Multi-Criteria Decision-Making in Sustainable Development

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Achieving sustainability, particularly in cleaner production, demands a multifaceted decision-making process influenced by numerous subjective criteria. Effective management is pivotal in shaping sustainable development worldwide, necessitating the selection, development, and evaluation of project managers with the requisite skills. Multi-criteria decision-making (MCDM) provides a systematic framework for evaluating alternatives based on multiple criteria, a necessity in today's intricate decision-making. The research exploration focuses on two notable MCDM methods: the SWARA and the ARAS. These methods enable decision-makers to handle subjective criteria comprehensively.

Keywords: multi-criteria decision-making (MCDM) ; sustainable development

1. Introduction

In today's global landscape, the convergence of economic growth and technological progress underscores the critical role of high-quality human capital in ensuring sustainable development. Achieving sustainability, particularly in cleaner production, demands a multifaceted decision-making process influenced by numerous subjective criteria [1][2]. Effective management is pivotal in shaping sustainable development worldwide, necessitating the selection, development, and evaluation of project managers with the requisite skills.

MCDM methods are valuable for considering alternative courses of action, yet they often yield varying rankings. Sustainable economic development is now a global priority, closely aligned with the United Nations Sustainable Development Goals (SDGs) [3]. Effective leadership catalyses driving sustainable development on a global scale. Recent global crises have underscored the imperative of economic sustainability [4] and increasing scrutiny of corporate governance and environmental impact [5].

Sustainability assessments have evolved over the past two decades to encompass economic, environmental, social, and institutional considerations [6][7]. At the organisational level, entities acknowledge their impact on the environment and society, highlighting the importance of integrating sustainability principles into business practices [8]. In this context, managers with specific attributes emerge as critical guides for responsible decision making, innovation, and ethical practices, all contributing to sustainable economic development [9].

Decision makers require a robust methodology to address the intricacies of this issue, ensuring a comprehensive and transparent decision-making process. It requires a method that seamlessly integrates algorithms, applied mathematics, complex variables, decision theory, decision analysis, engineering mathematics, and interdisciplinary mathematics, all of which play pivotal roles in MCDM while simultaneously acknowledging the subjective nature of criteria weights [10][11][12].

Trust, ethical decision-making, and open stakeholder communication are integral to this process [13].

Transparency and fairness are indispensable for credibility and trust [14][15]. To achieve this, engaging stakeholders through surveys, interviews, workshops, or expert panels is essential for constructing a robust and inclusive decision-making process that fully aligns with their interests and values [16][17]. The goal is to balance a systematic framework and stakeholders' viewpoints with techniques such as surveys, interviews, workshops, or expert panels facilitating stakeholder engagement in criteria weighting [18]. This holistic evaluation transcends mere cost considerations and incorporates external perspectives, thus achieving a comprehensive and equitable assessment [19].

The SHARDA methodology offers a systematic framework that accommodates stakeholders' viewpoints, ultimately ensuring an equitable and robust decision-making process. It underscores the importance of valuing stakeholder input and considering their perspectives, which in turn garners their buy-in and support [20][21].

2. Multi-Criteria Decision-Making in Sustainable Development

As decision makers delve into the MCDM problems, they must recognise the evolved methodologies to address complex decision scenarios. MCDM provides a systematic framework for evaluating alternatives based on multiple criteria, a necessity in today's intricate decision-making. The research exploration focuses on two notable MCDM methods: the SWARA and the ARAS. These methods enable decision-makers to handle subjective criteria comprehensively. SWARA aids in discerning the importance of each criterion, while ARAS facilitates the ranking and selection of optimal choices based on effectiveness ratios.

2.1. Multiple Criteria Decision Making (MCDM)

In decision making, rationality is a fundamental goal, characterised by critical attributes that persist throughout the process:

- Goal orientation: A steadfast focus on achieving intended goals.
- Relevant and objective information: Using objectively evaluated, pertinent information as the bedrock of decision making.
- Systematic and structured approach: Adherence to a clear, systematic, and organised action plan guided by methodical rules comprehensible to non-participants.

