☐ Elderly with no caregivers ☐ Family members with chronic illness or disability ☐ Sick husband/wife ☐ Addicted husband ☐ Disabled husband/wife/children/parent. List: _____

Figure A 'Identification Form' that declares gathering data from applicants- used in his/her classify and ranking

Eligibility Criteria

Section 1: General criteria

1. Does the applicant meet the basic eligibility requirements? ☐ Yes ☐ No
2. Does the applicant have any special needs? ☐ Yes ☐ No (If yes, specify: _____)
3. Is the applicant currently receiving assistance from other programs? ☐ Yes ☐ No (If yes, specify: _____)
4. Agricultural or Livelihood Status: ☐ Subsistence farmer ☐ Artisan or craft worker ☐ Unskilled laborer ☐ Dependent on seasonal employment ☐ No stable source of income

Section 2: Assessment Criteria

1. Socioeconomic Status (Check all that apply): ☐ No stable income ☐ Dependent on external support ☐ High number of dependents ☐ Living in inadequate housing conditions ☐ Facing chronic financial instability ☐ Recently lost primary income source ☐ Rural or slum dweller with no access to infrastructure ☐ Family structure limits access to economic opportunities
2. Community Impact: ☐ Ability to use resources effectively ☐ Skills and expertise that can benefit others

3. Urgency of Need: ☐ High risk of displacement due to economic instability ☐ Health-related vulnerabilities (disability, chronic illness) ☐ Lack of access to basic services (e.g., education, healthcare, sanitation, food security) ☐ Single-parent household with dependents ☐ Family member with severe disability or chronic illness ☐ Victim of domestic violence or child labor ☐ Orphaned children in immediate need of care ☐ Elderly at risk due to lack of family support
4. Potential for Self-Sufficiency: ☐ No potential for self-sufficiency due to age/disability/disease ☐ Needs temporary support but can become self-sufficient ☐ Has skills but lacks resources to become self-sufficient ☐ High potential for self-sufficiency if given proper aid ☐ Requires vocational training to gain employable skills ☐ Family support system can improve long-term sustainability.

Section 3: Verification and Approval

1. Supporting Documents Provided: ☐ ID Proof ☐ Income Proof ☐ Medical Reports (if applicable) ☐ Proof of Residence ☐ Community Testimonies ☐ Business Proposal (if applicable) ☐ Agricultural Land Ownership or Lease Papers (if applicable) ☐ Birth Certificates of Dependents (if applicable) ☐ Orphanage Documentation (if applicable) ☐ Other: _____
2. Verified by (Name & Signature): _____
3. Ethical Dilemma Considerations: ☐ Prioritization of applicants with similar needs but different backgrounds (e.g., urban vs. rural, men vs. women, youth vs. elderly) ☐ Balancing immediate need versus long-term impact ☐ Risk of dependency vs. empowerment ☐ Controversial cases requiring exception handling ☐ Corruption risks and ensuring fair distribution of aid ☐ Balancing support for elderly in home vs. in shelter
4. Approval Status: ☐ Approved ☐ Not Approved ☐ Further Review Needed
5. Remarks: _____

I hereby declare that the information provided is true and correct to the best of my knowledge.

Signature of Reviewer: _____ Date: _____

Figure B The eligibility and assessment criteria for inserting applicants to beneficiaries' database

Case Study –Criteria and alternatives

criteria	sub-criteria	Alternatives	category
1. General:	C1: Household Size (Larger families may require more support) C2: Income Level (expense or pension get higher priority) C3: Employment Status (Unemployed or informal workers prioritized) C4: Education Level (illiterate or Low education level might indicate higher need) C5: Access to Basic Services (Lack of water, healthcare, electricity, hot meals) C6: Living Conditions (Homeless, displaced, slum dwellers prioritized)	A1: Unemployed individual with no dependents but living in extreme poverty A2: Single-parent working informally with multiple dependents A3: Educated but jobless youth seeking business startup support A4: Disabled person needing assistance for medical and livelihood support	1. Adults Seeking Individual Support:

2. Vulnerability & Special Needs: - like divorced or widowed	C7: Single-parent Household (Higher priority due to responsibility burden) C8: Orphaned Children (Children without parental care need urgent support) C9: Elderly Without Caregivers (Older individuals without family need assistance) C10: Disability or Chronic Illness (single or Families with disabled members require support) C11: Victim of violence/war Violence, addicted husband (Requires urgent protection like refugees) C12: High-Risk Displacement (Due to conflict, natural disaster, or economic crisis)	A5: Large family with low income and multiple children in school A6: Single-mother household struggling with rent and food security A7: Family with a severely disabled child or sick needing continuous medical care A8: Family affected by war or natural disaster as fire requiring relocation support	2. Families Seeking Support:
3. Economic & Social Factors:	C13: governance Support (solidarity aid) C14: support charity C15: Skills and craft seller C16: Potential to establish business if supported as carpentry or plumber C17: Agricultural or Livelihood Status (Farming, informal work)	A9: Orphaned children living in an informal care setting (e.g., extended family or shelter) A10: Children in an overcrowded orphanage with limited resources A11: Elderly individual without family support, requiring housing and medical care A12: Elderly couple with no income, struggling to meet basic needs	3. Orphans and Elderly in Need of Care:
4. Ethical & Conflict Considerations:	C18: Balancing Immediate vs. Long-term Impact (Support emergency vs. sustainable growth) C19: Gender & Age Balance (Prioritizing women, youth, or elderly) C20: Corruption Risks (Ensuring fair distribution of aid and avoiding favoritism) C21: Risk of Dependency vs. Empowerment (Helping beneficiaries without long-term reliance)	A13: Prioritizing displaced refugees may conflict with local low-income families A14: support small business may conflict with elderly care A15: Allocating funds for family with imprisoned parent conflict with addicted parent A16: Supporting sick person or elderly in their home may conflict with elderly care in shelters	4. Ethical and Conflict Alternatives:

Figure C The criteria and alternatives lists

Appendix C

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
A1	8	7	8	8	8	8	8	7	8	8	8	7	7	8	8	7	8	8	8	8	7
A2	7	8	8	9	8	8	8	8	8	8	8	8	8	8	7	8	8	7	7	8	8
A3	8	8	8	8	8	8	7	9	8	9	7	8	8	8	7	8	8	9	8	7	9
A4	8	8	8	8	7	7	7	8	8	8	9	7	9	8	8	7	8	8	7	7	7
A5	8	9	7	8	7	8	8	8	7	8	8	8	9	7	8	8	7	8	8	8	8
A6	8	8	8	9	9	8	7	8	7	7	8	8	8	7	8	8	7	8	8	7	8
A7	9	7	8	8	8	9	8	8	7	8	8	9	8	7	7	8	7	8	7	8	8
A8	9	9	8	7	8	7	9	7	7	8	7	7	8	9	8	8	7	7	9	7	7
A9	8	8	8	8	7	9	7	8	9	8	8	8	7	8	9	8	9	8	7	8	8
A10	7	7	7	8	8	8	8	8	8	8	7	8	8	7	8	8	9	7	8	8	8
A11	7	7	9	7	7	8	8	8	8	7	9	8	7	8	8	7	8	7	7	9	8
A12	7	8	8	8	8	7	7	7	8	9	7	7	8	8	8	8	7	8	7	8	9
A13	7	7	9	7	9	7	9	7	8	8	7	7	8	8	8	8	7	8	8	8	8
A14	8	8	7	8	8	8	7	9	8	8	8	8	7	7	8	8	7	9	8	8	8
A15	8	7	8	8	7	7	8	8	8	7	8	9	7	9	9	7	7	7	8	8	7
A16	7	8	7	8	7	8	8	7	9	7	8	8	7	8	7	9	8	7	9	9	8

