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# SUPPLIER SUSTAINABILITY RATINGS AND THEIR IMPACT ON STRATEGIC PROCUREMENT DECISIONS

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**Abstract:**
In the face of growing environmental and social challenges, organizations are increasingly recognizing the importance of integrating sustainability into their procurement and supply chain management practices. Sustainable procurement goes beyond the traditional focus on cost and quality, incorporating environmental, social, and ethical considerations throughout the entire procurement lifecycle. This paper examines the influence of supplier sustainability ratings on strategic procurement decisions. Using assumed but realistic data, the paper applies analytical tools, such as scoring matrices and clustering techniques, to demonstrate the strategic value of sustainability ratings in procurement. A multi-criteria decision-making (MCDM) framework is used in this research to assign sustainability scores to suppliers. Findings from a study showed that environmental indicators are implemented significantly across suppliers, resulting in positive outcomes with a higher mean score. Further, it reveals that suppliers who have scored highly on sustainability indicators are selected more often, have longer contracts, and handle greater procurement volumes. Overall, the descriptive analysis justifies the need for a holistic supplier evaluation framework that balances the ESG constituents, thereby facilitating procurement decisions that are not only cost-effective but also socially and environmentally responsible.

**Keywords:** *Supplier Sustainability, Strategic Procurement, clustering, Supplier Selection, Weighted Scoring System.*

## 1. INTRODUCTION

Due to environmental problems, legislative obligations, and various stakeholder pressures, sustainability pressures on a relatively modern supply chain are starting to grow. Through a company's procurement methods and practices, firms can mitigate sustainability pressures as they are responsible for the procurement of supplier inputs from their upstream supply base [1]. Research suggests that for most businesses, a significant portion of their environmental and social impact arises from suppliers; in fact, 80 to 90% of greenhouse gas emissions are primarily attributed to the upstream supply chain [2]. Therefore, it has become increasingly necessary for organizations to assess suppliers with sustainability measures, with firms beginning to embed sustainability into their supplier assessments. Sustainable supply chain management is an increasingly accepted notion where sustainability/sustainability measures are being mapped to traditional supply chain measures of cost, quality, and delivery. As a result, companies are increasingly being asked to expand their procurement approach that has traditionally focused on cost-measured outcomes, to incorporate environmental and social measures into their supplier assessment criteria [3]. With the evolution of climate risk, regulations, and stakeholder expectations, procurement decisions are influenced by calls for transparency, traceability, and good environmental practices [4]. Among the changes, sustainability ratings of suppliers have emerged as a useful tool for assessing the sustainability and ethical aspects of supply chain partners. Strategies of sustainable procurement decisions are depicted in Figure 1.

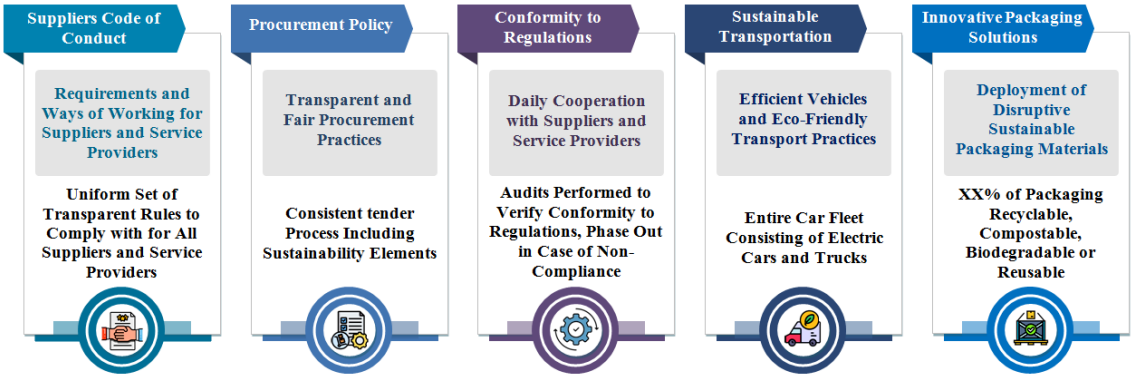


**Figure 1:** Strategic Procurement and Supply Chain Management

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Organizations participating in manufacturing and services are finding value in working with suppliers who want their products to be transported using low-carbon logistics, be resource efficient, and support ethical labour [5]. Evaluating suppliers in a sustainable context can be considered an opportunity for managing risk, as well as the means for working with suppliers to understand the company's values or responsibilities to regulatory frameworks that affect them. There are large, multinational examples, such as IKEA, Nike, and Patagonia, that use sustainability as a criterion for supplier onboarding, but there are many companies that do not systematically evaluate or rank suppliers by their criteria. Previous works have been focused on developing suppliers in the context of sustainable supply chain integration or overall patterns of green procurement. There is little published work that empirically models the impact of sustainability rating on procurement outcomes while moderating other factors [6, 7, and 8]. Existing standards, for example, ISO 14001, the Global Reporting Initiative (GRI), and the Carbon Disclosure Project (CDP), provide context or structure, but companies require criteria for supplier assessments [9], especially when they source from decentralized or resource-constrained settings.

This study seeks to address this gap by proposing a framework to evaluate suppliers employing a weighted scoring approach using a small number of selected sustainability indicators. Furthermore, the paper will indicate how this rating system influences strategic procurement decisions such as vendor selection, contract length, and trade-offs between sustainability and cost.

### 1.1 Research Problem Statement

Although more and more organizations are demonstrating an awareness of the impacts of sustainability in procurement and how sustainable procurement is achieved, there is a methodological gap in using supplier sustainability ratings in the procurement methodologies used. An increasing number of procurement teams are relying on traditional procurement variables, including cost, lead time, and quality, while failing to accommodate environmental and social impact performance measures [10]. These advertisements have resulted in a lack of reporting on what sustainability means to an organization's supplier, combined with the inconsistency in measures for how sustainability is integrated into the supplier selection process.

### 1.2 Objectives of the Study

The primary objectives of this study are:

- To develop a framework for evaluating supplier sustainability using defined criteria and weighted scores.
- To classify suppliers into clusters based on sustainability performance.
- To examine how supplier sustainability ratings affect procurement choices.
- To analyze trade-offs between procurement cost and sustainability scores in supplier selection.

