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SHARDA–ARAS: A Methodology for Prioritising Project Managers in Sustainable Development

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Abstract: In sustainable economic development, top-level human capital, especially project management, is paramount. This article integrates the Systematic Hierarchical Attribute Ratio Delphic Rating (SHARDA) method and the Additive Ratio Rating (ARAS) method as a robust framework for identifying and training project managers. The research draws on a diverse panel of experts against the United Nations Sustainable Development Goals (SDGs) backdrop, emphasising stakeholder engagement and transparency in the decision-making processes. This study investigates the complexity of multi-criteria decision-making (MCDM) methods and focuses on SWARA and ARAS methods. These methodologies comprehensively improve the decision-making process, considering a range of subjective criteria. The extended and modified hierarchical SWARA method helps us understand each measure's importance, while the ARAS method simplifies ranking and selection based on performance ratios. The research methodology seamlessly integrates these methods to form the SHARDA–ARAS methodology that addresses the challenging task of selecting project managers for sustainable development. This methodology guarantees a systematic and inclusive decision-making process, incorporating stakeholder perspectives seamlessly aligned with global sustainability goals. The studio's innovation is wrapped in the synthesis of SWARA and ARAS into the SHARDA–ARAS methodology, presenting a nuanced and effective tool for project manager selection. Promoting an interconnected and holistic approach that contributes to sustainable development emphasises the methodology's ability to balance economic, environmental, and social aspects. Thus, the article provides an invaluable method for organisations seeking global sustainable economic development.

Keywords: Systemic Hierarchical Attribute Ratio Delphic Assessment method; SHARDA; MCDM; sustainability; SWARA; ARAS; hierarchy

MSC: 90B50; 90C29; 91A35; 91B06

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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 [10–12].

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]. This article highlights the critical role played by algorithms, applied mathematics, complex variables, decision theory, decision analysis, engineering mathematics, and interdisciplinary mathematics in the holistic approach of selecting and developing project managers with the requisite skills for sustainable economic development. It introduces the Systemic Hierarchical Attribute Ratio Delphic Assessment (SHARDA) methodology as a valuable and integrated framework for informed and objective decision-making.

2. Literature Review

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 [30–32], ANP [33], TOPSIS [34], PROMETHEE [35,36], and VIKOR [37], among others. Fuzzy sets [38–41] 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. The paper presents a generic MCDM model that illustrates fundamental concepts and steps.

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.

3. Materials and Methods

This study pioneers a distinctive research approach to foster stakeholder engagement in the intricate realm of sustainable economic development decision making. The methodology intertwines qualitative and quantitative research designs, leveraging primary and secondary data sources to attain a nuanced and comprehensive perspective. This study outlines a new research approach for stakeholder engagement in sustainable economic development decision making. The methodology combines qualitative and quantitative data to integrate stakeholder perspectives into the criteria weighting process, enhancing decision-making integrity.

- Study design: The research design artfully combines qualitative and quantitative methodologies, each playing a distinct yet synergistic role in the investigation. Through its exploratory nature, qualitative research delves into the intricacies of stakeholder perceptions and experiences. Concurrently, quantitative research lends to a structured, numerical framework, allowing for rigorous analysis and measurement.
- Qualitative research design: The qualitative component involves an exploratory research design, facilitating a deeper understanding of stakeholder perspectives. This design uses in-depth interviews, workshops, and expert panels to uncover nuanced insights, motivations, and contextual factors influencing decision making in sustainable economic development.
- Quantitative research design: The quantitative arm employs a descriptive research design, systematically quantifying and analysing specific aspects of the decision-making process. Surveys form a crucial instrument in this phase, generating structured data that can be statistically analysed to derive meaningful patterns, correlations, and trends.
- Data collection: A structured Delphi process encompassing surveys, interviews, workshops, and expert panels to acquire stakeholder input. The qualitative data collection methods contribute rich, qualitative insights, while surveys offer a quantifiable dataset, combining to provide a holistic understanding of stakeholder perspectives.
- Criteria weight determination: Introducing the SHARDA method, the research adopts a hierarchical approach to systematically evaluate the relative importance of criteria and sub-criteria. This method provides a structured and transparent process for stakeholders to assign weights, ensuring a robust foundation for decision making. Evaluation of choice options performance and analysis: The ARAS method is applied quantitatively to assess project manager performance and determine optimality. This

approach utilizes effectiveness ratios and offers a quantitative lens to the decision-making process, enabling precise comparisons among alternatives.

Validation and analysis: Experts critically examine factors influencing decision outcomes in the validation and analysis phase. The SHARDA method is rigorously tested through expert opinions and benchmarking practices, ensuring its validity, reliability, and relevance in sustainable economic development. Sample selection: The study includes stakeholders from diverse groups relevant to sustainable economic development. The selection of experts is based on considerations of relevance, expertise, and active involvement, ensuring a representative and comprehensive set of perspectives. Table 1 presents the experts' qualifications and additional conditions. Ethical considerations: Adherence to ethical guidelines is paramount. The research team ensures informed consent, confidentiality, and a profound respect for the rights of participants. The study is conducted in full compliance with ethical regulations governing research involving human participants, upholding the highest standards of ethical conduct. The study emerges as a systematic approach for selecting and developing project managers in sustainable economic development. What sets the proposed methodology apart is its resilience against rank reversals and its ability to quantify the direct ratio of each considered choice concerning the optimal (Pareto) solution.

Table 1. The experts' qualifications and additional conditions.

	Expert	Qualifications	Additional Conditions
E_1	Project Management Expert	Extensive experience in project management methodologies and practices	Familiarity with challenges and requirements of managing projects in sustainable development
		Profound understanding of characteristics and competencies expected from project managers	
E_2	Sustainable Development Specialist	Expertise in sustainable development principles, frameworks, and strategies	Knowledge of sustainability's environmental, social, and economic aspects
		Understanding of the role of project managers in integrating sustainable practices into project initiatives	
E_3	Decision-Making and MCDA Expert	Expertise in decision-making processes and methodologies	Familiarity with MCDA techniques and their application in evaluating criteria weights
		Insights into the appropriateness and effectiveness of the SHARDA method in the given context	
E_4	Academics and Researchers	Specialisation in project management, sustainable development, or related disciplines	Conducts research in project management and sustainable economic development
		Theoretical knowledge and expertise in evaluating criteria and decision-making methodologies	
E_5	Industry Practitioner	Practical experience as a project manager or executive in organisations involved in sustainable economic development	Understanding of challenges in selecting and developing project managers in this domain
		Insights into the applicability and relevance of the SHARDA method in real-world scenarios	
E_6	Stakeholder Representative	Represents stakeholders such as government bodies, NGOs, or community representatives	Provides a broader perspective on social and environmental dimensions of sustainable economic development
		Offers insights into criteria that align with the interests and values of stakeholders	

3.1. A Generic MCDM Model

A distinguishing feature of SHARDA is its emphasis on stakeholder involvement and transparency. The research recognises that decisions with far-reaching impacts require diverse perspectives. SHARDA ensures a comprehensive decision-making process that aligns seamlessly with global sustainability objectives.

By crafting a narrative that seamlessly transitions from the broader MCDM environment to the specifics of SHARDA, decision makers can follow a logical progression, understanding the context and significance of the introduced methodology.

In the realm of MCDM, the generic model (Figure 1) offers a systematic approach to decision making. The generic MCDM model emphasises problem definition, criteria identification, alternative generation, evaluation, and sensitivity analysis for optimal decision outcomes. The expert panel process involves a structured and collaborative approach guided by a neutral moderator or facilitator. The moderator plays a crucial role in guiding the process and ensuring productive exchanges of ideas among panel members. The panel provides expertise and knowledge to determine criteria weights and values through discussions, assessments, and consensus building.