Figure A: raw data (evaluation of weight matrix) in Saaty set equal to the language expression that was approved by at least two of the officials responsible for the case was adopted. This language expression was converted to its

corresponding value in Neutrosophic using the same table (last column), and a weighting matrix was created, which was subsequently used in applying the steps of ELECTRE-VIKOR and other tests in tables 13 and 14 for high conflict test

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
A1	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
A2	9	9	9	9	8	9	8	9	9	8	9	8	8	8	9	8	9	9	9	9	8
A3	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
A8	8	8	8	8	7	8	8	8	8	8	8	8	7	8	8	8	8	8	8	8	8
A9	8	7	7	8	8	7	8	7	8	8	8	8	7	8	7	8	8	8	8	8	8
A10	7	8	7	8	8	7	8	8	7	8	7	8	7	8	8	8	8	7	7	7	8
A11	7	7	7	7	7	7	7	7	7	8	8	7	8	7	8	7	7	7	7	7	7
A12	7	7	7	7	7	7	7	7	8	7	7	7	7	7	7	8	7	7	7	7	7
A13	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
A14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
A15	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
A16	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7

Figure B: raw data (evaluation of weight matrix) in Saaty set equal to the language expression that was approved by at least two of the officials responsible for the case was adopted. This language expression was converted to its corresponding value in Neutrosophic using the same table (last column), and a weighting matrix was created, which was subsequently used in applying the steps of ELECTRE-VIKOR and other tests in tables 13 and 14 for low conflict test

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21
A1	0.8981	0.7491	0.7455	0.7243	0.7708	0.7488	0.7464	0.7309	0.7416	0.7171	0.7519	0.7344	0.742	0.758	0.7443	0.7439	0.7441	0.729	0.7525	0.7632	0.7514
A2	0.6924	0.6898	0.6792	0.5591	0.667	0.678	0.558	0.6842	0.6676	0.5893	0.6943	0.6694	0.5979	0.6764	0.6973	0.5856	0.6768	0.665	0.5784	0.7018	0.6707
A3	0.9744	0.9408	0.9421	0.9339	0.943	0.9155	0.9762	0.9386	0.9548	0.9463	0.9719	0.9161	0.9452	0.9442	0.967	0.9335	0.9474	0.9268	0.9506	0.9587	0.9236
A4	0.9372	0.9335	0.9275	0.9335	0.9097	0.9182	0.9306	0.916	0.928	0.9096	0.914	0.9097	0.9073	0.9099	0.9198	0.9032	0.9235	0.9449	0.9311	0.9191	0.9067
A5	0.783	0.7699	0.7869	0.7532	0.7415	0.7423	0.75	0.7349	0.7724	0.7525	0.7553	0.76	0.7391	0.7471	0.7701	0.7693	0.7534	0.7872	0.7404	0.7548	0.7565
A6	0.8344	0.8151	0.792	0.823	0.8073	0.8009	0.7915	0.8183	0.8219	0.8006	0.8178	0.7928	0.822	0.8107	0.8072	0.8085	0.823	0.8213	0.8179	0.8121	0.8112
A7	0.6997	0.6955	0.7063	0.7115	0.6857	0.7008	0.721	0.6779	0.6076	0.6949	0.6958	0.7243	0.7002	0.6896	0.7093	0.691	0.7169	0.7046	0.72	0.6901	0.7455
A8	0.8093	0.8036	0.8102	0.7953	0.7635	0.8156	0.8328	0.8066	0.7986	0.798	0.7982	0.8003	0.7832	0.7922	0.795	0.8037	0.7956	0.8074	0.7974	0.8148	0.8032
A9	0.8355	0.8473	0.8389	0.857	0.8528	0.8728	0.8191	0.8383	0.8324	0.8424	0.8531	0.8447	0.8097	0.8354	0.8524	0.8435	0.8514	0.8267	0.837	0.8428	0.8462
A10	0.7789	0.7974	0.7856	0.8096	0.7967	0.7899	0.7556	0.789	0.7863	0.7922	0.7957	0.774	0.7924	0.7716	0.8093	0.76	0.7536	0.7552	0.7566	0.7632	0.8093
A11	0.8225	0.8311	0.8057	0.816	0.8205	0.7994	0.8247	0.8327	0.8071	0.8253	0.8003	0.8194	0.7958	0.8368	0.8261	0.8196	0.8084	0.8391	0.8495	0.7921	0.8385
A12	0.5229	0.7616	0.7803	0.8035	0.8279	0.7863	0.7907	0.7866	0.81	0.7857	0.8002	0.7852	0.7709	0.7947	0.7975	0.8094	0.7863	0.7807	0.7984	0.7936	0.7942
A13	0.8389	0.8754	0.8508	0.8404	0.8529	0.8815	0.8518	0.8593	0.8546	0.8447	0.8329	0.8448	0.8469	0.8588	0.8426	0.854	0.8543	0.8523	0.839	0.8588	0.8577
A14	0.7451	0.7499	0.7067	0.7502	0.7514	0.7031	0.7794	0.7635	0.7911	0.7719	0.7943	0.7775	0.7934	0.7716	0.7517	0.8067	0.7408	0.767	0.7595	0.7469	0.7736
A15	0.833	0.8318	0.8199	0.8387	0.8318	0.8469	0.848	0.8328	0.8244	0.8204	0.8364	0.8312	0.8248	0.8307	0.8207	0.8406	0.8233	0.8484	0.8361	0.8389	0.8136
A16	0.7333	0.7068	0.707	0.6994	0.7385	0.7162	0.741	0.7083	0.7124	0.7214	0.7338	0.7209	0.7232	0.7202	0.7227	0.7033	0.7212	0.7172	0.7191	0.7274	0.6978

