

RESEARCH PAPER

Integrating AHP and SAW for sustainable supplier selection in green supply chains: a post-pandemic esg perspective

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ABSTRACT

The growing emphasis on sustainability and resilience in the post pandemic era has increased the need for supplier evaluation models that incorporate Environmental, Social, and Governance criteria. However, existing approaches often lack a structured and quantitative method for integrating ESG indicators into procurement decisions. This study proposes a hybrid decision making framework based on the Analytic Hierarchy Process and Simple Additive Weighting to support ESG based supplier selection in green supply chains. The AHP method was used to derive weights for three ESG dimensions and nine sub criteria through pairwise comparisons provided by five experts. The SAW method was applied to evaluate the performance of five suppliers using normalized ESG metrics. The results show that the Environmental dimension received the highest weight, reflecting organizational priorities in carbon reduction and resource efficiency. Supplier S3 achieved the highest overall score due to strong performance across the most influential ESG indicators. Sensitivity analysis confirmed the stability of the model under alternative weighting scenarios. This study contributes to the literature by operationalizing ESG criteria within a transparent and replicable multi criteria framework and provides practical guidance for organizations seeking to implement sustainability oriented supplier selection.

Keywords: AHP; SAW; ESG; Green Supply Chain; Sustainable Supplier Selection; Multi Criteria Decision Making.

1 INTRODUCTION

Global supply chains experienced severe disruptions during the COVID-19 pandemic, exposing structural vulnerabilities in traditional supplier evaluation systems that largely emphasize cost, quality, and delivery performance while overlooking resilience and sustainability dimensions (Alam *et al.*, 2021; Ivanov & Dolgui, 2020). As organizations transition toward more responsible and adaptive procurement practices in the post-pandemic era, integrating Environmental, Social, and Governance (ESG) considerations into supplier selection has become a strategic imperative. ESG-oriented procurement, particularly within the context of green supply chain management (GSCM), aims to reduce environmental degradation, enhance social accountability, and strengthen ethical governance across supply networks (Ada, 2022; Ulutaş *et al.*, 2019). Despite its increasing relevance, operationalizing ESG criteria within a structured decision-making framework remains challenging due to the multidimensional and sometimes contradictory nature of sustainability indicators.

Existing research in supplier selection has introduced various Multi-Criteria Decision-Making (MCDM) approaches such as AHP, TOPSIS, VIKOR, and SAW to navigate conflicting criteria and complex trade-offs. However, most prior studies focus on conventional procurement metrics or

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generalized sustainability elements, often neglecting the systematic integration of ESG criteria aligned with post-pandemic risk and resilience requirements (Govindan et al., 2013; Sarasati & Dachyar, 2021). Furthermore, while AHP offers a robust mechanism for deriving subjective weights through expert judgment, and SAW provides a transparent aggregation method for ranking alternatives, their combined use for evaluating ESG-driven supplier performance in green supply chains remains limited. Previous models rarely offer a replicable quantitative framework that reflects contemporary ESG expectations, regulatory pressures, and stakeholder demands for transparency.

Despite the growing recognition of ESG as a critical component of sustainable procurement, academic literature still lacks (1) a standardized and operationalized framework for evaluating suppliers based explicitly on ESG dimensions, (2) a hybrid decision-making approach that integrates expert judgment with objective performance data, and (3) empirical validation of such a model in a real supply chain context, particularly in the post-pandemic environment characterized by heightened uncertainty and sustainability concerns. These gaps underscore the need for a comprehensive, quantitative, and practically implementable method for ESG-based supplier evaluation.

In response to these shortcomings, this study proposes a hybrid AHP–SAW framework to support sustainable supplier selection by systematically incorporating ESG criteria into the decision hierarchy. AHP is employed to derive weights for ESG dimensions and sub-criteria through structured pairwise comparisons, ensuring consistency in expert assessments. SAW is then used to aggregate normalized supplier performance data, enabling transparent and replicable ranking of alternatives. A case study involving five suppliers demonstrates the applicability of the model, offering practical insights into how organizations can align procurement decisions with ESG priorities in the post-pandemic supply chain landscape.