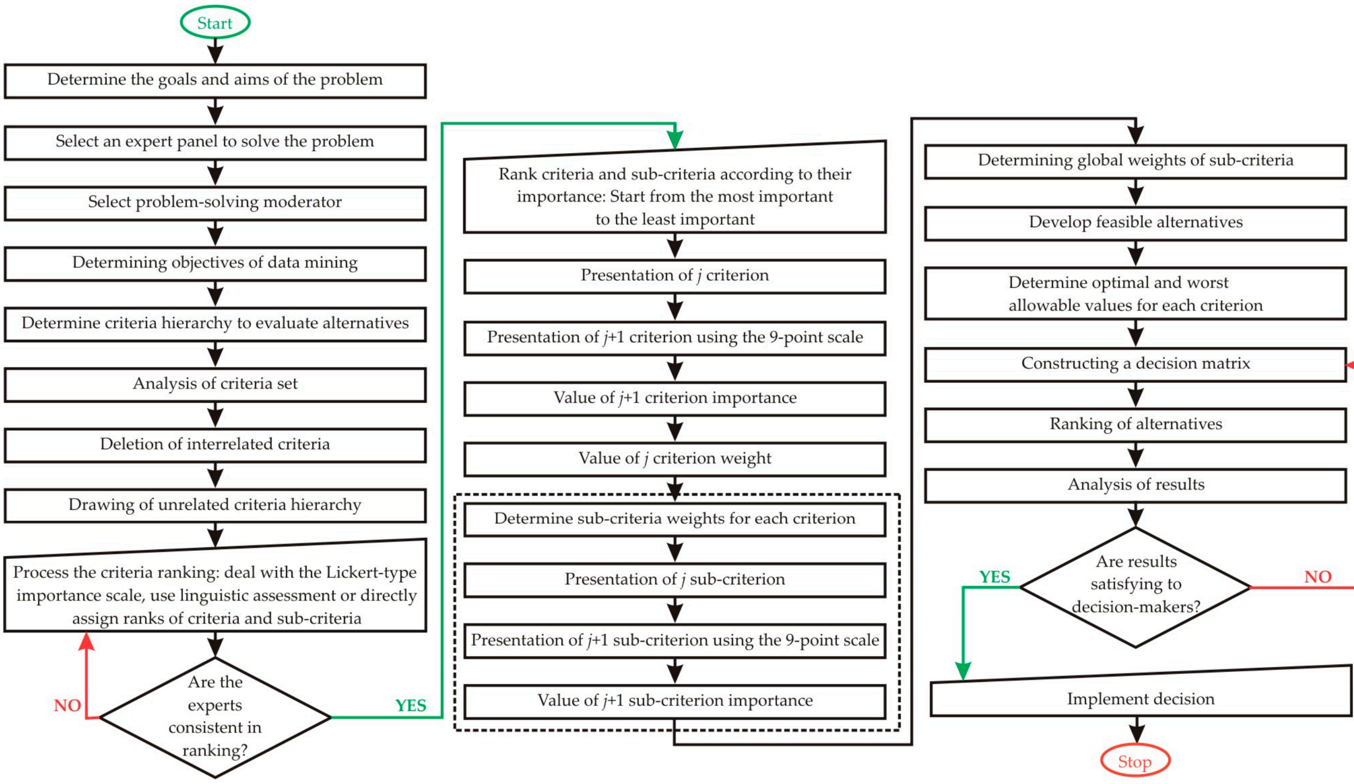

Figure 1. The multiple criteria expert system for personnel selection (developed by the authors).

The main steps include:

- Moderator's presentation: Introduction of the decision problem, objectives, and criteria.
- Problem domain definition: Examine problem characteristics, considering alternatives, attributes, constraints, and relevant factors.
- Discussion and knowledge sharing: Panel members' meetings and expertise sharing on criteria importance and relative weights.
- Criteria and objectives identification: Specify and prioritise criteria and objectives.
- Eliciting judgments and perspectives: Open discussions or structured exercises elicit panel members' judgments and perspectives.
- Determining criteria weights: The expert panel assigns relative weights, considering relevance, impact, feasibility, and trade-offs.
- Weight criteria: Determine relative criterion importance by assigning weights.
- Calculate overall scores: Multiply ratings by weights and sum up to obtain overall scores.

- Define rating scale: Establish a quantified rating scale for assessing candidates' proficiency levels.
- Alternative generation: Create diverse options or courses of action.
- Gather alternative information: Collect relevant alternative information through resumes, interviews, etc.
- Evaluation against criteria: Assess each alternative's performance using qualitative or quantitative techniques. Appoint evaluators, provide consistent instructions, and ensure information consistency.
- Consensus building: The facilitator aggregates opinions and judgments to reach a consensus on criteria, weights, and values.
- Aggregate evaluations and calculate scores: Combine evaluations and calculate overall scores, considering criteria and their weights.
- Analysis, validation, and decision making: Analyse results, validate with real-world data or expert opinions, and make the final decision for implementation.

By adhering to these steps, decision makers effectively analyse and evaluate alternatives, facilitating informed decisions and successful implementation.

Using the SHARDA method, stakeholders assembled a diverse expert panel for a Delphi study, evaluating project managers' characteristics in sustainable economic development. Table 1 summarises the expert qualifications and additional conditions they meet.

With their respective qualifications and additional conditions, these experts form a diverse panel capable of evaluating project managers for sustainable project implementation using the SHARDA method.

The experts using the Delphic process formed the two-level criteria set helpful for solving the considered problem (Table 2).

Table 2. Two-level criteria set.

	Level 1		**Level 2**
	Overall Criteria		Sub-Criteria
x_1	Leadership Abilities	$x_{1.1}$	Strategic Vision
		$x_{1.2}$	Decision-Making Skills
		$x_{1.3}$	Team Building and Motivation
x_2	Technical Expertise	$x_{2.1}$	Industry Knowledge
		$x_{2.2}$	Project Management Skills
		$x_{2.3}$	Problem-Solving and Analytical Abilities
x_3	Communication Skills	$x_{3.1}$	Verbal and Written Communication
		$x_{3.2}$	Active Listening
		$x_{3.3}$	Stakeholder Engagement and Relationship Building
x_4	Adaptability and Flexibility	$x_{4.1}$	Ability to Manage Change
		$x_{4.2}$	Resilience and Stress Management
		$x_{4.3}$	Learning and Development Orientation
x_5	Ethical and Social Responsibility	$x_{5.1}$	Environmental Awareness
		$x_{5.2}$	Social Impact Consideration
		$x_{5.3}$	Ethical Decision Making

The hierarchical structure enables more detailed analysis and an assessment of project managers' strengths and weaknesses, facilitating informed decision making in selecting and developing project managers for sustainable economic development initiatives.

3.2. Enhancing the SWARA Method with the Delphic Process for Criteria Weight Determination in Group MCDM–SHARDA (Systemic Hierarchical Attribute Ratio Assessment) Method

Decision makers in MCDM, more than traditional attribute weights, are needed to adequately represent varying attribute significance, as these weights are typically assigned based on expert preferences. In 2010, the stepwise weighted valuation ratio analysis (SWARA) methodology was introduced to address this issue in initial dispute resolution. Decision makers in sustainable economic development require systematic approaches for determining criteria weights and evaluating choices. It led to the emergence of the SHARDA method, which integrates a hierarchical structure and the expanded SWARA technique.

Main steps in the SHARDA method:

a. Decision-making process using SHARDA: Involves assembling an expert panel, ensuring anonymity in their opinions, and employing the Delphic process to gather expert opinions and achieve consensus.
b. Problem definition and hierarchy: Decision makers define the problem, identify relevant criteria, and establish a hierarchical structure.
c. Enhanced SWARA for criteria: Decision makers utilise the SWARA method to evaluate criteria weights.
d. Enhanced SWARA for sub-criteria: Decision makers utilise the SWARA method to evaluate sub-criteria weights within each criterion group.
e. Weight assignment for criteria groups and aggregating expert opinions: Relative weights are assigned to criteria groups, considering project requirements and priorities. Expert opinions are combined to determine criteria weights at each hierarchy level.
f. Evaluation of candidate qualifications: Candidates are evaluated based on specific criteria such as leadership abilities, technical expertise, communication skills, adaptability, and ethical and social responsibility.
g. Criteria values normalisation: Criteria values are normalised using standard scaling techniques.

Criteria weight determination using the expanded SWARA method (Figure 2)*:* The SWARA method offers a systemic process to determine criteria consequences. It starts with defining the decision problem and identifying the evaluation criteria. Criteria weights aid decision makers in further analyses, such as ranking alternatives or evaluating options.

Criteria weight calculation:

Decision makers assign criteria weights at the highest hierarchy level. Firstly, the moderator ranks criteria and sub-criteria in descending importance order. For this study, the authors selected the Eckenrode rating technique based on criteria importance ratings (r_i) (Table 3).

