*Environment and Social Psychology (2025) Volume 10 Issue 11* ISSN: 2424-8975 (O)
doi: 10.59429/esp.v10i11.3977 2424-7979 (P)

# RESEARCH ARTICLE

# Gender Diversity in Environmental Leadership and Its Impact on Sustainability

**Omar Saad Ahmed[1], Doaa Saad Jasim[2], Zina Muin Mohammed[3], Rasha Abdulkhaliq Abduljabbar Al-Dargazaly[4], Hasan Ali Abbas[5*]**

[1] *Al-Turath University, Baghdad 10013, Iraq*

[2] *Al-Mansour University College, Baghdad 10067, Iraq*

[3] *Al-Mamoon University College, Baghdad 10012, Iraq*

[4] *Al-Rafidain University College, Baghdad 10064, Iraq*

[5] *Madenat Alelem University College, Baghdad 10006, Iraq*

*** Corresponding author:** Hasan Ali Abbas, hasan.ali@mauc.edu.iq

## ABSTRACT

**Background:** Growing scholarship suggests that leadership gender diversity may influence corporate sustainability performance, yet systematic cross-sector evidence remains limited. This study investigates the relationship between female leadership representation and key environmental performance indicators, addressing a notable gap in empirical sustainability literature.

**Objective:** This study aims to examine the association between gender diversity in senior leadership and corporate environmental sustainability performance across multiple sectors.

**Methods:** The study analyzes a stratified sample of 50 organizations across energy, manufacturing, environmental services, technology, and logistics sectors in North America, Europe, and Asia-Pacific. A mixed-methods design was employed, combining quantitative analysis of environmental performance metrics, as: carbon emissions, energy consumption, waste diversion rates, and water-use efficiency with 10 semi-structured interviews conducted with senior executives. Quantitative methods included descriptive statistics, Pearson correlations, and multiple regression models controlling for sector, size, and region.

**Results:** Organizations in the highest quartile of gender diversity (≥46% women in leadership) showed 40.8% lower carbon emissions, 28.6% higher energy efficiency, 20% higher waste diversion, and 24.1% greater water-use efficiency compared to organizations in the lowest quartile. Regression models confirmed statistically significant associations between female leadership and composite sustainability performance ($\beta = 0.43$, $p < 0.01$), explaining $R^2 = 0.61$ of the variances.

Conclusion: Gender-inclusive leadership is strongly associated with improved environmental performance across multiple indicators. While the study does not claim causality, the findings indicate that gender-diverse leadership teams adopt more structured, consistent, and proactive sustainability practices. Further research is recommended to explore longitudinal effects, regulatory interactions, and the roles of mid-level managers and broader gender identities.

***Keywords:*** Gender diversity; environmental sustainability; corporate governance; leadership representation; sustainability performance; resource efficiency; carbon emissions.

**ARTICLE INFO**
Received: 30 July 2025 | Accepted: 19 November 2025 | Available online: 25 November 2025

**CITATION**
Ahmed O S, Jasim D S, Mohammed Z M. Gender Diversity in Environmental Leadership and Its Impact on Sustainability. *Environment and Social Psychology* 2025; 10(11): 3977. doi:10.59429/esp.v10i11.3977

# 1. Introduction

Environmental sustainability is a critical challenge facing the world and highlights the necessity for transformative leadership that can navigate complex ecological, social and economic problems. While governments, the corporate world, and civil society work internally and together to solve serious problems like climate change, biodiversity loss, and resource depletion, the importance of leadership diversity is mounting. There is a growing body of scholarship arguing that increased representation of women in leadership enhances sustainability-oriented governance and environmental decision-making[1-5]. Recent research proposes that increased representation of women and individuals from varied backgrounds in environmental leadership enhances decision-making quality, innovation, and the effectiveness of sustainability outcomes. Empirical studies show that gender-diverse leadership is associated with stronger environmental, social, and governance (ESG) performance across multiple contexts. For example, evidence from highly polluting industries indicates that female board participation improves ESG disclosure quality and environmental risk governance [1], while studies in European and Asian markets demonstrate that women leaders promote sustainability-integrated operational strategies and ethical decision-making [2, 6]. Collectively, these findings suggest that gender diversity may influence environmental outcomes through strategic, cultural, and operational pathways rather than symbolic representation alone.

Despite increasing recognition of women's contributions to climate governance, gender disparities persist across government agencies, NGOs, and corporate sustainability departments. Although women play essential roles in community-level climate adaptation and natural resource management, they remain underrepresented in senior decision-making positions. Environmental degradation tends to disproportionately affect women in developing regions due to structural inequalities, but women leaders have also been shown to strengthen resilience-building, peacebuilding, and environmental conflict mitigation [7, 8]. These dynamics underscore the need for leadership structures that reflect diverse experiences and vulnerabilities. Furthermore, organizational research reveals that leadership teams lacking diversity often exhibit limited perspective breadth, reduced innovation capacity, and narrower sustainability-oriented decision-making. Cultural biases, inequitable access to mentoring, and weak institutional support continue to constrain women's advancement into leadership roles. These systemic barriers hinder the integration of socially responsive and inclusive approaches that are essential for effective environmental governance.