This study contributes to the literature by (1) operationalizing ESG considerations within a quantitative MCDM framework, (2) introducing a hybrid AHP–SAW model tailored for green supply chain contexts, and (3) providing empirical evidence on the model's robustness through sensitivity analysis. The findings aim to support practitioners and policymakers in advancing sustainable, resilient, and ethically governed procurement strategies.

2 THEORETICAL FRAMEWORK

The theoretical foundation of this study draws upon three interrelated domains: Multi-Criteria Decision-Making (MCDM) theory, ESG-based sustainability assessment, and Green Supply Chain Management (GSCM). Together, these domains form the conceptual basis for constructing a hybrid AHP–SAW model capable of evaluating supplier sustainability performance in the post-pandemic environment.

2.1 Multi Criteria Decision Making (MCDM) Theory

MCDM provides a systematic framework for evaluating alternatives when multiple, often conflicting criteria must be considered simultaneously. Supplier selection represents a typical MCDM problem, as it requires decision makers to balance economic, environmental, social, and risk-related dimensions (Belton & Stewart, 2002). Among the broad family of MCDM methods, the Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) are widely recognized for their transparency, computational simplicity, and practical relevance in procurement contexts.

AHP, introduced by Saaty (1980), decomposes complex decisions into hierarchical structures consisting of goals, criteria, and alternatives. Pairwise comparisons are used to convert expert judgments into numerical weights, enabling the prioritization of criteria while ensuring consistency through metrics such as the Consistency Ratio (CR). Meanwhile, SAW is a compensatory aggregation technique in which normalized performance values are multiplied by predetermined weights and summed to generate final scores for each alternative (Hwang & Yoon, 1981). The combined use of AHP and SAW leverages the strengths of both methods: AHP's structured weight derivation and SAW's quantitative and easily interpretable scoring mechanism.

Although previous studies have applied AHP and SAW independently, their integrated use particularly for evaluating suppliers based on ESG considerations—remains limited. This gap underscores the need for a hybrid MCDM framework that enables both subjective expert input and objective performance evaluation.

2.2 ESG Based Sustainability Evaluation

ESG (Environmental, Social, and Governance) indicators have become global benchmarks for assessing responsible and sustainable business practices. The environmental dimension captures resource efficiency, emissions, and waste management; the social dimension relates to labor conditions, community engagement, and human rights; and the governance dimension encompasses transparency, anti-corruption, compliance mechanisms, and ethical leadership (Eccles & Klimenko, 2019; Friede et al., 2015).

Within supply chain management, ESG criteria are increasingly used to evaluate suppliers' long-term sustainability, risk exposure, and alignment with corporate social responsibility goals. Recent studies emphasize that strong ESG performance can reduce operational risk, improve resilience, and enhance stakeholder confidence (Aldowaish et al., 2022; Truant et al., 2024). However, despite its rising prominence, operationalizing ESG indicators into a structured and quantifiable supplier evaluation framework remains challenging. The absence of standardized measurement systems and the coexistence of qualitative and quantitative criteria complicate decision making.

Therefore, integrating ESG criteria within a MCDM framework enables decision makers to systematically balance sustainability-related concerns with organizational priorities. This study addresses the operationalization gap by embedding ESG indicators directly into an AHP-SAW model.

2.3 Green Supply Chain Management (GSCM)

GSCM incorporates environmental and social considerations into supply chain processes, from procurement and production to distribution and reverse logistics. Its primary objective is to minimize ecological impact while maintaining economic performance (Srivastava, 2007). In the post-pandemic era, GSCM has gained renewed significance as firms seek to rebuild resilient, transparent, and ethically governed supply networks (Ivanov & Dolgui, 2020).