Each of the experts rates all criteria in the given hierarchy level:

r_{ki}.

The k is $k = 1, \ldots, l$.

The l is the number of experts.

The moderator calculates sums of given importance ratings to each criterion r_{ki} and the sum of ratings given to all criteria importance in the considered hierarchy level, and then divides geomeans of ratings R_j given to each criterion by the sum of ratings given to all criteria importance P.

$$R_j = \sqrt[n]{\prod_{k=1}^{l} r_{kj}}\ j = \overline{1,\ n} \quad (1)$$

$$P = \sum_{j=1}^{n} R_j \quad (2)$$

$$t_j = \frac{R_j}{P} \quad (3)$$

n is the number of criteria in the considered hierarchy level, and t_j is the relative significance of the criterion. It helps to assign ranks to all criteria in the regarded hierarchy level and rank criteria in descending order according to their importance level.

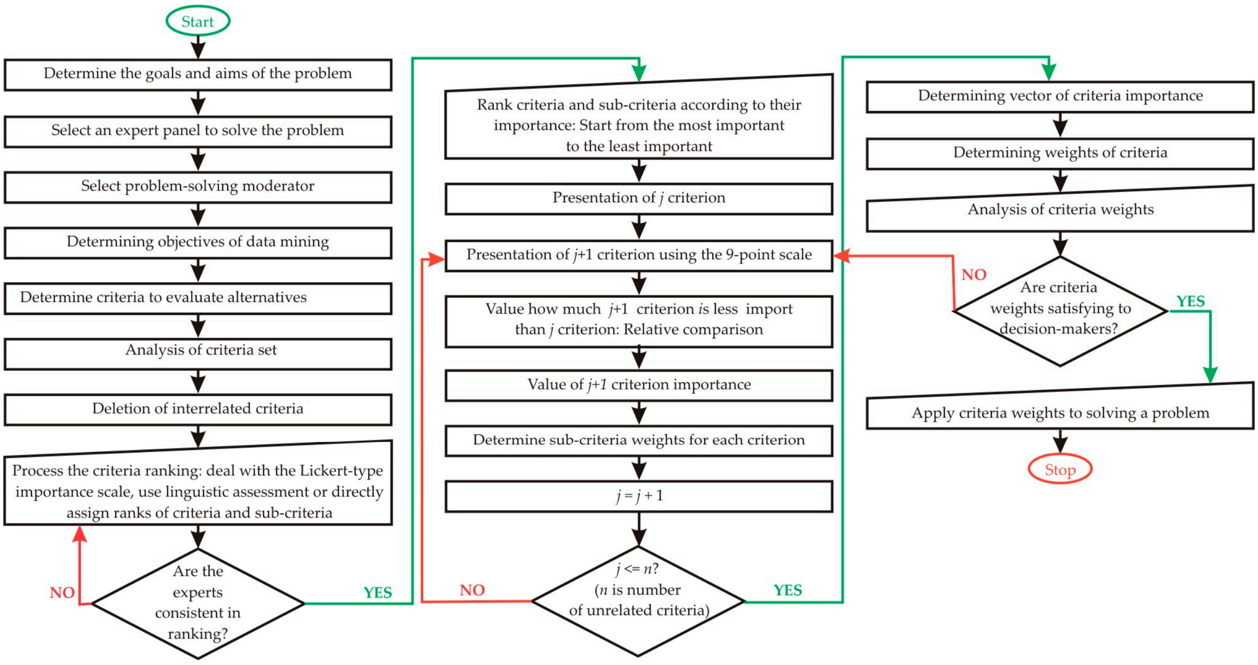

Figure 2. Determining the criteria weights using the expanded SWARA method (developed by the authors).

Table 3. The ten-point Likert-type relative importance scale (r_i) for assessing managers' qualitative skills.

Relative Importance	Definition
1	Not Important: The skill is deemed unimportant or has no significant impact on managerial performance and effectiveness.
2	Slightly Important: The skill has minimal importance and contributes only marginally to managerial performance and effectiveness.
3	Somewhat Important: The skill holds some importance, but its contribution is relatively modest compared to other skills.
4	Moderately Important: The skill possesses a moderate level of importance and has a noticeable impact on managerial performance and effectiveness.
5	Important: The skill is essential and significantly affects managerial performance and effectiveness.
6	Quite Important: The skill substantially influences managerial performance and effectiveness.
7	Very Important: The skill is essential and is a significant factor in determining managerial performance and effectiveness.
8	Extremely Important: The skill is critical in managerial performance and effectiveness.
9	Absolutely Important: The skill comprehensively evaluates managerial performance and effectiveness.
10	Most Critically Important: The skill is the most critically important and is statistically significant in assessing managerial performance and effectiveness.

Each decision maker assigns criterion importance (s_1) to the first criterion (x_1), where $j = 1$:

$$\begin{aligned} v_1 &= 1; \\ s_1 &= 1. \end{aligned} \tag{4}$$

The coefficient s (s_{j+1}) helps to determine the importance ratio of criterion $(j+1)$ compared to criterion (j):

$$s_{j+1} = \frac{s_{j+1}}{s_j}. \tag{5}$$

Decision makers determine the importance level of each criterion determined using the Equation (6):

$$v_{j+1} = v_j s_{j+1}. \tag{6}$$

Decision makers determine the relative importance weights of each criterion calculated using Equation (7):

$$q_j = \frac{v_j}{\sum_{j=1}^{n} v_j}. \tag{7}$$

The moderator calculates the sums of assigned coefficients (s_{j+1}) for each criterion (S_j), and then for all criteria (S_g).

$$S_j = \sum_{l=1}^{p} s_j; \tag{8}$$

$$S_g = \sum_{j}^{n} S_j. \tag{9}$$

Equation (10) helps to calculate criteria weights:

$$w_j = \frac{S_j}{S_g}. \tag{10}$$

In the second stage, decision makers prepare tables for calculating criteria weights using the expanded SWARA method (Tables 2 and 3), which show calculation results). These tables allow experts to determine criteria weights based on group ranks established through the SWARA process (Table 4).

Table 4. The six experts' importance assessment of each criterion using the ten-point Likert-type relative importance scale (r_i) (Table 3).

	Criteria	**E$_1$**	**E$_2$**	**E$_3$**	**E$_4$**	**E$_5$**	**E$_6$**	**Median**	**Geometric Mean**	**Rank**
x_1	Leadership Abilities	8.5	9	8	9.5	9	9	9.0	8.82	1
x_2	Technical Expertise	9	8.5	8.5	8	8	8.5	8.5	8.41	2
x_3	Communication Skills	8	8	8	8	7	9	8.0	7.98	3
x_4	Adaptability and Flexibility	8	7	8	8	8	7.5	8.0	7.74	4
x_5	Ethical and Social Responsibility	6	9.5	7	6	6.0	6.0	6.0	6.65	5

For instance, the expert must evaluate criterion x_5 as the least significant or at least as equally significant as criterion x_4, and criterion x_1 must be assessed as the most significant or equally significant as criterion x_2. Each of the experts first presents essential criteria. The most significant criterion is rank 1, and the least significant criterion is rank 5. The basis of the overall ranks of the expert group is the sum values of ranks. According to the calculations by applying SWARA, group criteria and weights were established, as shown in Tables 4–9. The SHARDA method's application of the SWARA method results in group criteria and weights, enhancing objectivity and transparency throughout the decision-making process.

Table 5. The pair-wise comparison nine-level importance ratio scale (developed by authors based on Saaty [44]).

Intensity of Importance	*s*	Definition
0	1.0	Criterion j and $j + 1$ are equally essential or of equal significance
0.1	0.9	Criterion i is slightly more important than criterion $j + 1$
0.2	0.8	Criterion i is moderately more critical than criterion $j + 1$
0.3	0.7	Criterion i is considerably more important than criterion $j + 1$
0.4	0.6	Criterion i is significantly more critical than criterion $j + 1$
0.5	0.5	Criterion i is substantially more critical than criterion $j + 1$
0.6	0.4	Criterion i is very strongly more critical than criterion $j + 1$
0.7	0.3	Criterion i is extremely more critical than criterion $j + 1$
0.8	0.2	Criterion i is absolutely more important or most critically important compared to criterion $j + 1$
0.9	0.1	Criterion i is of maximum importance compared to criterion $j + 1$

Table 6. The importance assessment (s_j) (Table 5) of each criterion by the six experts.