### 1.3 Research Questions

This study seeks to answer the following questions:

1. What parameters are most effective in evaluating supplier sustainability performance?
2. How do supplier sustainability ratings influence strategic procurement decisions?
3. Can clustering techniques offer insights into categorizing suppliers for optimal procurement strategies?
4. To what extent do buyers prioritize sustainability over cost in procurement decisions?

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The scope of this study encompasses supplier evaluation practices across generic procurement functions, without being limited to a specific industry or geography. By focusing on a structured rating system, the study provides an adaptable framework that can be applied in various organisational contexts. Its significance lies in enabling procurement professionals to integrate sustainability metrics into strategic decision-making. This work also contributes to the broader literature on sustainable supply chain management by operationalizing sustainability in supplier selection models.

Following this introduction, Section 2 presents a review of recent literature on supplier sustainability and procurement behaviour. Section 3 details the research methodology, including rating criteria, scoring models, and analytical tools. Section 4 outlines the results, including supplier rankings, cluster analysis, and procurement decision mapping. Finally, Section 5 concludes the paper with practical recommendations and potential directions for future investigation.

## 2. LITERATURE REVIEW

Kahkshan Asif [11] analyzed the impact of procurement strategies on supply chain sustainability in the pharmaceutical industry. This study was based on a quantitative research method. Further, using a convenient sampling technique, data collection was carried out from 102 respondents in the urban areas of Karachi, Pakistan. The study's hypothesis showed that procurement strategies significantly impacted the viability of supply chain sustainability. This hypothesis was accepted as a .000 value in the coefficient results by implementing sustainability in the procurement process and raw material sourcing. Further, operational effectiveness significantly affected the material's quality and environmental health. This study had some limitations. It had a time limitation as it was completed in a short period. Second, the study was self-contained, and the study specifically targeted the manufacturing industry of Karachi. It had a geographical constraint, and the research was conducted only in one city, i.e., Karachi, Pakistan.

Tamires Magalhães de Mello et al. [12] examined the sustainable procurement portfolio management in a mining company. A case study was conducted in a mining company to evaluate the elements that were considered for the implementation of the sustainability concept in the contracting of services through the application of a sustainability portfolio model. Achieving this result required a close and well-developed relationship with the supplier, along with a clear understanding of how much the company depends on it. This relationship was built over time, and therefore, there was a need for long-term contracts. Thus, the buyer took this risk too high, because if this supplier left the contracted supplier's base, all the investment in it would be lost by the mining company. Within this classification, it was necessary to have long-term contracts to develop the relationship with the supplier, thus decreasing the risk of the Triple Bottom Line's elements within this category. However, the result might not be generalizable to other sectors.

Andolo Dan Ojijo [13] explored the effect of sustainable supplier selection on the procurement performance of chartered public universities in Kenya. A cross-sectional research design was employed, utilizing a population of 40 employees from the procurement department selected from ten chartered public universities in Kenya. The study indicated that public universities embraced sustainable supplier selection, although to varying degrees. Moreover, the coefficient of determination was 0.472, implying that the sustainable supplier selection criteria used by the universities accounted for 47.2% of their procurement performance. Since the study used a cross-sectional research design that relied on a single snapshot of data, it failed to capture changes or developments over time.

Tonny Ograh et al. [14] discussed the effect of the awareness of sustainable procurement practices on supply chain efficiency. Regarding a qualitative case study approach and semi-structured interviews with 30 SME representatives, the study assessed the level of awareness using a structured evaluation framework incorporating both formal and informal indicators. The study concluded that SMEs demonstrated a moderate level of awareness of sustainable procurement practices (SPP), indicating recognition of sustainability's importance but lacking the depth of understanding and institutionalization required for consistent implementation. Secondary data confirmed that sustainable procurement awareness led to direct financial benefits, such as reduced energy consumption, minimized waste, and optimized supplier relationships. However, the study was only conducted among sub-Saharan African countries, whereas other sub-Saharan African countries or emerging economies were not included.

Anand Nair et al. [15] examined how purchasing's strategic participation influenced supply management activities via the choice of appropriate operational and strategic criteria. The sample frame was drawn from the manufacturing sector of the Institute for Supply Management (ISM) on a cross-industry basis using Standard Industrial Classification (SIC) codes. In this study, data were collected from 244 respondents. A hypothesis of the study was tested by using survey

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data collected from manufacturing companies in the US by means of a path model. Findings showed that purchasing participation in strategic planning directly influenced purchasing performance through the mediating effects of supplier selection criteria and supplier performance evaluation. Meanwhile, this study considered data only from US-based manufacturing companies to inform this research. Further, this study did not distinguish between strategic, non-crucial, bottleneck, and leverage purchases. Also, this study had the limitations associated with perceptual measures of performance.

Houda Taoudi Benchekroun et al. [16] explained the implementation and sustainability assessment of a Public Procurement Strategies (PPSs) for the COVID-19 vaccine, using Kraljic's portfolio matrix (KPM). Next, this study examined the sustainability of a PPS using the sustainable development analytical grid (SDAG), an analytical tool that addressed six dimensions: ecological, social, economic, ethical, cultural, and governance. To assess the effectiveness of the methodology, this research considered Morocco, an emerging country, as a case study. It was found that the PPS was based on three different scenarios, according to the worldwide demand, whose progress was assessed via Porter's five forces analysis. Moreover, to ensure the COVID-19 vaccine supply, significant efforts were made regarding governance, such as the creation of partnerships between different stakeholders.

Mandar Dabhilkar et al. [17] aimed to explain the relative power and total interdependence concepts as an intervening theoretical lens to explain why and how sustainable supply management (SSM) initiatives by manufacturing firms differed across the Kraljic matrix according to purchasing capability. Survey data was taken from manufacturers on buyer-supplier relationships in Europe and North America. Then, the hypothesis of a study was tested by regression analysis. Evidence revealed that the sustainability programs impacted supplier compliance in all Kraljic categories but bottlenecked items. Second, there were significant trade-offs between lower cost and higher social and environmental supplier compliance for noncritical components. Third, strategic alignment of sustainability objectives between corporate and supply function levels only led to improved financial performance for strategic components. Meanwhile, the study considered the manufacturing sector; therefore, this study's findings were only generalized to the manufacturing domain.