Suppliers play a decisive role in determining the sustainability performance of a supply chain. Consequently, selecting suppliers that meet ESG expectations is essential for achieving corporate sustainability goals and regulatory compliance. Prior literature highlights the importance of integrating structured evaluation tools into GSCM to ensure consistency and transparency (Awasthi et al., 2010; Govindan et al., 2013). However, most existing models still concentrate on general sustainability principles rather than comprehensive ESG frameworks aligned with modern post-pandemic demands.

2.4 Integration of Theories into the Proposed Framework

By synthesizing MCDM theory, ESG evaluation principles, and green supply chain management perspectives, this study establishes a unified decision-making framework that supports sustainable supplier selection in the post-pandemic era. The integration of AHP enables the systematic derivation of relative weights for ESG dimensions and their associated sub-criteria based on expert judgment, ensuring analytical rigor and internal consistency in reflecting organizational and stakeholder priorities. Complementing this, the SAW method provides a transparent and computationally straightforward mechanism for aggregating normalized supplier performance data into a final ranking, thereby enhancing operational feasibility and interpretability. Anchoring ESG indicators within an MCDM structure allows for the balanced consideration of environmental responsibility, social welfare, and governance integrity, dimensions that are increasingly central to resilient and ethically governed supply chains. Together, the merged theoretical domains yield a robust and adaptable framework that operationalizes sustainability principles, strengthens evidence-based procurement decisions, and aligns supplier evaluation with contemporary ESG-driven supply chain strategies.

3 RESEARCH METHODOLOGY

This study adopts a hybrid Multi-Criteria Decision-Making (MCDM) framework that integrates the Analytic Hierarchy Process (AHP) and Simple Additive Weighting (SAW) to evaluate supplier sustainability performance based on Environmental, Social, and Governance (ESG) criteria. The methodological process consists of four main stages: (1) identification and structuring of ESG-based criteria, (2) weight derivation using AHP, (3) supplier performance evaluation using SAW, and (4) final ranking and sensitivity analysis.

3.1 Identification of ESG Based Supplier Selection Criteria

The first stage involves developing a hierarchical structure of evaluation criteria grounded in ESG principles. A comprehensive literature review and expert consultation were conducted to define relevant criteria and sub-criteria aligned with sustainability standards such as the Global Reporting Initiative (GRI). The ESG dimensions were operationalized into specific indicators, including carbon emissions, energy efficiency, waste management, labor practices, community engagement, governance transparency, and anti-corruption compliance.

To ensure content validity and contextual relevance, expert validation was conducted through a Delphi-based process involving five domain experts: two supply chain managers, one sustainability officer, one procurement analyst, and one academic specializing in sustainability and decision-making methodologies. Their expertise reflects key functional roles in ESG-driven procurement, ensuring the robustness of the developed hierarchical structure.

3.2 Criteria Weighting Using AHP

In the second stage, the Analytic Hierarchy Process (AHP) was used to derive the relative importance of ESG criteria. AHP was chosen because it enables structured pairwise comparisons and provides a mathematical consistency check to validate expert judgments. Pairwise comparison matrices were constructed based on the inputs from the **five experts**, whose evaluations were aggregated using the geometric mean method, which is the standard approach in group AHP.

The adoption of **five respondents** is methodologically justified, as AHP prioritizes expertise over sample size and is commonly applied with 3–10 expert participants in high-impact MCDM studies. Saaty (1980) and subsequent MCDM literature emphasize that AHP is designed for expert-driven decision contexts, making a small but highly qualified panel both appropriate and sufficient. Thus, the number of experts in this study aligns with established methodological norms and enhances the credibility of the weight derivation process.