Criteria	E_1	E_2	E_3	E_4	E_5	E_6				v_j	q_j
x_1	1	1	1	1	1	1	1	1	1	1	0.234
x_2	1	0.9	1	0.8	0.9	0.9	0.9	0.91	2	0.914	0.214
x_3	0.9	0.9	1	1	0.9	1	1.0	0.95	3	0.867	0.203
x_4	1	0.9	1	1	1	0.8	1.0	0.95	4	0.821	0.192
x_5	0.7	1	0.9	0.8	0.7	0.9	0.9	0.83	5	0.678	0.158
			n—number of criteria; k—number of experts. $\sum$ =					4.64		4.280	1.000

Table 7. Importance assessment of sub-criteria by experts using the ten-point Likert-type relative importance scale (r_j) (presents Table 3).

	$x_{1.1}$	$x_{1.2}$	$x_{1.3}$	$x_{2.1}$	$x_{2.2}$	$x_{2.3}$	$x_{3.1}$	$x_{3.2}$	$x_{3.3}$	$x_{4.1}$	$x_{4.2}$	$x_{4.3}$	$x_{5.1}$	$x_{5.2}$	$x_{5.3}$
E_1	9	8	7	9	8	7	9	8	7	8	7	8	9	8	9
E_2	8	7	9	7	8	9	8	9	9	7	8	7	7	9	8
E_3	7	9	8	8	9	8	7	8	7	9	7	9	8	7	7
E_4	8	8	7	7	7	8	9	7	8	8	9	7	7	8	9
E_5	9	7	9	9	7	9	7	9	9	7	8	8	8	9	7
E_6	7	9	8	8	8	7	8	8	7	9	7	9	7	7	8
$\sum$	51	44	47	47	50	44	38	44	41	52	41	44	48	40	39
Geomean	8.46	7.32	7.78	7.78	8.3	7.27	6.29	7.29	6.703	8.65	6.8	7.29	7.94	6.63	6.38
$\sum$Geomeans		23.6			23.3			20.28			22.7			20.9	
q	0.36	0.31	0.33	0.33	0.36	0.31	0.31	0.36	0.33	0.38	0.30	0.32	0.38	0.32	0.30
Rank	1	3	2	2	1	3	3	1	2	1	3	2	1	2	3

Table 8. Importance assessment of sub-criteria (S-C) by experts (s_i) (Table 5).

	$x_{1.1}$	$x_{1.3}$	$x_{1.2}$	$x_{2.2}$	$x_{2.1}$	$x_{2.3}$	$x_{3.2}$	$x_{3.3}$	$x_{3.1}$	$x_{4.1}$	$x_{4.3}$	$x_{4.2}$	$x_{5.1}$	$x_{5.2}$	$x_{5.3}$
E_1	1	0.9	0.9	1	1	0.8	1	1	1	1	1	0.8	1	0.8	0.8
E_2	1	1	0.8	1	0.9	0.9	1	1	0.8	1	1	1	1	1	0.9
E_3	1	1	1	1	0.9	0.9	1	0.8	0.8	1	1	0.8	1	0.8	0.8
E_4	1	0.8	0.8	1	1	1	1	1	1	1	0.8	0.8	1	1	1
E_5	1	1	0.8	1	1	1	1	1	0.8	1	1	1	1	1	0.8
E_6	1	1	1	1	1	0.8	1	0.8	0.8	1	1	0.8	1	1	1
$\sum$	6	5.7	5.3	6	5.8	5.4	6	5.6	5.2	6	5.8	5.2	6	5.6	50.3
s	0.35	0.34	0.31	0.35	0.34	0.31	0.36	0.33	0.31	0.35	0.34	0.31	0.36	0.33	00.31
Rank	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3

Table 9. Final importance of *S-C*.

	Criteria														
	x_1			x_2			x_3			x_4			x_5		
w	0.234			0.214			0.203			0.192			0.158		
S-C	$x_{1.1}$	$x_{1.2}$	$x_{1.3}$	$x_{2.1}$	$x_{2.2}$	$x_{2.3}$	$x_{3.1}$	$x_{3.2}$	$x_{3.3}$	$x_{4.1}$	$x_{4.2}$	$x_{4.3}$	$x_{5.1}$	$x_{5.2}$	$x_{5.3}$
q	0.35	0.31	0.34	0.34	0.35	0.31	0.31	0.36	0.33	0.35	0.31	0.34	0.36	0.33	0.31
w	0.082	0.073	0.080	0.073	0.075	0.066	0.063	0.073	0.067	0.067	0.060	0.065	0.057	0.052	0.049

Note: Using a ten-point scale, the values in the table represent the importance assessments of each criterion's sub-criteria by the respective experts.

Relative importance scale for the expanded SWARA method:

The authors introduce a new scale to estimate criteria weights based on their relative importance compared to other criteria (Table 5) in the expanded SWARA method.

The scale assigns values between 1.0 and 0.1 to reflect the relative importance of one criterion compared to the next. A higher value indicates a greater degree of importance.

The specific scale and values can be adjusted to suit the context of the decision problem and the decision maker's preferences.

Ten-Point Likert-Type Relative Importance Scale:

A ten-point Likert-type relative importance scale (Table 3) assesses managers' qualitative skills in various decision-making contexts. This scale allows decision makers or experts to express their agreement or disagreement with the importance of specific skills exhibited by managers, facilitating nuanced evaluations.

The SHARDA method introduces a systematic approach that combines a hierarchical structure with the expanded SWARA technique for criteria weight determination, particularly in sustainable economic development contexts. It addresses limitations, enhances objectivity, and contributes to sustainable development objectives by providing a structured approach for criteria weight determination and decision making. It promotes transparency, consensus building, and documentation throughout the process.

The scale provides a structured and systematic approach to evaluating the relative importance of different qualitative skills exhibited by managers. When using this scale, decision makers or experts assign a score from 1 to 10 to each skill based on their perception of its importance. The assigned scores enable a more nuanced understanding of the importance and impact of each skill, facilitating informed decision-making processes related to the assessment and development of managerial capabilities.

Establish reference points: Identify reference points within the range corresponding to the qualitative categories. Determine specific numerical values for each qualitative category that best reflect their qualitative distinctions. For example:

- Excellent: Assign a numerical value of 9–10, indicating a high level of knowledge.
- Good: Assign a numerical value of 7–8, indicating above-average knowledge.
- Average: Assign a numerical value of 5–6, indicating an average level of knowledge.
- Below Average: Assign a numerical value of 3–4, indicating below-average knowledge.

3.3. Additive Ratio Assessment (ARAS) Method in Multiple Criteria Decision-Making

The additive ratio assessment (ARAS) method is essential in multiple criteria decision-making (MCDM). It effectively addresses the complex task of ranking and selecting the most suitable alternative when faced with multiple options. This method is precious in sustainable decision-making scenarios, where it considers the interplay between profits and losses, ensuring sound and informed decision analysis.

Historically, MCDM problems have involved ranking a finite number of decision alternatives, each characterised by a distinct set of criteria. This multifaceted nature of decision-making calls for robust methodologies. Bernoulli laid the groundwork for advanced MCDM methods by working on additive utility functions. At the same time, further research has explored the challenges of achieving consensus among group decision-makers [52], underscoring the collective nature of decision-making processes.

When applied to sustainable decision making, the ARAS method focuses on effectiveness ratios related to profits and losses. It directly correlates the utility function value with an alternative's relative efficiency, influenced by the interplay between the values and weights of critical criteria within a given project.

A vital advantage of the ARAS method is its ability to provide accurate and reliable results while mitigating the occurrence of rank reversal phenomena, a common issue in MCDM problems. It ensures that each alternative's performance is assessed relative to the best attainable performance, resulting in a robust and equitable evaluation process.

The ARAS method comprises a systematic sequence of steps to facilitate the decision-making process:

- Problem definition: It begins with a clear and comprehensive definition of the decision problem, including criteria and objectives.
- Criteria weights determination: Decision makers assign weights to the criteria based on their relative importance.
- Normalisation with sum of solution values: A normalisation procedure transforms the initial data into normalised scores.
- Ratio assessment: The next step involves the calculation of the additive ratio for each alternative.
- Rank alternatives: Alternatives are subsequently ranked based on their ratio scores, simplifying the complex decision-making process.