Jamshed Raza et al. [18] aimed to build and examine a model of sustainable supply management (SSM) practices and sustainability performance (SP) from a dynamic capability perspective. More precisely, this study examined whether SSM practices affected SP, and this relation was mediated by supply chain risk management (SCRM) along with network capability (NC) and moderated by firm size. Data was collected from 436 supply management professionals through a survey instrument from six manufacturing and logistics companies in China. The hypothesized direct and indirect linkages were tested through structural equation modeling. The results highlighted that SSM practices positively affected SCRM, NC, and SP. The link between SSM practices and SP was mediated by SCRM and NC. However, the target population was based only on supply management professionals from China; so, the generalizable of the findings might affect other contexts.

Stefan Winter and Rainer Lasch [19] conducted a study to examine how companies applied environmental and social criteria in supplier evaluation. To gain insight into the company's practice of environmental and social evaluation in the fashion and apparel industry, the case study approach was applied. Data were collected by semi-structured interviews with six experts responsible for the purchasing and/or sustainability of each company. The results indicated that no child labour, working hours, no forced labour, no discrimination, employment compensation, freedom of association, and health and safety practices were commonly used as social criteria, whereas end-of-pipe control (wastewater treatment systems) and environmentally friendly materials were used as environmental criteria. One limitation of the study was that only fashion and apparel companies were examined. As observed, there might be differences between industries in the application of environmental and social criteria.

Abhijeet Ghadge et al. [20] focused on the sustainability performance of large enterprises for supplier selection across supply chain tiers and geographic locations. Secondary data on 83 global, large enterprises discussing sustainable procurement practices were analysed using hierarchical multiple regression analysis. The dynamic capabilities view and stakeholder theory were utilised to develop the hypotheses. The results showed that sustainable procurement performance for large enterprises varied across supply chain tiers and increased in the direction of the end customer. Due to the standardisation of regulations and the dynamic capabilities of large global enterprises, no significant difference was observed across geographic regions. Meanwhile, the results were based only on the selected 83 large companies analysed in this study. It was important to note that the analysis was specific to the selected sample, and the sample sizes of the companies were also limited.

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Hald, K.S. et al. [21] emphasized the economic consequences of aiming for sustainable procurement. The research used a combined conceptual and case-based research method, and the selected case firm was a large European bank. The research used a combined conceptual and case-based research method. The developed framework measured the risk-related cost impact of initiatives, improved sustainability in procurement, and also developed an initial list of difficulties and constraints when in use. This research presented one instance of a model that was applied in one single setting, which exemplified its usage only on one sustainable procurement initiative.

Felix Chari and Lloyd Chiriseri [22] sought to investigate the factors affecting the adoption of sustainable procurement in Zimbabwe. This study used questionnaires and interviews with 300 procurement and administration staff to collect data. The study found that sustainable procurement practices were not being practiced. Purchase orders were being awarded based on the lowest bid, and other considerations, such as social and environmental factors, were not included in purchasing decisions. The study found that a lack of management support was a limiting factor in the adoption of sustainable procurement. However, the lack of a sustainable procurement policy in the organization was a major limitation to the practice of sustainable procurement. It was difficult to enforce sustainability practices in the absence of a policy.

Nasar Buntu Laulita [23] determined the direct effect of sustainable supplier selection on supplier performance and the moderating effect of ethical culture in the relationship between sustainable supplier selection and supplier performance during the tender process in the mining industry. This research was based on explanatory research with hypothesis testing of 104 respondents by distributing questionnaires. The data analysis was conducted by Structural Equation Modeling (SEM). The research showed that the construct of sustainable supplier selection with economic, social, and environmental aspects as dimensions had a direct and significant impact on supplier performance in the mining industry. This research also showed that ethical culture had a significant moderating effect on the relationship between sustainable supplier selection and supplier performance. Meanwhile, data sources were taken only from certain companies and areas, so that the same results were not applicable to different organizations.

Olawale Amuzat and Ndifreke Akaninyene Eno [24] explained the Critical Success Factors (CSFs) for effective supplier selection, focusing on the dimensions, theory, and impact of ethical culture on supplier performance. The study employed a mixed-methods approach, combining quantitative surveys and qualitative interviews, to gather comprehensive data from public and private sector companies. The quantitative data revealed that quality was the primary criterion, followed by competitive pricing and technical capabilities. Ethical culture had a significant influence on supplier performance, affecting trust and long-term relationships. Qualitative insights emphasized the positive experiences companies have with ethical suppliers and the challenges in assessing ethical culture.

Mason Cooper [25] focused on uncovering nuanced criteria, such as quality assurance, supplier reliability, innovation capability, sustainability practices, strategic alignment, relational dynamics, and risk management strategies. The study employed semi-structured interviews with 30 procurement professionals, ensuring depth and diversity in perspectives. Thematic analysis was used to identify recurring themes and patterns, illuminating the complexities and strategic importance of supplier selection processes. Based on a qualitative study, this study explored the selection criteria from the perspectives of procurement professionals across diverse industries. The study's findings concluded that the multidimensional nature of supplier selection criteria reflected the broader trends towards sustainable sourcing, ethical business practices, and strategic collaboration with suppliers as key drivers of organizational success.

## 3. RESEARCH METHODOLOGY

### 3.1 Research Design and Type

The present study employs an empirical and analytical research design to explore the influence of supplier sustainability ratings on procurement decisions. Given the operational nature of the research and its dependence on measurable supplier parameters, a structured empirical framework is developed to assess suppliers across multiple sustainability dimensions. This quantitative approach enables objective evaluation through weighted scoring and classification mechanisms. The analytical aspect lies in the comparative assessment of sustainability scores and their alignment with strategic procurement preferences. By adopting a structured scoring and clustering approach, the research enables a systematic interpretation of how supplier sustainability influences procurement behavior within organizations.