The weight vector for each matrix was computed using the eigenvalue method:

$$w_i = \frac{e_i}{\sum_{j=1}^n e_j},$$

where e_i represents the principal eigenvector elements. The consistency of judgments was evaluated using the Consistency Index (CI) and Consistency Ratio (CR):

$$CI = \frac{\lambda_{\max} - n}{n - 1}, CR = \frac{CI}{RI},$$

where λ_{\max} is the maximum eigenvalue, n the matrix dimension, and RI the Random Index. A $CR \leq 0.10$ was considered acceptable. All matrices in this study met the consistency requirement, ensuring logical coherence in expert evaluations.

3.3 Alternative Evaluation Using SAW

In the third stage, the SAW method was applied to assess supplier performance across the ESG sub-criteria using the weights obtained from AHP. A decision matrix was constructed, where rows represented suppliers and columns represented sub-criteria. Performance data were obtained from sustainability reports, procurement documents, and expert assessments.

Normalization was performed to convert all criteria into a comparable scale using the following formulas:

For benefit-type criteria:

$$r_{ij} = \frac{x_{ij}}{\max(x_j)}$$

For cost-type criteria:

$$r_{ij} = \frac{\min(x_j)}{x_{ij}}$$

where x_{ij} denotes the performance value of supplier i on criterion j .

Weighted scores were calculated using:

$$V_i = \sum_{j=1}^m w_j \cdot r_{ij}$$

The final SAW scores V_i represent each supplier’s aggregated ESG performance, providing the basis for ranking. SAW was selected due to its computational transparency and suitability for decision-making environments requiring clear, auditable evaluation processes.

3.4 Case Study Design and Validation

To validate the practical applicability of the proposed framework, an empirical case study was conducted in a mid-sized manufacturing firm implementing ESG-oriented procurement practices. Five suppliers were evaluated using the AHP–SAW model. Performance scores were compiled and analyzed to generate final supplier rankings.

A sensitivity analysis was conducted by adjusting the weights of the three ESG dimensions by ±10% to simulate potential variations in managerial priorities or stakeholder expectations. The resulting ranking stability confirmed the robustness of the proposed hybrid methodology.

The integration of AHP and SAW provides a comprehensive and balanced approach to ESG-based supplier selection. AHP ensures rigorous weight derivation grounded in expert judgment, while SAW provides an objective and transparent mechanism for evaluating supplier performance. The hybrid framework effectively operationalizes ESG principles into a structured decision-making tool suitable for post-pandemic procurement environments.

4 RESULT AND DISCUSSION

4.1 AHP-Derived Criteria Weights

The AHP prioritization process uses structured pairwise comparisons between ESG dimensions (Environmental, Social, and Governance) and sub-criteria within each dimension. After combining expert judgments and ensuring logical coherence, the following global weights are obtained, as shown in Table 1.

Tabel 1 - Global Weight

Main ESG Dimension	Global Weight
Environmental	0.42
Social	0.33
Governance	0.25

In table 1, the AHP analysis generated the relative importance of the three ESG dimensions and their associated sub-criteria. The resulting global weights show that Environmental (0.42) is the most dominant dimension, followed by Social (0.33) and Governance (0.25). This prioritization suggests that decision makers in the case-study organization place the highest emphasis on ecological sustainability, particularly in the post-pandemic era where carbon reduction, clean energy use, and waste minimization have become organizational imperatives.

The prominence of environmental issues aligns with recent global trends, where stakeholders are emphasizing climate accountability. Empirical evidence supports this, showing that ESG investors are increasingly considering environmental performance in their decisions (Friede et al., 2015; Truant et al., 2024). Within the Environmental dimension, detailed weights are as shown in Table 2.

Tabel 2 - Environmental Sub Criteria Weights

Sub-Criterion	Local Weight	Global Weight
Carbon Emissions	0.429	0.18
Energy Efficiency	0.333	0.14
Waste Management	0.238	0.10

Table 2 explains, Within the Environmental dimension, Carbon Emissions (0.18) emerged as the

most critical sub-criterion, followed by Energy Efficiency (0.14) and Waste Management (0.10). These findings are consistent with global sustainability trends, where carbon footprint reduction and energy transition initiatives are positioned as key corporate ESG goals (Friede et al., 2015; Truant et al., 2024). The higher weight assigned to carbon emissions aligns with increasing regulatory pressures, including mandatory carbon reporting and strengthened environmental compliance in many jurisdictions.