The heart of the decision-making process is the creation of a decision-making matrix (DMM), encapsulating the preferences for potential alternatives evaluated across multiple criteria. This foundational matrix ensures a fair and robust decision-making process in various contexts [53].

Decision makers populate the DMM with preferences for m possible choices (rows) evaluated on n significant criteria (columns):

$$X = \begin{bmatrix} x_{o1} & \cdots & x_{oj} & \cdots & x_{on} \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix}; \; i = \overline{0,m}; j = \overline{0,n}. \tag{11}$$

m is the number of alternatives, n is the number of criteria describing each option, x_{ij} represents the performance value of i alternative in terms of the j criterion, and x_{oj} is the optimal value of the j criterion.

When decision makers do not know the optimal value for a criterion, they can approximate it using Equation (12):

$$\begin{gathered} x_{oj} = \max x_{ij} \text{value of qualitative scale used to assess criterion, or} \\ x_{oj} = 1.2 \max_i x_{ij}, \text{ if } \max_i x_{ij} \text{ is unknown preferable quantitative value} \\ x_{oj} = \min x_{ij} \text{value of qualitative scale used to assess criterion, or} \\ x_{oj} = 0.8 \min_i x_{ij}, \text{ if} \operatorname*{mix}_i x_{ij} \text{ is unknown preferable quantitative value} \end{gathered} \tag{12}$$

The performance values x_{ij} and criteria weights w_j are typical entries of the DMM. Experts determine the criteria system and the initial values and weights of the criteria.

Decision makers could normalise the criteria values using the ratio to the optimal value to facilitate meaningful comparisons. This normalisation process transforms the criteria values into dimensionless values within the range of [0, 1]. Normalisation enhances the comparability of criteria and enables practical assessments and evaluations across different criteria.

In the next stage, decision makers normalise the initial values of all criteria to obtain the normalised decision-making matrix $\overline{X}$:

$$\overline{X} = \begin{bmatrix} \overline{x}_{o1} & \cdots & \overline{x}_{oj} & \cdots & \overline{x}_{on} \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ \overline{x}_{i1} & \cdots & \overline{x}_{ij} & \cdots & \overline{x}_{in} \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ \overline{x}_{m1} & \cdots & \overline{x}_{mj} & \cdots & \overline{x}_{mn} \end{bmatrix};\ i = \overline{0, m}; j = \overline{0, n}. \tag{13}$$

For criteria with preferable values as maxima, decision makers use the following normalisation procedure:

$$\overline{x}_{ij} = \frac{x_{ij}}{\sum_{i=o}^{m} x_{ij}} \tag{14}$$

For criteria with preferable values as minima, decision makers employ a two-stage normalisation procedure:

$$\begin{gathered} x_{ij} = \frac{1}{x_{ij}^*}; \\ \overline{x}_{ij} = \frac{x_{ij}}{\sum_{i=o}^{m} x_{ij}}. \end{gathered} \tag{15}$$

The third stage involves constructing the normalised-weighted matrix, denoted as $\hat{X}$. Decision makers calculate this matrix by assigning weights to the criteria. Experts and stakeholders determine the values of weights w_j, typically falling within the range of $0 < w_j < 1$. The sum of weights should satisfy the following conditions:

$$\sum_{j=1}^{n} w_j = 1. \tag{16}$$

$$\hat{X} = \begin{bmatrix} \hat{x}_{o1} & \cdots & \hat{x}_{oj} & \cdots & \hat{x}_{on} \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ \hat{x}_{i1} & \cdots & \hat{x}_{ij} & \cdots & \hat{x}_{in} \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ \hat{x}_{m1} & \cdots & \hat{x}_{mj} & \cdots & \hat{x}_{mn} \end{bmatrix};\ i = \overline{0, m}; j = \overline{0, n}. \tag{17}$$

Subsequently, decision makers calculate the normalised–weighted values for each criterion $\hat{x}_{ij}$:

$$\hat{x}_{ij} = \overline{x}_{ij} w_j;\ i = \overline{0, m}. \tag{18}$$

w_j is the weight (importance) of the *j* criterion, and $\overline{x}_i$ is the normalised rating of the *j* criterion.

Decision makers employ the optimality function, which calculates the utility degree of an alternative relative to the best alternative, to determine the priorities of other options. Decision makers determine the optimality function values as follows:

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij};\ i = \overline{0, m}. \tag{19}$$

S_i is the value of the optimality function of the *i* alternative.

Higher values of the optimality function correspond to preferable options.

Decision makers determine the utility degree of the alternative by comparing the analysed choice with the ideally best one, S_0 (Pareto optimal solution). Equation (20) helps decision makers calculate the utility degree K_i of an alternative a_i:

$$K_i = \frac{S_i}{S_o};\ i = \overline{0, m}, \tag{20}$$

S_i and S_o are the optimality criterion values obtained from Equation (19).

The values of K_i fall within the interval [0, 1]. Decision makers can order these values in an increasing sequence, reflecting the desired order of precedence. The utility function values derived from this process enable decision makers to determine the complex relative efficiency of each potential alternative.

4. Results

The experts assessed the importance presented on a ten-point scale. The moderator presented the criteria groups in descending importance level as the expert panel determined in three rounds of the Delphic process. Table 1 in the first column represents the list of criteria and each expert's importance assessment based on a nine-point Likert-type scale provided in the corresponding cells.

Experts in the next round used the scale (Table 5) to evaluate the importance of relative difference coefficients to determine the weights of criteria groups (Table 6).

In the following step, the experts use the SWARA method to evaluate sub-criteria weights within each criterion group (Tables 7–9).

Table 9 presents the summarised final importance of the sub-criteria.

All six experts assessed all sub-criteria (skills) for the 15 candidates using a ten-point Likert-type scale (Table 10).

Table 10. Assessment of candidates' skills by experts.

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}
$x_{1.1}$ Strategic Vision															
E_1	7	6	8	6	6	8	6	7	6	8	8	6	5	6	9
E_2	7	7	6	8	7	6	6	8	7	6	9	6	6	9	6
E_3	8	6	8	7	8	7	6	6	7	8	9	7	5	7	7
E_4	7	7	8	9	6	8	7	9	8	7	8	6	6	9	7
E_5	7	6	8	7	7	6	6	7	6	9	9	6	6	8	8
E_6	8	7	8	6	6	7	7	7	7	7	8	6	6	6	9
	7.32	6.48	7.63	7.09	6.63	6.95	6.32	7.27	6.80	7.44	8.49	6.16	5.65	7.39	7.59
$\sum$	44	39	46	43	40	42	38	44	41	45	51	37	34	45	46
$x_{1.2}$ Decision-Making Skills															
E_1	7	6	9	7	7	8	8	6	5	8	9	7	6	6	7
E_2	8	6	7	7	7	6	8	5	6	6	9	9	7	9	6
E_3	8	7	9	8	7	7	9	6	5	8	8	9	6	7	7
E_4	7	6	8	8	7	8	8	5	6	7	9	6	6	9	6
E_5	6	6	8	6	7	6	9	6	6	9	8	7	7	8	6
E_6	8	6	9	7	7	7	7	5	6	7	9	8	7	6	6
	7.29	6.16	8.30	7.13	7.00	6.95	8.14	5.48	5.65	7.44	8.65	7.59	6.48	7.39	6.32
$\sum$	44	37	50	43	42	42	49	33	34	45	52	46	39	45	38