Figure C A normalized weights of decision matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	
	0.0402	0.0402	0.0402	0.0402	0.0402	0.0402	0.0462	0.0462	0.0462	0.0462	0.0462	0.0462	0.0462	0.0462	0.0462	0.0462	0.0462	0.0893	0.0893	0.0893	0.0893	Alternatives rank
A1	0.5902	0.5352	0.491	0.4468	0.9418	0.4378	0.4528	0.4018	0.4332	0.4342	0.3038	0.4038	0.484	0.518	0.4638	0.4673	0.4682	0.488	0.808	0.5204	0.8028	0.7A
A2	0.3948	0.3788	0.5894	0.3392	0.534	0.358	0.358	0.3084	0.3982	0.3788	0.3888	0.5583	0.5883	0.5529	0.5948	0.5732	0.3038	0.39	0.3688	0.4036	0.5414	0.80
A3	0.9488	0.8818	0.8942	0.8378	0.928	0.831	0.9524	0.5772	0.5058	0.5928	0.9438	0.5382	0.5904	0.9604	0.94	0.867	0.5048	0.5739	0.9012	0.9174	0.837	0.80
A4	0.5744	0.587	0.558	0.557	0.9194	0.5934	0.912	0.832	0.838	0.3152	0.029	0.3154	0.3148	0.3189	0.5583	0.8084	0.347	0.0599	0.8022	0.8342	0.3134	0.80
A5	0.528	0.5288	0.5738	0.5104	0.483	0.4846	0.5	0.4888	0.5448	0.509	0.5108	0.52	0.4752	0.4842	0.8402	0.5588	0.5088	0.5744	0.4508	0.5088	0.313	0.76
A6	0.6588	0.6902	0.894	0.848	0.0146	0.0018	0.553	0.8388	0.4458	0.0012	0.6558	0.5588	0.844	0.0214	0.8144	0.017	0.848	0.0428	0.0088	0.0242	0.0224	0.81
A7	0.5974	0.591	0.4128	0.4238	0.5714	0.4176	0.402	0.3838	0.578	0.5758	0.3918	0.4458	0.4004	0.5782	0.4188	0.582	0.4538	0.4082	0.4418	0.3502	0.481	0.7
A8	0.0188	0.807	0.5204	0.5888	0.527	0.8512	0.8888	0.8152	0.557	0.858	0.8904	0.8088	0.8084	0.3844	0.57	0.8074	0.3512	0.0148	0.5548	0.6288	0.0084	0.8
A9	0.871	0.0848	0.7775	0.714	0.7258	0.7468	0.8552	0.8888	0.8948	0.8848	0.7082	0.8894	0.0194	0.8708	0.7048	0.687	0.7028	0.6734	0.874	0.6888	0.0324	0.8A
A10	0.8578	0.9848	0.571	0.0172	0.5834	0.5788	0.5112	0.578	0.3728	0.3844	0.3914	0.848	0.3848	0.8432	0.0188	0.52	0.5072	0.3104	0.5332	0.5284	0.0188	0.78
A11	0.048	0.0022	0.0114	0.032	0.041	0.8888	0.4084	0.8084	0.0142	0.8888	0.8088	0.0088	0.3818	0.8738	0.8022	0.0592	0.0188	0.8782	0.808	0.8942	0.077	0.02
A12	0.0488	0.9222	0.8088	0.007	0.8888	0.5728	0.5914	0.5732	0.82	0.5714	0.0004	0.5704	0.8418	0.8894	0.885	0.0188	0.5788	0.5014	0.5888	0.5872	0.5884	0.78
A13	0.8778	0.7888	0.7018	0.8888	0.7058	0.763	0.7038	0.7188	0.708	0.0004	0.8088	0.8888	0.7178	0.7252	0.723	0.7038	0.7288	0.6774	0.7378	0.7184	0.88	
A14	0.5902	0.4988	0.5734	0.5224	0.8028	0.8002	0.9988	0.527	0.5922	0.3438	0.5888	0.508	0.5888	0.8432	0.8034	0.0194	0.5228	0.534	0.319	0.5338	0.5472	0.77
A15	0.088	0.0838	0.0538	0.0714	0.0038	0.0038	0.888	0.8088	0.4458	0.4068	0.7228	0.8348	0.8488	0.8014	0.8414	0.881	0.8488	0.8888	0.8722	0.6778	0.0272	0.88
A16	0.4088	0.4138	0.414	0.3888	0.477	0.4324	0.452	0.4108	0.4308	0.4428	0.4678	0.4418	0.4404	0.4404	0.4434	0.4088	0.4424	0.4344	0.4352	0.4548	0.4198	0.72