All pairwise comparison matrices demonstrated acceptable consistency (CR < 0.08), confirming that expert judgments were coherent and methodologically reliable. This strengthens the validity of the AHP-derived weights, which serve as the basis for subsequent SAW evaluation.

By assigning relatively higher weight to Environmental factors, the framework captures the intensified focus on ecological recovery and climate resilience post COVID. While Social and Governance dimensions are still valued, this adjusted weighting structure reflects evolving regulatory demands (e.g., carbon reporting mandates) and stakeholder expectations making the model timely and strategically relevant.

4.2 SAW Based Supplier Evaluation and Ranking

Following the determination of ESG criteria weights via the AHP method, the subsequent phase involved evaluating and ranking suppliers using the Simple Additive Weighting (SAW) technique. SAW was selected for its simplicity, computational efficiency, and its ability to accommodate normalized performance data both quantitative and qualitative aligned with the priority structure established by AHP.

Using the AHP-derived weights, the SAW method was applied to evaluate and rank the five suppliers. Normalized performance values were multiplied by corresponding weights and aggregated to produce final scores.

The results are presented below on table 3.

Table 3 - Final Results of Supplier Evaluation

Supplier	Total Weighted Score	Final Rank
S3	0.867	1
S2	0.812	2
S5	0.735	3
S1	0.702	4
S4	0.651	5

Table 3 explains Supplier S3 achieved the highest overall score, demonstrating consistently strong performance across the most influential ESG sub-criteria, particularly carbon emissions, labor practices, and governance transparency. This balanced performance profile indicates that S3 is not only environmentally responsible but also socially compliant and ethically governed attributes that are aligned with resilient, post-pandemic supply chain expectations.

Supplier S2 ranked second, driven by high scores on several environmental and governance-related indicators, although slightly lower performance in energy efficiency weakened its overall ranking. Meanwhile, Supplier S5 outperformed S1 and S4 primarily due to stronger social sustainability metrics, suggesting that improvements in labor standards and community engagement may significantly enhance supplier competitiveness.

Supplier S4, positioned last, showed deficiencies in several high-weighted sub-criteria. Notably, weak waste management practices and limited governance transparency contributed to its poor performance. This highlights a key implication: suppliers that fail to meet ESG expectations risk losing strategic positioning within sustainability-driven supply chains.

The application of SAW revealed a crucial insight: suppliers demonstrating resilience, environmental responsibility, and ethical governance consistently outperform others in ESG based assessments. This confirms that in the post pandemic supply chain landscape, long term sustainability and regulatory alignment are increasingly non-negotiable attributes. SAW thus serves as a decision support tool that clarifies trade-offs and supports evidence-based supplier selection in complex procurement scenarios.

4.3 Interpretation of Findings and Theoretical Alignment

The integration of AHP and SAW in this study provides insights that extend beyond conventional supplier evaluation outcomes. The prominence of environmental factors, especially carbon emissions, supports the growing recognition that environmental impact is a critical determinant of supply chain viability. This finding aligns with studies by Golan et al. (2020) and Ivanov & Dolgui (2020), who argued that environmental sustainability is increasingly linked to supply chain resilience in the post-pandemic world.

The results also reveal that social and governance criteria, while weighted slightly lower, still play a substantial role in differentiating supplier performance. This confirms arguments in ESG literature suggesting that strong governance mechanisms and socially responsible practices are crucial in mitigating operational disruptions, reputational risks, and stakeholder dissatisfaction (Aldowaih et al., 2022; Truant et al., 2024).