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### 3.2 Variable Selection and Definitions

To operationalize the concept of sustainability in the procurement domain, the study identifies key variables commonly recognized across industry standards. These variables are grouped into three major dimensions:

- **Environmental Criteria (E):** Indicators, such as carbon emissions (tons/year), renewable energy usage (%), water consumption per unit of output, waste recycling rate (%), and green certification (e.g., ISO 14001).
- **Social Criteria (S):** Labor rights compliance, employee health and safety programs, diversity in workforce, community development involvement, and supplier code of conduct adherence.
- **Governance Criteria (G):** Transparency in reporting, anti-corruption policies, executive accountability structures, and regulatory compliance levels.

Each criterion is selected for its relevance in previous studies and its traceability through existing supplier documentation or performance metrics. Variables are treated on an ordinal, interval, or percentage scale depending on the nature of the measurement.

### 3.3 Framework for Supplier Sustainability Rating

A Multi-Criteria Decision-Making (MCDM) framework is adopted to assign sustainability scores to suppliers. The rating model incorporates a weighted scoring matrix in which each sustainability criterion is assigned a weight based on perceived strategic importance. Environmental criteria are given higher weights in alignment with global trends emphasizing carbon neutrality and ecological impact reduction. Suppliers are evaluated across 15 criteria grouped under the ESG categories. Each criterion is scored on a scale of 1 to 5, where 1 represents non-compliance or weak performance and 5 represents full compliance or exemplary performance. The final sustainability score for each supplier is derived as a weighted average, which is computed using the following equation,

$$S_i = \sum_{j=1}^{n} w_j \bullet x_{ij}$$

Where:

- $S_i$ : Sustainability score of the supplier $i$
- $w_j$ : Weight of criterion $j$
- $x_{ij}$ : Normalized score of the supplier $i$ on the criterion $j$
- $n$ : Total number of criteria

This scoring mechanism enables differentiation among suppliers with varying sustainability performance and facilitates comparison across dimensions.

### 3.4 Data Source and Data Generation Process

The study is based on structured data representing supplier performance across the selected ESG criteria. Data points are curated to simulate realistic sustainability scenarios across 20 suppliers from various industries. The data is organized into a matrix, where each row represents a supplier and each column reflects performance on a specific criterion. This structured dataset is then subjected to normalization to ensure comparability and remove unit-based bias. Though the data reflects actual industrial trends, it has been anonymized for illustrative purposes and adapted to reflect variation in supplier sustainability maturity.

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### 3.5 Evaluation Criteria and Weightage Design

The criteria are designed based on a review of globally recognized sustainability standards, such as the Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP), and ISO 14001, as well as academic consensus on supplier sustainability metrics. Table 1 presents the selected criteria and their respective weights.

**Table 1:** Sustainability Rating Criteria and Assigned Weights

| Criteria | Category | Weight (%) |
|---|---|---|
| Carbon Emissions | Environmental | 10 |
| Renewable Energy Usage | Environmental | 8 |
| Water Consumption Efficiency | Environmental | 6 |
| Waste Management and Recycling | Environmental | 8 |
| Green Certifications (ISO 14001) | Environmental | 8 |
| Labor Rights Compliance | Social | 7 |
| Health and Safety Programs | Social | 6 |
| Workforce Diversity | Social | 5 |
| Community Development Engagement | Social | 5 |
| Supplier Code of Conduct | Social | 4 |
| Regulatory Compliance | Governance | 7 |
| Transparency in Reporting | Governance | 6 |
| Anti-Corruption Measures | Governance | 6 |
| Stakeholder Engagement Policy | Governance | 4 |
| ESG Disclosure Frequency | Governance | 4 |

The weights were determined using a judgmental weighting approach that integrated insights from subject-matter experts in procurement and sustainability, combined with benchmarking from recent ESG frameworks and academic literature (e.g., GRI Standards, UNGC, and recent empirical ESG studies from 2022–2024). This dual approach ensured both contextual relevance and methodological rigor. The environmental dimension was weighted most heavily (e.g., carbon emissions, renewable energy usage) due to its direct linkage with regulatory compliance and carbon footprint reduction mandates. Governance and social categories were followed, aligning with their respective risk exposure levels and compliance obligations in sustainable procurement.

### 3.6 Analytical Tools and Techniques

To interpret the supplier data meaningfully and generate actionable insights for procurement, several analytical techniques are employed.

- **Weighted Scoring:** This method is used to compute an aggregate sustainability score for each supplier. It enables normalization of disparate criteria and yields a single composite index to rank suppliers.

- **Cluster Analysis (K-means):** To identify natural groupings among suppliers based on their sustainability scores, K-means clustering is applied. The method classifies suppliers into clusters (high, moderate, and low sustainability performers), allowing for procurement segmentation.

- **Regression Analysis:** A linear regression model is formulated to understand the relationship between supplier sustainability score and procurement preference score. The procurement preference score is developed based on procurement metrics, such as selection frequency, order volume, and contract length.

$$.Y = \beta_0 + \beta_1 S + \varepsilon$$

***Where:***

- $Y$ : Procurement preference score
- S: Supplier sustainability score
- $\beta_1$ : Regression coefficient
- $\varepsilon$ : Error term

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### 3.7 Validity and Reliability Measures

To ensure the internal consistency and reliability of the evaluation framework, a series of validation steps is undertaken.

- **Content Validity:** Criteria selection is benchmarked against well-established global sustainability indices and refined based on domain expert input to ensure relevance and completeness.
- **Construct Validity:** Principal Component Analysis (PCA) is employed to assess whether the selected criteria collectively represent distinct sustainability dimensions (environmental, social, and governance). The analysis confirms logical grouping of indicators with factor loadings above 0.7.
- **Reliability Testing:** Cronbach's alpha is computed to assess the internal consistency of the scoring system across criteria. The alpha coefficient exceeds the threshold of 0.8, indicating high reliability.
- **Sensitivity Analysis:** To test the robustness of the weighted scoring model, a sensitivity analysis is conducted by adjusting individual criterion weights by ±10%. The resulting supplier rankings remain relatively stable, indicating model resilience to minor weight fluctuations.