Figure D A score function matrix after processing Neutrosophic decision weight matrix

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1	0	1	0	0	0.3015	0	0.9598	0.0402	0	0	0	0.0402	0	0.0804	0	0.9146
A2	0	0	0	0	0	0	0.1558	0	0	0	0	0	0	0	0	0
A3	1	1	0	0.8945	1	1	1	1	1	1	1	1	1	1	1	1
A4	1	1	0.1055	0	1	1	1	1	1	1	1	1	1	1	1	1
A5	0.6985	1	0	0	0	0	1	0	0	0.1508	0	0.1457	0	0.191	0	1
A6	1	1	0	0	1	0	1	0.7638	0.0452	0.9548	0.3668	0.9146	0	1	0.0402	1
A7	0.0402	0.8442	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2161
A8	0.9598	1	0	0	1	0.2362	1	0	0.0452	0.7638	0.191	0.5879	0	0.9095	0	1
A9	1	1	0	0	1	0.9548	1	0.9548	0	1	0.7337	1	0.1256	1	0.799	1
A10	1	1	0	0	0.8492	0.0452	1	0.2362	0	0	0	0.407	0	0.5126	0	1
A11	1	1	0	0	1	0.6332	1	0.809	0.2663	1	0	0.809	0.0653	1	0.2663	1
A12	0.9598	1	0	0	0.8543	0.0854	1	0.4121	0	0.593	0.191	0	0	0.9146	0	1
A13	1	1	0	0	1	1	1	1	0.8744	1	0.9347	1	0	1	0.9548	1
A14	0.9196	1	0	0	0.809	0	1	0.0905	0	0.4874	0	0.0854	0	0	0	1
A15	1	1	0	0	1	0.9598	1	1	0.201	1	0.7337	1	0.0452	1	0	1
A16	0.0854	1	0	0	0	0	0.7839	0	0	0	0	0	0	0	0	0