The supplier rankings illustrate that ESG performance is not only a measure of ethical responsibility but also a strategic differentiator. Suppliers like S3 that exhibit balanced strength across ESG dimensions are better positioned to support long-term supply chain sustainability and risk reduction. Conversely, suppliers with deficiencies in high-priority criteria, particularly environmental, are likely to become weaker partners in the evolving global supply landscape.

4.4 Sensitivity Analysis and Robustness of the Model

To assess the robustness and reliability of the proposed AHP SAW decision making framework, a sensitivity analysis was conducted by adjusting the weights assigned to the three main ESG criteria Environmental, Social, and Governance by $\pm 10\%$. This process was designed to simulate changes in stakeholder preferences or strategic shifts in sustainability focus, thereby testing whether such variations significantly impact the final supplier rankings.

Four weighting scenarios were analyzed:

1. Base Scenario (original AHP derived weights):
Environmental (0.42), Social (0.33), Governance (0.25)
2. Environmental +10% Scenario:
Environmental (0.462), Social (0.297), Governance (0.241)
3. Social +10% Scenario:
Environmental (0.378), Social (0.363), Governance (0.259)
4. Governance +10% Scenario:
Environmental (0.378), Social (0.297), Governance (0.325)

Each supplier's total score was recalculated under these adjusted weighting scenarios using the previously normalized ESG performance data. The final rankings were then compared to the base case to evaluate sensitivity to criterion weight changes.

Across all scenarios, Supplier S3 consistently remained the top ranked supplier, with the highest total weighted score in every case. This indicates that S3 demonstrates strong and balanced performance across all ESG dimensions, and that its superiority is not overly dependent on any single criterion. This stability underscores the robustness and reliability of the model, suggesting that decisions made using this framework are unlikely to be significantly altered by modest changes in strategic priorities.

In contrast, Suppliers S2 and S5 exhibited moderate shifts in their relative positions, particularly under the Social +10% scenario. Under this scenario, S5's score improved slightly relative to S2's, reducing the gap between them and, in some simulations, nearly reversing their ranks. This sensitivity reflects the comparative strength of S5 in social metrics (e.g., labor practices, health & safety), and highlights the importance of carefully calibrating ESG weightings to reflect an organization's true strategic and ethical priorities.

Meanwhile, Suppliers S1 and S4 consistently occupied the lower ranks, regardless of scenario. Their positions indicate a general underperformance across multiple ESG areas, reinforcing their unsuitability as preferred partners in a sustainability focused supply chain.

The results of this sensitivity analysis provide valuable managerial insight. They confirm that the model is structurally sound and decision stable, while also highlighting areas where minor shifts in emphasis such as increased focus on social responsibility can alter the relative attractiveness of mid tier suppliers. For organizations aiming to align procurement decisions with dynamic ESG strategies, this flexibility and transparency offer considerable strategic advantage.

Moreover, this analysis supports the argument advanced by Azadnia et al., (2015), which emphasizes the critical role of weight assignment in multi criteria decision making. Without deliberate and context-specific calibration, supplier evaluations may fail to reflect organizational values or emerging regulatory pressures, particularly in sectors where certain ESG aspects carry

disproportionate impact.

The findings demonstrate that ESG-based supplier selection provides a comprehensive approach to balancing environmental responsibility, social accountability, and governance transparency in procurement decisions. Practically, the results help organizations prioritize suppliers that contribute to long-term sustainability goals, reduce regulatory exposure, and enhance supply chain resilience.

Theoretically, this study extends prior MCDM-based supplier selection research by integrating a structured and operationalized ESG evaluation model, addressing a notable gap in sustainability and supply chain literature. The AHP–SAW hybrid model offers a replicable and transparent framework that bridges subjective expert assessment with objective supplier performance data, reinforcing its applicability for both academic research and managerial practice.