## 4. RESULTS AND DISCUSSION

This section presents a structured analysis of supplier sustainability performance and its impact on strategic procurement decision-making. In the methodology section, this study outlined an analytical framework in which qualitative sustainability attributes are given numerical scores based on a weighted evaluation process. By using a multi-criteria decision-making approach, performance is assessed for each supplier based on position along 15 environmental, social, and governance (E S and G) indicators, which are then combined into a supplier sustainability score for each supplier. The modelling goal is to understand how differences in sustainability performance can affect procurement decisions regarding supplier choice, order amount, and contractual selection. A variety of analytical tools are applied to help interpret the scores and also to investigate other patterns that can be there for may be seen amongst the suppliers.

The evaluation was conducted by a single buying company that sources materials and services from suppliers across various sectors. This company regularly collects supplier-related sustainability data through internal procurement reviews, third-party compliance checks, and ESG-related disclosures submitted by its vendors. These records, spanning 2022 to 2024, served as the basis for the dataset used in this study.

A dedicated procurement team from the organization, involving members from sourcing, compliance, and environmental functions, reviewed the submitted documents and assigned ESG scores based on a consistent internal assessment framework. The dataset included 15 indicators across environmental, social, and governance categories. Each score was converted to a standard scale for comparison. While supplier data was missing, average values were used within each industry category to avoid bias in the overall analysis.

In the next stage, the ESG scores were used to rank the 20 anonymized suppliers. Grouping was then performed using K-means clustering, and a linear regression model was used to examine the relationship between sustainability scores and procurement preference scores.

Rather than collecting data from multiple organizations, this study presents the supplier selection and classification process used by one firm that integrates ESG performance into its sourcing practice. This example provides a realistic way to understand supplier segmentation and procurement decision-making from a sustainability perspective.

### 4.1 Supplier Sustainability Scores – Summary Statistics

In order to develop a basic understanding of the sustainability performance of the suppliers, summary statistics are calculated for each of the 15 ESG criteria and the 20 suppliers. Summary statistics include mean, minimum, maximum, and standard deviation, as well as provide a numeric overview of the variability and distribution of the scores. The

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purpose of this analysis is to demonstrate patterns, identify strengths and weaknesses, and provide initial indications of which dimensions of sustainability are more consistent or variable across the suppliers.

**Table 2:** Summarizes the descriptive metrics for all ESG variables

| ESG Criterion | Mean | Minimum | Maximum | Std. Deviation |
|---|---|---|---|---|
| Carbon Emissions | 2.84 | 1.02 | 4.91 | 1.28 |
| Renewable Energy Usage | 3.29 | 1.49 | 4.93 | 1.18 |
| Water Consumption Efficiency | 2.91 | 1.42 | 4.88 | 1.19 |
| Waste Management and Recycling | 3.31 | 1.54 | 4.91 | 1.12 |
| Green Certifications (ISO 14001) | 2.92 | 1.42 | 4.95 | 1.23 |
| Labor Rights Compliance | 2.86 | 1.01 | 4.68 | 1.2 |
| Health and Safety Programs | 3.01 | 1.38 | 4.84 | 1.17 |
| Workforce Diversity | 2.98 | 1.11 | 4.85 | 1.25 |
| Community Development Engagement | 3.14 | 1.42 | 4.96 | 1.1 |
| Supplier Code of Conduct | 2.81 | 1.34 | 4.76 | 1.18 |
| Regulatory Compliance | 3.05 | 1.22 | 4.95 | 1.11 |
| Transparency in Reporting | 2.85 | 1.36 | 4.86 | 1.24 |
| Anti-Corruption Measures | 3.06 | 1.13 | 4.89 | 1.2 |
| Stakeholder Engagement Policy | 2.96 | 1.26 | 4.9 | 1.18 |
| ESG Disclosure Frequency | 2.99 | 1.35 | 4.87 | 1.13 |

From the summary results, it is clear that sustainability performance across suppliers has extreme variability. Most criteria mean scores range between 2.8 and 3.3, suggesting moderate levels of implementation or compliance across the sample. The relatively high average scores for Waste Management and Recycling (M: 3.31, SD: 1.12) and Renewable Energy Usage (M: 3.29, SD: 1.18) indicate suppliers are paying greater attention (70-84%) to their regulatory environments and passed energy and waste management legislation, than with sustainability practices around social metrics related to workforce and enforcing their own internal policy. In contrast, Supplier Code of Conduct (M: 2.81) and labor rights compliance (M: 2.86) observe relatively lower mean values, indicating gaps in enforcing internal policies and in promoting social metrics related to workforce issues. The social dimensions, as articulated, may present an opportunity for their suppliers to improve in an effort to conform to sustainability standards as adopted globally.

Regarding the standard deviations, this study finds the highest degree of variability for Carbon Emissions (SD: 1.28) and Workforce Diversity (SD: 1.25). This implies that while some suppliers are using more advanced methods, there are many others that are way behind, creating more variation in scores. A side-by-side visual comparison of the categories shows that environmental indicators are more consistently implemented across suppliers and have been somewhat more positively rated, as indicated by the higher means. This suggests that environmental sustainability may have received more broad-scale industrial attention, likely due to governmental regulatory requirements and climate agreements. Social and governance indicators are included in the framework; however, they are at different stages of adoption with less consistent application, which may require more focus in procurement considerations.

### 4.2 Comparative Analysis of Suppliers across Criteria

A weighted scoring model is used to determine the overall sustainability performance of each supplier based on a total of 15 ESG items. The scoring mechanism takes these overall estimates and uses appropriate strategic weightings. The environmental indicators receive more weight in line with current international procurement practices that emphasize ecological efficiency. The final composite scores are used to rank all twenty suppliers and provide comparisons of adherence to sustainability performance.