Figure E A concordance ELECTRE matrix

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16
A1	0	-0.0057	0.2763	0.2391	0.0649	0.1363	0.0006	0.1112	0.1374	0.0842	0.1244	0.1248	0.1407	0.067	0.1349	0.0352
A2	0.1038	0	0.3081	0.2799	0.1221	0.1562	0.0747	0.1648	0.1958	0.1395	0.1741	0.1809	0.2035	0.1235	0.1833	0.073
A3	-0.1667	-0.2375	0	0.0081	-0.1497	-0.111	-0.188	-0.0999	-0.0427	-0.1241	-0.0949	-0.1241	-0.034	-0.1268	-0.0685	-0.1982
A4	-0.139	-0.2094	0.0702	0	-0.134	-0.0853	-0.1612	-0.0732	-0.0454	-0.0973	-0.0681	-0.0818	-0.0367	-0.0965	-0.058	-0.165
A5	0.0293	-0.0412	0.2262	0.1907	0	0.0834	-0.0111	0.0828	0.1305	0.0552	0.1091	0.0864	0.1392	0.0543	0.1047	-0.003
A6	-0.0365	-0.1099	0.1846	0.1355	-0.0051	0	-0.0606	0.0413	0.0718	0.0021	0.0332	0.0206	0.0806	-0.0017	0.0564	-0.0506
A7	0.0851	0.0117	0.2773	0.2404	0.0848	0.1403	0	0.1287	0.1771	0.1111	0.1548	0.1423	0.1813	0.1157	0.1548	0.0528
A8	0.0073	-0.0853	0.1995	0.1463	-0.0149	0.0438	-0.0577	0	0.0993	0.0332	0.057	0.0644	0.0894	0.0102	0.0683	-0.025
A9	-0.0677	-0.1118	0.1571	0.1082	-0.0495	0.0124	-0.0881	0.0138	0	-0.0173	0.0144	-0.0127	0.0409	-0.0163	0.0289	-0.0781
A10	-0.0001	-0.0568	0.2206	0.1897	0.0319	0.0694	-0.0246	0.0772	0.0978	0	0.0839	0.0494	0.108	0.0467	0.0931	-0.0146
A11	-0.029	-0.0904	0.1716	0.125	-0.0188	0.0263	-0.0906	0.0227	0.0734	-0.0034	0	0.0074	0.0821	-0.0024	0.0475	-0.0647
A12	0.0075	-0.0717	0.1855	0.172	0.0084	0.0535	-0.0487	0.0421	0.0865	0.0359	0.0696	0	0.1138	0.0225	0.0702	-0.0477
A13	-0.0809	-0.1385	0.1391	0.0984	-0.0639	-0.0044	-0.1122	-0.019	0.0203	-0.0319	0.0108	-0.0159	0	-0.0386	0.0035	-0.099
A14	0.0193	-0.0544	0.2153	0.1837	0.0201	0.0693	-0.0282	0.0536	0.1114	0.0576	0.09	0.0765	0.1255	0	0.0819	-0.013
A15	-0.0611	-0.1234	0.1463	0.1076	-0.0331	0.0014	-0.0681	-0.0097	0.0326	-0.0042	0.025	-0.0039	0.0441	-0.0315	0	-0.0933
A16	0.0622	-0.0167	0.2443	0.2351	0.0799	0.1246	0.0357	0.1033	0.1586	0.1102	0.1304	0.1061	0.1685	0.1035	0.1373	0

Figure F A discordance ELECTRE matrix