Despite growing scholarly attention to the relationship between gender diversity and sustainability governance, the existing evidence remains fragmented and methodologically uneven. Recent empirical studies indicate that female board representation strengthens ESG disclosure quality and environmental transparency in highly polluting industries and UK-listed firms [1-3, 9]. Further research shows that women leaders drive sustainability-integrated operations, improve environmental strategies, and enhance firm-level environmental performance across diverse jurisdictions [4, 6, 10]. Meta-analyses and literature reviews reinforce that female leadership contributes to more robust sustainability-oriented governance, eco-innovation, and greener operational practices [7, 11]. Beyond corporate contexts, work in environmental peacebuilding, climate adaptation, and natural resource management suggests that women's leadership enhances community resilience, conflict mitigation, and climate-responsive policies [8, 11, 12].

However, despite these advancements, significant gaps remain. Existing studies tend to be sector-specific, region-bound, or focused on isolated sustainability outcomes such as emissions disclosure, environmental reporting, or innovation intensity [13-15]. Research on high-tech SMEs, family firms, and manufacturing industries confirms positive associations between female leadership and environmental capabilities, yet such findings remain context-dependent and difficult to generalize across sectors [16, 17].

Studies examining "trickle-down" effects of board gender diversity on top-management gender composition and environmental practices offer promising insights, but rely on limited geographical or institutional settings [5, 18]. Additionally, cross-country analyses emphasize that cultural norms, quota regulations, and organizational practices shape women's leadership pathways, yet rarely link these structural factors to measurable environmental performance indicators .

Consequently, few studies provide a comprehensive, cross-sector examination that simultaneously evaluates how gender diversity in senior leadership relates to multiple environmental sustainability indicators, such as: carbon emissions, energy consumption, waste diversion, and water-use efficiency, within a unified analytical framework. Moreover, the mechanisms through which leadership composition influences environmental governance remain empirically underexplored. These gaps highlight the need for a multi-indicator, mixed-methods analysis capable of capturing the broader organizational and environmental implications of gender-diverse leadership structures.

To address the identified gaps and provide a structured analytical direction, this study is guided by the following research questions:

(1) To what extent is the proportion of women in senior leadership positions associated with organizations' environmental performance across multiple dimensions (carbon emissions, energy consumption, waste diversion, and water-use efficiency)?

(2) How do organizations with higher levels of leadership gender diversity differ from those with lower diversity in their implementation of sustainability practices and environmental governance structures?

(3) What organizational mechanisms (strategic, cultural, and operational) emerge from qualitative insights to explain the relationship between leadership composition and sustainability performance?

In response to these gaps, this study systematically examines the relationship between gender diversity in senior leadership and multiple dimensions of environmental sustainability performance across organizations. Specifically, the study analyzes whether the proportion of women in leadership roles is associated with four key outcomes—carbon emissions, energy consumption, waste diversion rates, and water-use efficiency—and develops a composite sustainability index to assess holistic performance. By adopting a mixed-methods design that combines quantitative indicators with qualitative insights from senior executives, the study aims to clarify how leadership composition may shape environmental governance, strategic priorities, and sustainability practices across sectors. This contribution strengthens the bridge between gender studies and environmental leadership research and offers evidence-based insights for policymakers, organizational leaders, and sustainability practitioners.

## 2. Theoretical foundations

The relationship between gender diversity and sustainability performance is underpinned by several established theoretical frameworks. Gender mainstreaming theory, widely institutionalized by UN Women, posits that incorporating gendered perspectives into decision-making enhances governance effectiveness by broadening the range of experiences, priorities, and risk perceptions represented at leadership levels. In parallel, intersectionality theory (Crenshaw, 1989) emphasizes that gender operates through multiple social identities and structural inequalities, influencing how different groups participate in leadership and sustainability processes. Although the empirical component of this study operationalizes gender diversity in binary form due to data constraints, contemporary scholarship underscores its multidimensional nature, encompassing underrepresented identities including non-binary and LGBTQ+ groups [7, 8, 17].

Complementing these frameworks, inclusive leadership theory suggests that diverse leadership teams enhance ethical reasoning, creativity, and decision quality, these capabilities essential for sustainability governance where long-term, multi-stakeholder perspectives are required [11, 16]. Recent research demonstrates that gender-diverse boards contribute to improved environmental disclosure, strengthened ESG oversight, and enhanced environmental innovation performance, reinforcing the strategic value of leadership diversity for sustainability outcomes. Together, these theoretical perspectives provide a conceptual basis for understanding the mechanisms through which gender-diverse leadership may influence environmental performance, while simultaneously highlighting the limitations inherent in current corporate diversity metrics that largely measure only binary representation. This study draws on these frameworks to empirically examine the environmental implications of leadership gender diversity within complex organizational contexts.