4.5 Discussion: Practical and Theoretical Implications

The results highlight several key insights regarding ESG oriented supplier evaluation. First, the dominance of the Environmental dimension aligns with the operational characteristics of the manufacturing sector, where activities directly influence emissions, resource consumption, and waste generation. This validates the high weight assigned to environmental criteria and reinforces the necessity for suppliers to improve ecological performance.

Second, the presence of trade-offs among ESG dimensions suggests that suppliers may excel in certain areas while exhibiting weaknesses in others. Supplier S2, for instance, performs strongly in environmental and governance metrics but shows comparatively lower performance in social indicators. Supplier S5 presents an opposite pattern. These differences reflect divergent maturity levels and strategic focus areas among suppliers. Organizations must recognize these trade-offs and design targeted supplier development programs to address specific ESG gaps.

Third, although expert judgment introduces potential subjectivity, this study mitigated bias by involving a diverse panel of experts and validating consistency using CR calculations. Nevertheless, some supplier data may include reporting bias. Future studies may enhance data reliability by incorporating third party verified ESG data or automated monitoring systems.

Finally, the hybrid AHP SAW model demonstrates strong analytical and practical advantages. AHP provides a rigorous structure for deriving weights and ensuring consistent expert evaluations. SAW complements this by offering a clear and transparent process for aggregating supplier performance. Together, the methods create a balanced model that captures the complexity of ESG criteria while maintaining interpretability for decision makers.

4.6 Comparison with Previous Studies

The findings of this study show both alignment with and advancement beyond existing research in sustainable supplier selection using Multi Criteria Decision Making (MCDM) methods. Previous studies have applied AHP, SAW, TOPSIS, VIKOR, and fuzzy approaches to supplier evaluation. However, much of the earlier work focused on traditional procurement indicators such as cost, quality, and delivery, or addressed sustainability in a general sense without developing a structured ESG based evaluation framework. For example, Ho et al. (2010) and Kannan and Haq (2007) demonstrated the effectiveness of AHP and SAW in supplier evaluation but did not incorporate comprehensive ESG criteria into the decision model. Similarly, Govindan et al. (2013) and Awasthi et al. (2010) integrated environmental and social factors into supplier assessments, yet did not explicitly operationalize ESG indicators or align their models with the evolving needs of post pandemic supply chains.

Compared with studies that employed AHP TOPSIS or fuzzy MCDM models, this research contributes a transparent and accessible hybrid framework by combining AHP for criteria weighting and SAW for performance aggregation. This approach preserves analytical rigor while maintaining ease of interpretation, which is essential for practical implementation in industry contexts. Additionally, unlike many previous works that evaluated sustainability using broad conceptual categories, this study constructs a detailed decision hierarchy centered on ESG components that reflect contemporary global expectations and regulatory pressures.

This research also provides empirical validation through a real case application and sensitivity analysis. The consistent ranking of suppliers under varying weight scenarios demonstrates the robustness of the model, which addresses a gap in earlier studies that often did not test the stability of their results. Overall, this study advances the literature by delivering a practical and operational ESG based MCDM framework that supports decision makers in adapting to the post pandemic sustainability landscape.

4.7 Managerial Implications

The results of this study offer several important implications for practitioners in supply chain management, procurement, and sustainability functions. First, the AHP SAW framework provides a structured and transparent decision support tool that helps organizations evaluate suppliers based on environmental, social, and governance criteria. This clarity is essential for demonstrating compliance with ESG reporting requirements and for ensuring that procurement decisions are aligned with corporate sustainability goals.

Second, the strong emphasis on environmental factors in the evaluation results indicates that organizations should prioritize suppliers with superior environmental performance. This finding can guide decisions related to supplier development, long term sourcing strategies, and environmental compliance programs. Companies may also consider providing technical assistance or collaborative improvement initiatives for suppliers that are strategically important but exhibit lower environmental performance.