The decision-making process encompasses several stages: problem identification, preference construction, alternative evaluation, and optimal course selection. In the context of formal analysis for decision-making problems, three primary categories are considered [22][23]:

- Normative analysis: Focuses on the ideal decision-making approach.
- Descriptive analysis: Explores how decision makers make real-world decisions.
- Prescriptive analysis: Examines methods to enhance the decision-making process.

2.2. A Brief Summary of MCDM Methods

MCDM is a well-established field that encompasses Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM) [24]. It aims to make optimal decisions by considering multiple viewpoints and criteria. The MCDM process involves interconnected steps, including problem definition and identification of critical characteristics. Decision makers set clear goals, identify alternatives, and develop criteria based on requirements and priorities. The field of MCDM has made significant advancements, offering decision makers a range of techniques. Decision-making techniques derived from MCDM facilitate systematic analysis and evaluation of alternatives. Stakeholders prioritise criteria aligning with the company's vision, offering benefits, promoting transparency, and facilitating structured decision making. According to Zadeh [25], it is challenging for conventional quantification to reasonably express overtly complex or hard-to-define situations. Hence, the notion of a linguistic variable is necessary in such cases. Regular review and updating of criteria are essential.

Method selection in MCDM requires careful consideration of the problem. Scholars have proposed various MCDM approaches, including WSM [26], ELECTRE [27], SAW [28], DEA [29], AHP [30][31][32], ANP [33], TOPSIS [34], PROMETHEE [35] [36], and VIKOR [37], among others. Fuzzy sets [38][39][40][41] effectively handle uncertainty and capture vagueness.

While scholars often prefer complex problem-solving models and their extensions, relying on fictitious case studies or inputs from other studies, decision makers lean towards simple and efficient methods for complex problems, and there is a tendency to refrain from using any method.

2.3. Weighting Methods in MCDM: A Concise Overview

The debate surrounding objectivity versus subjectivity in weighting methods encompasses philosophical and methodological dimensions. While proponents argue for objective criteria, the weights assigned often prove to be subjective and context-dependent.

From a philosophical standpoint, individuals' values and criteria importance is subjective due to personal experiences and beliefs. Different perspectives, priorities, and preferences can lead to varying assessments and weights.

Incorporating experts and stakeholders with domain knowledge is crucial for evaluating criteria and facilitating informed, though subjective, decision making. Recognising subjectivity in weighting criteria is vital for decision makers, as subjective methods consider preferences and judgments. Subjective weighting methods may require more time and consensus among decision makers, but provide transparent explanations of weight determination. Involving experts and stakeholders allows for a comprehensive assessment, yielding a deeper understanding of the problem and potential solutions.

Examples of subjective methods include swing weighting, graphical weighting, pairwise comparison (e.g., AHP), Delphi [42], nominal group technique, simple multi-attribute rating technique (SMART) [43], and others such as the eigenvector method, AHP [31][32], ANP [33], FARE [44], SWARA [45], and additional methods.

A comparative study by Eckenrode [46] examined six subjective methods for assessing criteria weights—Ranking, rating, three paired comparison methods (Partial I, Partial II, and Complete), and successive comparisons—and found no significant differences.

On the other hand, objective weighting methods offer computational efficiency, deriving criteria weights mathematically, independent of decision makers' preferences. Notable objective methods include:

- Mean weight [47]: Distributes weights evenly among all criteria when information is scarce or lacks decision-maker input.
- Standard deviation [48]: Assigns weights based on the standard deviations of criteria values, giving smaller weights to similar criteria values.
- Statistical variance procedure: Determines weights based on the statistical variance of information.
- Entropy method [49][50]: Objectively assigns weights based on criterion value entropy, with lower entropy indicating higher importance.
- Criteria importance through inter-criteria correlation (CRITIC): Utilises correlation analysis to measure each criterion's value [50].

While objective methods offer computational efficiency, subjective methods consider decision makers' preferences transparently [51]. Studies have shown different weights generated by these methods, indicating the need to consider the specific context and goals.

In summary, decision makers face the challenge of balancing objectivity and subjectivity in weighting criteria, with various methods available to address different contexts and preferences.

Building upon the rich foundation of MCDM methods, the research introduces SHARDA methodology. SHARDA stands as a significant evolution, seamlessly integrating the strengths of SWARA and ARAS into a unified framework.

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