Table 10. *Cont.*

	$\mathbf{P_1}$	$\mathbf{P_2}$	$\mathbf{P_3}$	$\mathbf{P_4}$	$\mathbf{P_5}$	$\mathbf{P_6}$	$\mathbf{P_7}$	$\mathbf{P_8}$	$\mathbf{P_9}$	$\mathbf{P_{10}}$	$\mathbf{P_{11}}$	$\mathbf{P_{12}}$	$\mathbf{P_{13}}$	$\mathbf{P_{14}}$	$\mathbf{P_{15}}$
$x_{1.3}$ Team Building and Motivation															
E_1	6	5	6	8	6	8	6	7	6	8	9	8	6	6	6
E_2	7	6	7	6	6	6	5	8	7	6	9	6	6	6	7
E_3	6	5	7	7	7	7	6	6	6	8	8	6	6	7	6
E_4	6	6	8	8	6	8	5	9	7	7	9	7	7	6	6
E_5	7	6	6	7	6	6	6	7	6	9	8	6	6	6	7
E_6	7	6	7	7	6	7	5	7	7	7	9	7	7	6	7
	6.48	5.65	6.80	7.13	6.16	6.95	5.48	7.27	6.48	7.44	8.65	6.63	6.32	6.16	6.48
$\sum$	39	34	41	43	37	42	33	44	39	45	52	40	38	37	39
$x_{2.1}$ Industry Knowledge															
E_1	7	9	9	6	8	9	8	6	6	8	7	6	8	6	6
E_2	7	7	7	6	7	7	8	7	5	6	7	7	8	9	7
E_3	6	8	9	6	7	9	9	6	6	6	8	5	8	7	7
E_4	7	7	9	7	7	8	8	7	5	7	7	6	9	9	8
E_5	8	9	8	6	7	8	9	6	6	6	7	7	6	8	6
E_6	7	7	9	7	7	9	7	7	5	7	8	6	7	6	7
	6.98	7.78	8.46	6.32	7.16	8.30	8.14	6.48	5.48	6.63	7.32	6.13	7.61	7.39	6.80
$\sum$	42	47	51	38	43	50	49	39	33	40	44	37	46	45	41
$x_{2.2}$ Project Management Skills															
E_1	9	6	8	7	6	8	6	6	8	6	7	6	6	5	7
E_2	8	5	7	7	7	7	6	6	6	7	8	7	7	6	6
E_3	9	6	8	6	8	7	5	7	6	6	8	7	6	5	7
E_4	8	5	7	7	6	7	6	6	7	7	7	8	6	6	6
E_5	9	6	7	8	7	7	7	6	6	6	6	6	7	6	6
E_6	8	5	8	7	6	7	6	6	7	7	8	7	7	6	6
	8.49	5.48	7.48	6.98	6.63	7.16	5.97	6.16	6.63	6.48	7.29	6.80	6.48	5.65	6.32
$\sum$	51	33	45	42	40	43	36	37	40	39	44	41	39	34	38
$x_{2.3}$ Problem Solving and Analytical Abilities															
E_1	6	6	6	8	7	8	8	7	6	6	6	7	7	6	6
E_2	5	7	6	7	7	6	8	8	6	6	6	9	7	9	7
E_3	6	6	5	7	7	6	8	6	6	6	7	9	6	7	6
E_4	5	8	6	7	6	7	8	9	7	7	6	6	7	9	6
E_5	6	6	7	7	7	6	9	7	6	6	6	7	8	8	7
E_6	5	7	6	7	7	7	8	7	7	7	6	8	7	6	7
	5.48	6.63	5.97	7.16	6.82	6.63	8.16	7.27	6.32	6.32	6.16	7.59	6.98	7.39	6.48
$\sum$	33	40	36	43	41	40	49	44	38	38	37	46	42	45	39
$x_{3.1}$ Verbal and Written Communication															
E_1	7	8	6	6	6	8	6	9	5	6	9	6	6	6	7
E_2	8	7	7	6	7	6	5	7	6	7	9	7	7	9	6
E_3	8	7	6	7	8	7	6	9	5	5	8	7	6	7	7
E_4	7	7	7	6	6	8	5	8	6	6	9	8	6	9	6
E_5	6	7	6	6	7	6	6	8	6	7	8	6	7	8	6
E_6	8	7	7	6	6	7	5	9	6	6	9	7	7	6	6
	7.29	7.16	6.48	6.16	6.63	6.95	5.48	8.30	5.65	6.13	8.65	6.80	6.48	7.39	6.32
$\sum$	44	43	39	37	40	42	33	50	34	37	52	41	39	45	38

Table 10. *Cont.*

	$\mathbf{P_1}$	$\mathbf{P_2}$	$\mathbf{P_3}$	$\mathbf{P_4}$	$\mathbf{P_5}$	$\mathbf{P_6}$	$\mathbf{P_7}$	$\mathbf{P_8}$	$\mathbf{P_9}$	$\mathbf{P_{10}}$	$\mathbf{P_{11}}$	$\mathbf{P_{12}}$	$\mathbf{P_{13}}$	$\mathbf{P_{14}}$	$\mathbf{P_{15}}$
$x_{3.2}$ Active Listening															
E_1	8	6	6	6	6	7	8	7	6	8	7	6	8	6	6
E_2	9	7	7	8	5	7	8	8	6	6	7	7	8	9	6
E_3	9	6	5	7	6	6	8	6	6	6	8	7	8	7	7
E_4	8	7	6	8	5	7	8	9	7	7	7	8	9	9	6
E_5	9	6	7	8	6	8	8	7	6	6	7	6	6	8	7
E_6	8	7	6	6	5	7	7	7	7	7	8	7	7	6	6
	8.49	6.48	6.13	7.11	5.48	6.98	7.82	7.27	6.32	6.63	7.32	6.80	7.61	7.39	6.32
$\sum$	51	39	37	43	33	42	47	44	38	40	44	41	46	45	38
$x_{3.3}$ Stakeholder Engagement and Relationship Building															
E_1	5	8	8	7	6	6	6	6	6	7	6	6	9	6	7
E_2	6	8	7	7	7	6	6	5	7	7	7	7	9	9	6
E_3	5	8	8	7	8	6	7	6	7	6	6	5	8	7	7
E_4	6	7	7	8	6	7	6	5	8	7	7	6	9	9	7
E_5	6	8	7	7	7	6	6	6	6	8	6	7	8	8	7
E_6	6	8	8	7	6	7	6	5	7	7	7	6	9	6	7
	5.65	7.82	7.48	7.16	6.63	6.32	6.16	5.48	6.80	6.98	6.48	6.13	8.65	7.39	6.82
$\sum$	34	47	45	43	40	38	37	33	41	42	39	37	52	45	41
$x_{4.1}$ Ability to Manage Change															
E_1	7	9	6	6	6	7	9	8	6	8	9	7	6	6	6
E_2	7	7	6	7	7	6	7	7	6	6	7	9	5	7	7
E_3	8	8	7	5	8	7	9	7	6	8	9	9	6	7	6
E_4	7	7	6	6	6	7	8	7	7	7	9	6	5	8	6
E_5	7	9	6	6	7	6	8	7	6	9	8	7	6	6	7
E_6	8	7	6	6	6	7	9	7	7	7	9	8	5	7	7
	7.32	7.78	6.16	5.97	6.63	6.65	8.30	7.16	6.32	7.44	8.46	7.59	5.48	6.80	6.48
$\sum$	44	47	37	36	40	40	50	43	38	45	51	46	33	41	39
$x_{4.2}$ Resilience and Stress Management															
E_1	6	7	6	7	6	8	6	7	9	8	6	7	5	6	6
E_2	5	7	7	8	7	7	6	8	7	6	6	9	6	7	7
E_3	6	8	7	7	8	7	6	6	9	8	6	9	5	5	6
E_4	5	9	8	9	6	8	7	9	8	7	7	6	6	6	6
E_5	6	8	6	7	7	7	6	7	8	9	6	7	6	6	7
E_6	5	8	7	8	6	7	7	7	9	7	6	8	6	6	7
	5.48	7.80	6.80	7.63	6.63	7.32	6.32	7.27	8.30	7.44	6.16	7.59	5.65	5.97	6.48
$\sum$	33	47	41	46	40	44	38	44	50	45	37	46	34	36	39
$x_{4.3}$ Learning and Development Orientation															
E_1	7	7	9	6	6	8	6	8	7	6	7	6	6	6	7
E_2	9	8	7	7	7	6	6	8	7	7	7	5	7	9	6
E_3	8	8	9	5	8	7	7	7	7	6	7	6	7	7	7
E_4	7	8	9	6	6	8	6	7	8	7	7	5	7	9	6
E_5	9	8	8	7	7	6	6	7	7	6	7	6	7	8	6
E_6	8	8	9	6	6	7	6	7	8	7	8	5	7	6	6
	7.96	7.82	8.46	6.13	6.63	6.95	6.16	7.32	7.32	6.48	7.16	5.48	6.82	7.39	6.32
$\sum$	48	47	51	37	40	42	37	44	44	39	43	33	41	45	38