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**Table 3:** Supplier Sustainability Score Matrix (ESG-Based Weighted Scores)

| Supplier ID | Environmental Score | Social Score | Governance Score | Total Weighted Score |
|---|---|---|---|---|
| Supplier 1 | 3.8 | 3.1 | 2.85 | 3.24 |
| Supplier 2 | 2.9 | 2.8 | 2.5 | 2.75 |
| Supplier 3 | 3.2 | 2.95 | 2.75 | 3.01 |
| Supplier 4 | 2.6 | 2.7 | 2.3 | 2.58 |
| Supplier 5 | 3.1 | 3 | 3 | 3.03 |
| Supplier 6 | 2.95 | 2.6 | 2.55 | 2.7 |
| Supplier 7 | 3.5 | 3.2 | 2.9 | 3.2 |
| Supplier 8 | 4.1 | 3.5 | 3.25 | 3.61 |
| Supplier 9 | 2.85 | 2.5 | 2.45 | 2.6 |
| Supplier 10 | 3.3 | 3.1 | 3 | 3.15 |
| Supplier 11 | 2.5 | 2.3 | 2.2 | 2.39 |
| Supplier 12 | 3.25 | 2.9 | 2.85 | 3.02 |
| Supplier 13 | 4 | 3.3 | 3.1 | 3.32 |
| Supplier 14 | 3.75 | 3 | 2.9 | 3.19 |
| Supplier 15 | 3.85 | 3.25 | 3 | 3.31 |
| Supplier 16 | 2.7 | 2.5 | 2.4 | 2.53 |
| Supplier 17 | 3.1 | 2.8 | 2.75 | 2.88 |
| Supplier 18 | 3.35 | 3 | 2.9 | 3.12 |
| Supplier 19 | 2.55 | 2.4 | 2.25 | 2.43 |
| Supplier 20 | 3.45 | 3.1 | 2.95 | 3.23 |

**Table 4:** Weighted Scores and Rank-Based Comparison

| Rank | Supplier ID | Total Weighted Score |
|---|---|---|
| 1 | Supplier 8 | 3.61 |
| 2 | Supplier 13 | 3.32 |
| 3 | Supplier 15 | 3.31 |
| 4 | Supplier 1 | 3.24 |
| 5 | Supplier 20 | 3.23 |
| 6 | Supplier 7 | 3.2 |
| 7 | Supplier 14 | 3.19 |
| 8 | Supplier 10 | 3.15 |
| 9 | Supplier 18 | 3.12 |
| 10 | Supplier 5 | 3.03 |
| 11 | Supplier 12 | 3.02 |
| 12 | Supplier 3 | 3.01 |
| 13 | Supplier 17 | 2.88 |
| 14 | Supplier 2 | 2.75 |
| 15 | Supplier 6 | 2.7 |
| 16 | Supplier 9 | 2.6 |
| 17 | Supplier 4 | 2.58 |
| 18 | Supplier 16 | 2.53 |
| 19 | Supplier 19 | 2.43 |
| 20 | Supplier 11 | 2.39 |

The results provide contrasts between the top and the bottom performers. Supplier 8 is ranked highest at 3.61 overall due primarily to its environmental criteria. It performs exceptionally well in various environmental criteria, such as an approach to carbon reduction strategies and having an ISO 14001 certification. Supplier 8 also scores highly in their governance policies, which have noted transparency and anti-corruption practices. Suppliers 13 and 15 are very similar in their ranking and total sustainability performance as outcomes, but display a moderate distribution of performance across the ESG domains. Most of the suppliers rank lowest (Supplier 11 and Supplier 19) due to low overall environmental and governance scores. These suppliers are also found to adhere to a limited range of sustainability

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measures, with conspicuous deficiencies identified in waste recycling/destruction practices and certified governance protocols. An analysis of ESG-wise disparities underscores that environmental performance substantially influences the final weighted score. Suppliers with high environmental scores consistently rank higher, even when their social or governance indicators are relatively moderate. This pattern is a direct reflection of the substantial consideration allotted to environmental indicators (40% of the total score). Social facets, such as community participation or workforce diversity, also matter but ultimately have less impact on the final ranking due to a smaller score weight.

How strange that when recalculated without score weight, most of the mid-tier suppliers have shown some slight improvement. Still, the weight-based method even summarizes a bit better with procurement's practical priorities, where ecologically, compliance is simply considered as a criterion. This analysis confirms that organizations aiming for sustainable procurement practices are better served through the assignment of strategy weights (as well as an appropriate focus on ESG criteria). Once attention to weights is allocated for reasons beyond compliance, procurement teams can take a longer view of value-based supplier relationships instead of merely minimal requirements.

### 4.3 Clustering of Suppliers Based on Sustainability Dimensions

In order to observe patterns in supplier sustainability performances, a K-means clustering method is applied using the ESG scores computed for all 20 suppliers. The clustering processes used k = 3 to allow for segmentation into three groups that were meaningful to sustainability performance, specifically High, Moderate, and Low sustainability performers. Each supplier was assigned to a cluster based on proximity in a multi-dimensional ESG space. To visualize this classification, Principal Component Analysis (PCA) was used to reduce the 15-dimensional ESG data into two principal components. The projection of clusters is presented in Figure 5, and the corresponding cluster statistics are presented in Table 5.

**Table 5:** Cluster Profiles and Supplier Classification

| Cluster | No. of Suppliers | Avg. Environmental Score | Avg. Social Score | Avg. Governance Score | Cluster Label |
|---|---|---|---|---|---|
| 0 | 7 | 4.43 | 4.14 | 4.29 | High Sustainability |
| 1 | 6 | 3.03 | 2.69 | 2.91 | Moderate |
| 2 | 7 | 1.91 | 2.03 | 2 | Low Sustainability |

- Cluster 0 identifies suppliers who scored the best on all three ESG indicators, particularly on environmental indicators (e.g., greenhouse gas emissions management, and the ability to communicate carbon-free or renewable energy). The suppliers in this cluster are ideal candidates for strategic sourcing, as they would be aligned with sustainability objectives.

- Cluster 1 is the suppliers with moderate rates of performance. Most of these suppliers have a sustainability plan in place to move towards sustainability, but either do not have advanced green certifications or high recycling percentages.

- Cluster 2 has poor sustainability ratings. These suppliers do not show any social responsibility programs, governance transparency, or patterns of environmental compliance.