Third, the influence of social and governance criteria on supplier ranking highlights their relevance in managing risk. Suppliers with weak labor practices or insufficient governance transparency may expose organizations to operational disruptions, reputational harm, and regulatory penalties. Managers can use this framework to identify potential risks early and integrate ESG criteria into supplier audits, performance contracts, and continuous improvement efforts.

Finally, the results of the sensitivity analysis show that the model remains stable under different weighting configurations. This adaptability enables organizations to adjust the importance of ESG dimensions as regulations, stakeholder expectations, or corporate priorities evolve. The framework is therefore suitable for dynamic environments and supports long term sustainability planning across the supply chain.

Collectively, these implications highlight that incorporating ESG principles into supplier selection is essential for building resilient, responsible, and future oriented supply chains. The proposed AHP SAW model provides a practical tool for organizations seeking to strengthen their ESG performance while maintaining procurement effectiveness.

5 CONCLUSION AND FUTURE RESEARCH DIRECTIONS

5.1 Conclusion

This study developed and validated a hybrid decision making framework that integrates the Analytic Hierarchy Process and Simple Additive Weighting to support ESG based supplier selection in green supply chains. Responding to the increasing importance of sustainability and resilience in the post pandemic era, the proposed model operationalizes Environmental, Social, and Governance dimensions into a structured and quantifiable decision hierarchy. The AHP method provided systematic and consistent weighting of ESG criteria based on expert judgment, while the SAW method enabled transparent aggregation of supplier performance data.

The empirical case study demonstrated that the model is capable of distinguishing supplier performance based on their alignment with organizational ESG priorities. Supplier S3 obtained the highest ranking due to consistently strong performance across environmental, social, and governance indicators. The sensitivity analysis further confirmed the robustness of the model, as supplier rankings remained stable under alternative weight scenarios. These findings show that the integration of AHP and SAW offers both analytical rigor and practical usability for sustainability oriented procurement.

This study contributes to the literature by offering a detailed and operational ESG based MCDM model that addresses a critical gap in previous supplier selection research, which often treated sustainability conceptually without a structured evaluation framework. From a managerial perspective, the model provides a practical tool for organizations to incorporate ESG principles into procurement decisions and to identify suppliers that support long term sustainability and risk mitigation goals.

Although the model performs well in the examined context, its application is limited by the reliance on expert judgment and the availability of accurate supplier ESG data. Future research can extend this work by integrating additional data sources, including third party ESG ratings, real time monitoring systems, or multi tier supplier assessments. Comparative studies involving other hybrid MCDM techniques may also provide deeper insights into the suitability of different decision models for ESG based supplier evaluation.

5.2 Future Research Directions

This study provides a structured and operational framework for ESG based supplier selection; however, several limitations should be acknowledged. First, the assessment of criteria weights relies on expert judgment, which introduces the possibility of subjective bias despite the consistency checks applied through the AHP method. Although the expert panel represented relevant functional roles in supply chain sustainability, expanding the number and diversity of experts may improve the robustness of future evaluations.

Second, the accuracy of supplier performance ratings depends on the quality and availability of ESG related data. In many cases, supplier disclosures may contain reporting gaps or inconsistencies, particularly in areas where third party verification is limited. The reliance on self-reported data may influence the precision of the SAW calculations. Future studies could incorporate validated ESG databases, automated monitoring systems, or certification-based assessments to strengthen data reliability.

Third, the empirical validation in this research was limited to a single manufacturing case study with five suppliers. Although the results provide meaningful insights, the generalizability of the model may be constrained when applied to other industries or supply chain structures with different ESG priorities. Future research should test the framework across various sectors, including those with high social or governance risks, to examine its broader applicability.

Finally, this study used a deterministic approach to evaluate supplier performance. Future research could explore hybrid methods that combine AHP SAW with fuzzy logic, stochastic modeling, or machine learning based decision support to better accommodate uncertainty in ESG metrics. Researchers may also consider extending the model to evaluate multi-tier suppliers, since sustainability risks often originate beyond the first tier of the supply chain.

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