Table 10. *Cont.*

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}	P_{15}
$x_{5.1}$ Environmental Awareness															
E_1	6	6	8	6	6	7	6	7	6	8	9	6	6	6	9
E_2	6	6	7	6	7	7	7	8	7	6	9	7	5	9	6
E_3	6	7	7	6	8	7	5	7	7	8	8	6	6	7	7
E_4	6	6	7	7	6	7	6	8	8	7	9	7	5	9	7
E_5	5	6	7	6	7	7	7	7	6	9	8	6	6	8	8
E_6	5	6	7	7	6	7	6	7	7	7	9	7	5	6	9
	5.65	6.16	7.16	6.32	6.63	7.00	6.13	7.32	6.80	7.44	8.65	6.48	5.48	7.39	7.59
$\sum$	34	37	43	38	40	42	37	44	41	45	52	39	33	45	46
$x_{5.2}$ Social Impact Consideration															
E_1	6	8	6	6	6	6	8	7	8	6	6	9	8	6	6
E_2	6	7	7	7	7	8	8	8	7	6	5	7	8	9	7
E_3	7	8	5	7	8	7	9	7	7	6	6	9	8	7	6
E_4	6	7	6	8	6	8	8	8	7	7	5	9	9	9	6
E_5	6	7	7	6	7	7	9	7	7	6	6	8	6	8	7
E_6	6	8	6	7	6	7	7	7	7	7	5	9	7	6	7
	6.16	7.48	6.13	6.80	6.63	7.13	8.14	7.32	7.16	6.32	5.48	8.46	7.61	7.39	6.48
$\sum$	37	45	37	41	40	43	49	44	43	38	33	51	46	45	39
$x_{5.3}$ Ethical Decision Making															
E_1	9	8	6	8	6	8	8	6	6	8	7	6	5	6	7
E_2	9	7	6	8	7	6	8	7	7	6	8	7	6	5	6
E_3	8	8	7	8	8	7	9	5	7	8	8	6	5	6	7
E_4	9	7	6	9	6	8	8	6	8	7	7	6	6	5	6
E_5	8	8	6	8	7	6	9	7	6	9	6	7	6	6	6
E_6	9	8	6	8	6	7	7	6	7	7	8	7	6	5	6
	8.65	7.65	6.16	8.16	6.63	6.95	8.14	6.13	6.80	7.44	7.29	6.48	5.65	5.48	6.32
$\sum$	52	46	37	49	40	42	49	37	41	45	44	39	34	33	38

Note: The values in the table represent the experts' assessment of each candidate's skills (sub-criteria) using a ten-point Likert-type scale.

The decision makers following the generic problem solution model started the ARAS method. They prepared an initial decision-making matrix based on Tables 9 and 10 (Table 11). The criteria weights represent the higher-level factors or attributes essential in selecting and developing project managers in sustainable economic development (Table 11). Decision makers assigned each criterion a weight indicating its relative importance in decision making.

Table 11. Initial decision-making matrix.

Criteria		x_1			x_2			x_3			x_4			x_5	
w		0.234			0.214			0.203			0.192			0.158	
S-C	$x_{1.1}$	$x_{1.2}$	$x_{1.3}$	$x_{2.1}$	$x_{2.2}$	$x_{2.3}$	$x_{3.1}$	$x_{3.2}$	$x_{3.3}$	$x_{4.1}$	$x_{4.2}$	$x_{4.3}$	$x_{5.1}$	$x_{5.2}$	$x_{5.3}$
q	0.35	0.31	0.34	0.34	0.35	0.31	0.31	0.36	0.33	0.35	0.31	0.34	0.36	0.33	0.31
w	0.082	0.073	0.08	0.073	0.075	0.066	0.063	0.073	0.067	0.067	0.06	0.065	0.057	0.052	0.049
P_0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
P_1	7.32	7.29	6.48	6.98	8.49	5.48	7.29	8.49	5.65	7.32	5.48	7.96	5.65	6.16	8.65
P_2	6.48	6.16	5.65	7.78	5.48	6.63	7.16	6.48	7.82	7.78	7.8	7.82	6.16	7.48	7.65

Table 11. *Cont.*

Criteria	x_1			x_2			x_3			x_4			x_5		
P_3	7.63	8.3	6.8	8.46	7.48	5.97	6.48	6.13	7.48	6.16	6.8	8.46	7.16	6.13	6.16
P_4	7.09	7.13	7.13	6.32	6.98	7.16	6.16	7.11	7.16	5.97	7.63	6.13	6.32	6.8	8.16
P_5	6.63	7	6.16	7.16	6.63	6.82	6.63	6.63	6.63	6.63	6.63	6.63	6.63	6.63	6.63
P_6	6.95	6.95	6.95	8.3	7.16	6.63	6.95	6.98	6.32	6.65	7.32	6.95	7	7.13	6.95
P_7	6.32	8.14	5.48	8.14	5.97	8.16	5.48	7.82	6.16	8.3	6.32	6.16	6.13	8.14	8.14
P_8	7.27	5.48	7.27	6.48	6.16	7.27	5.48	7.16	7.27	7.32	7.32	7.32	6.8	7.16	6.8
P_9	6.8	5.65	6.48	5.48	6.63	6.32	5.65	6.32	6.8	6.32	8.3	7.32	6.8	7.16	6.8
P_{10}	7.44	7.44	7.44	6.63	6.48	6.32	6.13	6.63	6.98	7.44	7.44	6.48	7.44	6.32	7.44
P_{11}	8.49	8.65	8.65	7.32	7.29	6.16	8.65	7.32	6.48	8.46	6.16	7.16	8.65	5.48	7.29
P_{12}	6.16	7.59	6.63	6.13	6.8	7.59	6.8	6.8	6.13	7.59	7.59	5.48	6.48	8.46	6.48
P_{13}	5.65	6.48	6.32	7.61	6.48	6.98	6.48	7.61	8.65	5.48	5.65	6.82	5.48	7.61	5.65
P_{14}	7.39	7.39	6.16	7.39	5.65	7.39	7.39	7.39	7.39	6.8	5.97	7.39	7.39	7.39	5.48
P_{15}	7.59	6.32	6.48	6.8	6.32	6.48	6.32	6.32	6.82	6.48	6.48	6.32	7.59	6.48	6.32
$\sum$	115.21	115.97	110.08	116.98	110	111.36	109.05	115.19	113.74	114.7	112.89	114.4	111.68	114.53	114.6

Sub-criteria ($x_{11} - x_{53}$) are the sub-level factors or attributes that fall under each criterion. There are more specific considerations within each criterion.

q (local weights) values represent the local weights of the corresponding sub-criteria within their respective criteria. Local weights reflect how important each sub-criterion is concerning its parent criterion.

w (global weights) values represent the global weights of all sub-criteria. Global weights consider the importance of each sub-criterion within its parent criterion and the importance of the parent criterion in the overall decision-making process.

For criterion x_1, there are three sub-criteria ($x_{11},\ x_{12},\ x_{13}$). The local weights for these sub-criteria within x_1 are 0.35, 0.31, and 0.34, respectively.

The global weights for these sub-criteria (w) are 0.082, 0.073, and 0.08, respectively. These global weights consider the importance of the sub-criteria within x_1 and the importance of x_1 itself among all the criteria.

The SHARDA method helps to make informed decisions regarding the selection and development of project managers in sustainable economic growth, ensuring stakeholder involvement and transparency in the decision-making process.

Decision-makers following the ARAS method normalised the initial decision-making matrix (Table 12) (Equations (12)–(15)) and weighted it (Table 13) (Equations (16)–(18)). Table 13 presents problem solution results (optimality function's values S_i (Equation (19)) and the utility degree values K_i (Equation (20)).

Table 12. Normalised decision-making matrix.