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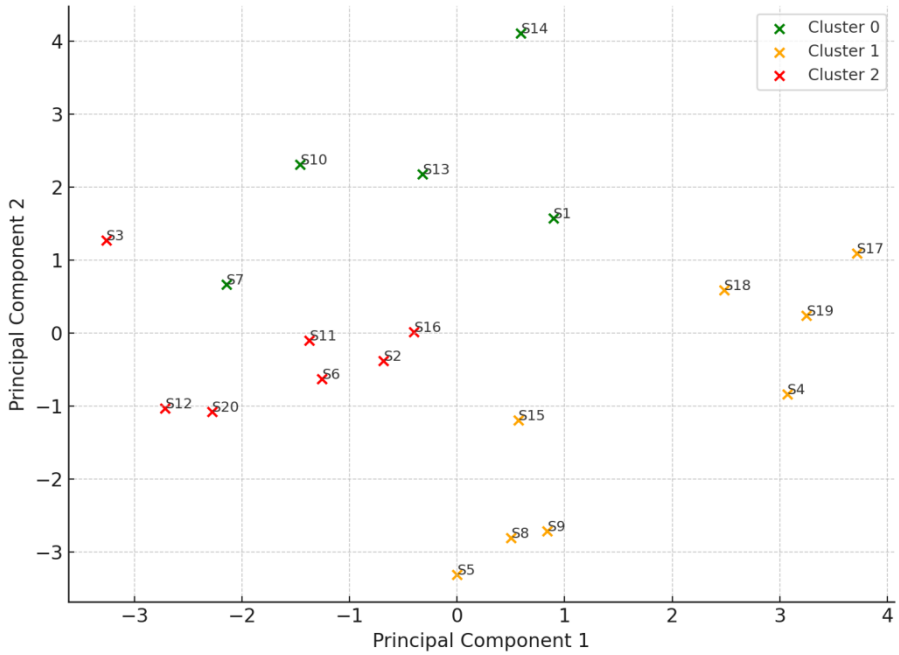


**Figure 2:** Supplier clustering visual with PCA/K-Means

Procurement teams may be chosen to prioritize suppliers from Cluster 0 for longer-term relationships and to explore joint planning for sustainability targets and contract terms. Cluster 1 suppliers may be considered for conditional relationships, recognizing their potential for improvement in certain ESG areas. Suppliers categorized in Cluster 2 may bring potential sustainability risks with them, which may need either a thorough audit or eventual phase-out based on the sourcing and procurement's risk appetite. This clustering ultimately provides ideas to assess and inform, directing the team to segment suppliers according to sustainability maturity (not just cost recovery and capacity) and support the development of more prudent and risk-aware sourcing methods.

### 4.4 Rating Influence on Procurement Decision-Making

This section investigates the relationship between sustainability scores for suppliers and the procurement decision-making process regarding whether suppliers with high sustainability scores are preferred in the strategic procurement process. A procurement preference score is calculated for each supplier to examine the relationship. The authors used three dimensions of selection regarding the procurement preference score: selection frequency (how many times the supplier was selected in bids), how many goods were procured from them, and the timeframe of goods (length of time in the contract). The three dimensions serve as representations of how much the supplier aligned with strategic procurement.

### Correlation and Regression Analysis

A linear regression model is employed to understand the predictive power of sustainability performance on procurement preference. The sustainability score is treated as the independent variable, while the procurement preference score is considered as the dependent variable. The regression equation is specified as:

$$Procurement\ Score = \beta_0 + \beta_1 \times Sustainability\ Score + \varepsilon$$

The output of the regression is presented in Table 6.

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**Table 6:** Linear Regression Output – Sustainability vs. Procurement Preference Score

| Model Coefficients | Estimate |
|---|---|
| Intercept ($\beta_0$) | 28.42 |
| Sustainability Score ($\beta_1$) | 1.97 |
| $R^2$ Value | 0.856 |
| Adjusted $R^2$ | 0.844 |
| Standard Error | 3.21 |
| p-value ($\beta_1$) | 0.0001 |

The regression coefficient for the sustainability score is positive, $\beta_1 = 1.97$ (i.e., for every one-point increase in the sustainability score, the procurement score increased by approximately two points). The $R^2 = 0.856$, which shows that approximately 86% of the variation in procurement preference is explained by differences in the sustainability performance of suppliers, which is a strong relationship. The p-value = 0.0001, demonstrating that this relationship is statistically significant.

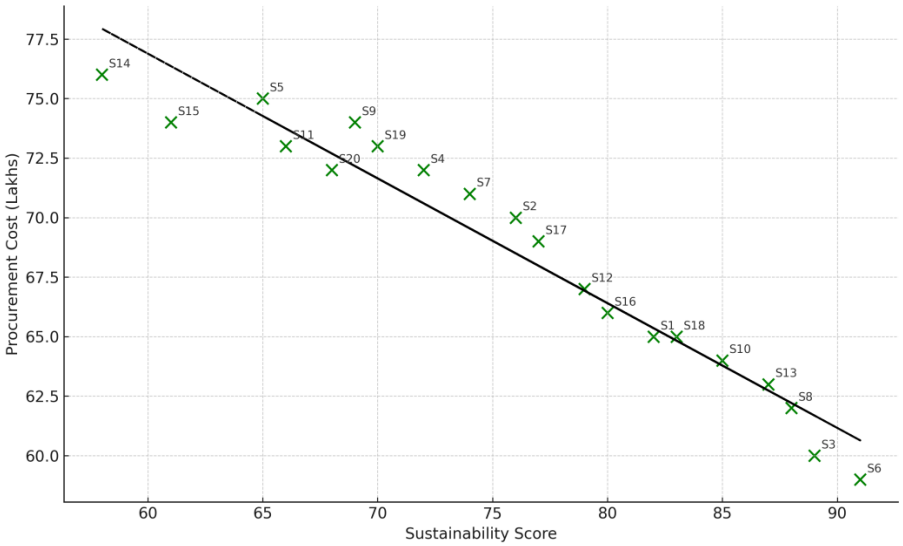


**Figure 3:** Strategic Procurement Decision Matrix Based on Supplier Scores

Organizations looking to align procurement with long-term sustainability goals can apply regression modelling to identify vendors who align most adequately to sustainability objectives during the pre-qualification and evaluation phases. This analysis lays the foundation for embedding ESG performance within procurement analytics systems and strategic sourcing processes.