S-C	$x_{1.1}$	$x_{1.2}$	$x_{1.3}$	$x_{2.1}$	$x_{2.2}$	$x_{2.3}$	$x_{3.1}$	$x_{3.2}$	$x_{3.3}$	$x_{4.1}$	$x_{4.2}$	$x_{4.3}$	$x_{5.1}$	$x_{5.2}$	$x_{5.3}$
w	0.082	0.073	0.08	0.073	0.075	0.066	0.063	0.073	0.067	0.067	0.06	0.065	0.057	0.052	0.049
P_0	0.087	0.086	0.091	0.085	0.091	0.090	0.092	0.087	0.088	0.087	0.089	0.087	0.090	0.087	0.087
P_1	0.064	0.063	0.059	0.060	0.077	0.049	0.067	0.074	0.050	0.064	0.049	0.070	0.051	0.054	0.075
P_2	0.056	0.053	0.051	0.067	0.050	0.060	0.066	0.056	0.069	0.068	0.069	0.068	0.055	0.065	0.067
P_3	0.066	0.072	0.062	0.072	0.068	0.054	0.059	0.053	0.066	0.054	0.060	0.074	0.064	0.054	0.054

Table 12. *Cont.*

S-C	$x_{1.1}$	$x_{1.2}$	$x_{1.3}$	$x_{2.1}$	$x_{2.2}$	$x_{2.3}$	$x_{3.1}$	$x_{3.2}$	$x_{3.3}$	$x_{4.1}$	$x_{4.2}$	$x_{4.3}$	$x_{5.1}$	$x_{5.2}$	$x_{5.3}$
P_4	0.062	0.061	0.065	0.054	0.063	0.064	0.056	0.062	0.063	0.052	0.068	0.054	0.057	0.059	0.071
P_5	0.058	0.060	0.056	0.061	0.060	0.061	0.061	0.058	0.058	0.058	0.059	0.058	0.059	0.058	0.058
P_6	0.060	0.060	0.063	0.071	0.065	0.060	0.064	0.061	0.056	0.058	0.065	0.061	0.063	0.062	0.061
P_7	0.055	0.070	0.050	0.070	0.054	0.073	0.050	0.068	0.054	0.072	0.056	0.054	0.055	0.071	0.071
P_8	0.063	0.047	0.066	0.055	0.056	0.065	0.050	0.062	0.064	0.064	0.065	0.064	0.061	0.063	0.059
P_9	0.059	0.049	0.059	0.047	0.060	0.057	0.052	0.055	0.060	0.055	0.074	0.064	0.061	0.063	0.059
P_{10}	0.065	0.064	0.068	0.057	0.059	0.057	0.056	0.058	0.061	0.065	0.066	0.057	0.067	0.055	0.065
P_{11}	0.074	0.075	0.079	0.063	0.066	0.055	0.079	0.064	0.057	0.074	0.055	0.063	0.077	0.048	0.064
P_{12}	0.053	0.065	0.060	0.052	0.062	0.068	0.062	0.059	0.054	0.066	0.067	0.048	0.058	0.074	0.057
P_{13}	0.049	0.056	0.057	0.065	0.059	0.063	0.059	0.066	0.076	0.048	0.050	0.060	0.049	0.066	0.049
P_{14}	0.064	0.064	0.056	0.063	0.051	0.066	0.068	0.064	0.065	0.059	0.053	0.065	0.066	0.065	0.048
P_{15}	0.066	0.054	0.059	0.058	0.057	0.058	0.058	0.055	0.060	0.056	0.057	0.055	0.068	0.057	0.055

Table 13. Normalised–weighted decision-making matrix and problem solution results.

S-C	$x_{1.1}$	$x_{1.2}$	$x_{1.3}$	$x_{2.1}$	$x_{2.2}$	$x_{2.3}$	$x_{3.1}$	$x_{3.2}$	$x_{3.3}$	$x_{4.1}$	$x_{4.2}$	$x_{4.3}$	$x_{5.1}$	$x_{5.2}$	$x_{5.3}$	$\sum$	K_i	Rank
P_0	0.007	0.006	0.007	0.006	0.007	0.006	0.006	0.006	0.006	0.006	0.005	0.006	0.005	0.005	0.004	0.088	1.000	O
P_1	0.005	0.005	0.005	0.004	0.006	0.003	0.004	0.005	0.003	0.004	0.003	0.005	0.003	0.003	0.004	0.062	0.700	4
P_2	0.005	0.004	0.004	0.005	0.004	0.004	0.004	0.004	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.061	0.689	8
P_3	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.004	0.003	0.003	0.063	0.708	2
P_4	0.005	0.004	0.005	0.004	0.005	0.004	0.004	0.005	0.004	0.003	0.004	0.003	0.003	0.003	0.003	0.061	0.687	9
P_5	0.005	0.004	0.004	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.059	0.667	12
P_6	0.005	0.004	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.062	0.701	3
P_7	0.004	0.005	0.004	0.005	0.004	0.005	0.003	0.005	0.004	0.005	0.003	0.004	0.003	0.004	0.003	0.061	0.694	5
P_8	0.005	0.003	0.005	0.004	0.004	0.004	0.003	0.005	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.060	0.683	10
P_9	0.005	0.004	0.005	0.003	0.005	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.058	0.655	15
P_{10}	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.061	0.694	6 = 7
P_{11}	0.006	0.005	0.006	0.005	0.005	0.004	0.005	0.005	0.004	0.005	0.003	0.004	0.004	0.002	0.003	0.067	0.755	1
P_{12}	0.004	0.005	0.005	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.004	0.003	0.060	0.682	11
P_{13}	0.004	0.004	0.005	0.005	0.004	0.004	0.004	0.005	0.005	0.003	0.003	0.004	0.003	0.003	0.002	0.058	0.660	14
P_{14}	0.005	0.005	0.004	0.005	0.004	0.004	0.004	0.005	0.004	0.004	0.003	0.004	0.004	0.003	0.002	0.061	0.694	6 = 7
P_{15}	0.005	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.004	0.004	0.003	0.003	0.058	0.661	13

5. Conclusions

This study emphasises the meticulous approach required for selecting and developing project managers, which is crucial for fostering sustainable economic development. The Systemic Hierarchical Attribute Ratio Delphic Assessment (SHARDA) method, complemented by the additive ratio assessment (ARAS) methodology, emerges as a pivotal tool. This tandem offers decision makers a systematic framework resistant to rank reversals, and quantifies each choice's direct ratio concerning the optimal (Pareto) solution.

Advancement in MCDM for sustainable development: The SHARDA–ARAS methodology marks a notable advancement in multi-criteria decision making (MCDM). Tackling the complex task of selecting project managers for sustainable development, it provides a robust framework empowering decision makers to prioritise and evaluate candidates efficiently, aligning seamlessly with economic, environmental, and social sustainability considerations.

Alignment with UN SDGs and interdisciplinary mathematics: The research underscores the SHARDA–ARAS methodology's alignment with the United Nations Sustainable Development Goals (SDGs). This alignment emphasises the significance of selecting proficient project managers who contribute actively to global objectives and promote interdisciplinary mathematics to facilitate sustainable development.

Recognition of interconnected sustainability dimensions: Acknowledging the interconnected nature of sustainability—encompassing economic, environmental, and social dimensions—the article emphasises the indispensable role of project managers. Their capacity to balance these intricate facets within decision-making processes underscored contributing to holistic, sustainable development.

Stakeholder involvement and ethical considerations: The SHARDA–ARAS approach emphasises stakeholder involvement, ensuring decision-making transparency and fairness. Including diverse perspectives enhances the integrity of the selection process, reinforcing the ethical importance of equitable decision making within sustainable development.

Adaptive decision making and global relevance: The SHARDA–ARAS methodology advocating adaptive decision making in a rapidly changing global situation acknowledges the need for flexibility in selecting project managers capable of navigating evolving challenges. The article underscores the global relevance of these methodologies, positioning them as invaluable tools for organisations operating across diverse regions and highlighting their significance in interdisciplinary mathematics.

Universality and future research directions: What truly sets the SHARDA–ARAS methodology apart is its universality. These methodologies transcend boundaries and demonstrate adaptability to address complex problems in various fields. The authors envisioned future research directions, considering the diligent preparation of fuzzy and grey versions of the SHARDA method. It showcases the versatility of these approaches in addressing varying degrees of uncertainty and vagueness, setting the stage for their continued refinement and application in specific case studies. The SHARDA–ARAS methodology emerges as an advanced mathematical tool, supporting interdisciplinary and sustainable decision making across diverse contexts.

Comparative analysis with MAMCA: An additional analysis with the MAMCA method emphasises the contextual considerations, goals, available resources, and stakeholder engagement in choosing between them. While MAMCA highlights multi-actor involvement, SHARDA provides a mathematically rigorous approach. The decision-making scenario should align with the unique requirements of each context, ensuring an optimal fit for the specific decision-making landscape.

This research presents a methodology for project manager selection. It underscores the broader implications for sustainable development, ethics, and interdisciplinary mathematics, positioning the SHARDA–ARAS methodology as a versatile and universal tool for nuanced decision making in an ever-evolving global situation.

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