### 4.5 Trade-Off Analysis of Sustainability versus Procurement Cost

Procurement professionals are being tasked with incorporating sustainability considerations into sourcing; however, in doing so often raise questions regarding potential cost trade-offs. This section will explore the relationship between supplier sustainability performance and procurement cost in order to find patterns, exceptions, and effects that can be used by procurement professionals.

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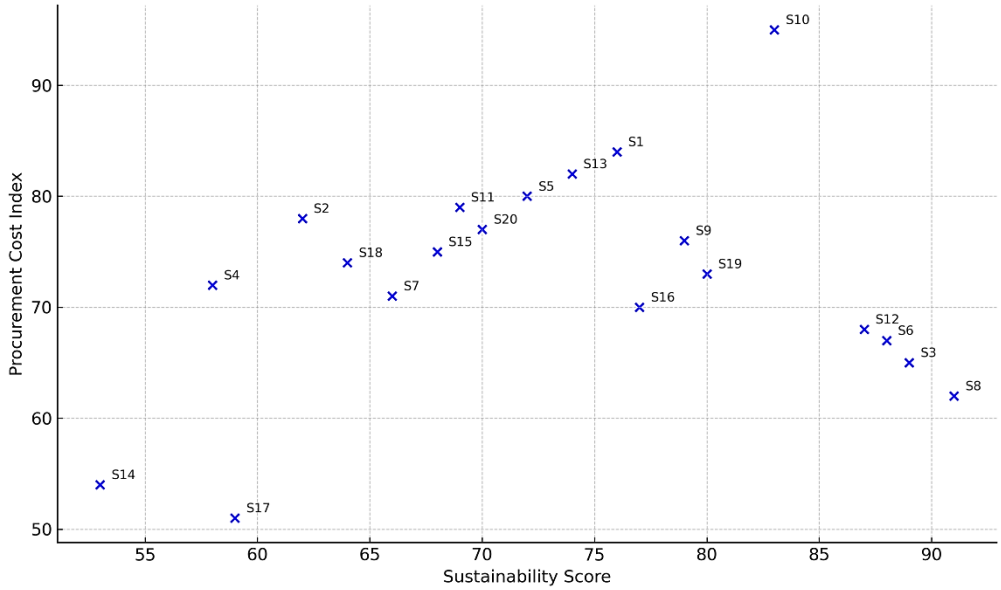


**Figure 4:** Cost vs. Sustainability Score

Figure 4 represents the relationship between suppliers' sustainability scores and their corresponding procurement cost indices. The plotted data suggest a weak to moderate inverse relationship—suppliers with higher sustainability scores tend to exhibit moderately higher procurement costs, though this trend is not absolute. Several outlier points highlight how sustainability does not necessarily equate to excessive expenditure.

A clear cluster of suppliers (e.g., S3, S6, and S12) demonstrates high sustainability scores (above 85) with moderate procurement cost indices (below 70). These suppliers represent the right balance for good and serve as viable options for strategic sourcing that fall within the typical expectations of ESG compliance and limitations on cost. On the opposite end, Supplier S10 shows a sustainability score of above 80 but corresponds with a procurement cost index number of almost 95, which falls into the high compliance cost and high cost procurement quadrant. Suppliers like these may represent the best option for corporate responsibility, but do not have an inclination towards budget fits. Organizations must question their longer-term return in relation to sustainability to bring suppliers of this nature into an organization and finalize an agreement that would be used vendor. An important anomaly is Supplier S8, which delivers a sustainability score of 88 while maintaining a cost index of 62. This indicates a strong sustainability performance without a significant cost impact. S8 serves as an example of best-in-class sourcing and suggests that organizations can identify suppliers that exceed both environmental benchmarks and procurement expectations.

On the converse side of the trade-off perspective, Suppliers S14 and S17 rank relatively low on sustainability (less than 60) as well as low in procurement costs (less than 55). While financially attractive, reliance on these suppliers over time could lead to risks associated with compliance, stakeholder discontent, or loss of market credibility in ESG buying markets. There may be potential for these suppliers to improve performance in a performance-based improvement group for vendors or possibly removal from the supply chain, depending on the organization's ESG priorities. Such a trade-off analysis reinforces the significance of a sophisticated data-centric procurement strategy. Instead of viewing cost and ESG as singular factors, firms would be better positioned to utilize composite indicators for supplier performance that combine the two dimensions. Additional strategies have been implemented for procurement teams to support a dual scorecard for cost benefit and sustainability contribution. This trade-off analysis dimension is supportive of construct development for a strategic procurement matrix introduced earlier (see Figure 3) that situates supplier performance relative to sustainability and cost in 4 quadrants.

## 5. CONCLUSION

This study examines how the supplier ratings impact the strategic procurement decisions, such as vendor selection, contract duration, and trade-offs between cost and sustainability. A framework has been developed to establish supplier

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sustainability using defined criteria and weighted scores. The evidence is clear on the potential of sustainability being integrated into supplier scorecards, not only as a reputational element but as a quantifiable portion of the decision-making process. Moreover, the linear regression coefficient indicated that the sustainability score is positive. This is evidence of the authors' claim that sustainability is not just a compliance requirement but is a strategic asset in procurement that well-manages supplier engagement behaviour. The overall performance of cost suppliers supports the opinion that sustainability can coexist with cost-effective procurement practices, especially with organizations that have well-established systems of environmental and social governance and control. Further, the organizational strategy would support decision-making that balanced financial soundness with ethical sourcing - it would allow organizations to adopt responsible procurement practices while remaining competitive. Different areas of the supplier sustainability process of strategic decision for sustainability impact can be focused on, highlighting other significant issues for improving and enhancing research possibilities for further learning. Future research might use different approaches. As the majority of the world enlarges and the availability of resources reduces or is minimized, many firms understand that the process of sustainability rating must also be redesigned in the current scenario.

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