# 3. Literature review

Research on gender diversity in leadership, especially within the environmental field – has been due to increasing attention paid to the need for better representation in leadership positions in the past few years. Researchers have increasingly understood that diverse leadership teams — drawing from a wide pool of perspectives, experiences and decision-making styles, generally improve organizational performance. In this way, a stronger link between gender. To synthesize this expanding body of knowledge, the literature can be grouped into three thematic domains: (1) theoretical and conceptual frameworks, (2) empirical evidence linking women's leadership to environmental outcomes, and (3) systemic and institutional effects of gender diversity across sectors and governance structures. Representation and organizational performance has been investigated, especially within innovative, sustainable sectors [19].

## 3.1. Theoretical and conceptual foundations

Theoretical models consistently highlight gender diversity as a determinant of enhanced decision-making, ethical reasoning, and risk assessment. Inclusive leadership theory, gender mainstreaming frameworks, and stakeholder governance perspectives argue that leadership heterogeneity expands cognitive resources and strengthens collective problem-solving [1, 9, 20]. Scholars emphasize that women leaders bring relational, participatory, and long-term orientations to organizational governance—attributes closely aligned with sustainability imperatives [2, 3]. Literature in global governance and institutional development further suggests that gender diversity promotes accountability, transparency, and integrative sustainability systems across sectors [4, 21]. These conceptual foundations collectively position gender diversity as a structural driver of sustainability outcomes rather than a symbolic or representational attribute.

## 3.2. Empirical evidence on gender-diverse leadership and environmental performance

A growing empirical base demonstrates positive correlations between women's leadership and environmental performance across diverse industries and geographies. Studies in highly polluting industries, energy-intensive sectors, and global manufacturing show that female board representation improves carbon reporting, ESG disclosure quality, and environmental risk governance [6, 7, 18, 22, 23]. Evidence from China and the UK indicates that gender-diverse boards foster corporate green innovation, strengthen CSR-oriented leadership, and enhance firm environmental sensitivity [11, 12, 24-26]. Research in family firms, SMEs, and high-tech industries reveals that women leaders cultivate eco-innovation capabilities, dynamic resource management, and long-term environmental strategies [13-16, 27, 28].

Several studies also highlight performance differentials: gender-balanced boards consistently outperform male-dominated boards across ESG indices, emissions reduction, waste management, and green

technology adoption [17, 18, 29, 30] At the executive level, female CEOs have been shown to improve ESG scores, sustainability reporting accuracy, and organizational environmental responsibility[31]. Quantile regression research further suggests that the positive effects of gender diversity persist across low-, medium-, and high-performing firms, reinforcing robustness across conditional distributions[15, 21].

### 3.3. Systemic and institutional effects of gender diversity

Beyond firm-level performance, gender diversity generates broader institutional impacts. Cross-country studies show that female leadership strengthens sustainability governance norms, enhances climate accountability frameworks, and accelerates adoption of clean energy policies [32-34]. Research across global health, peacebuilding, and environmental conflict management demonstrates that women leaders reinforce community resilience, environmental justice, and crisis-mitigation capacities [25, 35-37].

Gender diversity also influences internal organizational systems: it produces "trickle-down" effects that diversify top management teams, expands environmental management training, and institutionalizes sustainability practices across departments [28, 35]. Longitudinal analyses show that gender-diverse boards maintain stronger environmental performance trajectories over time, while organizations with homogenous leadership exhibit performance stagnation or decline under regulatory uncertainty [9, 36]. Collectively, these studies reveal that gender diversity drives structural transformation across organizational, sectoral, and institutional levels.

Although theoretical and empirical evidence overwhelmingly supports the positive impacts of gender diversity on sustainability governance, several critical gaps persist. Many studies remain sector-specific or geographically isolated, limiting cross-sector generalizability. Research often focuses on single environmental outcomes, such as carbon emissions, ESG ratings, or green innovation, rather than adopting a multi-indicator approach [14, 17, 38].

Furthermore, few studies systematically evaluate multiple environmental performance metrics (carbon emissions, energy use, waste diversion, water efficiency) within a unified analytical framework. Mechanisms linking leadership composition to sustainability outcomes, such as governance routines, cultural dynamics, and strategic decision pathways—remain insufficiently operationalized. These gaps highlight the need for comprehensive, cross-sector, mixed-methods analyses, such as the present study, to clarify how gender-diverse leadership shapes multidimensional environmental sustainability performance.

## 4. Materials and methods

### 4.1. Data sources and justification

The study aims to build a solid empirical basis for scientific propositions by using various sources of data in a reliable, valid, and cross-comparable way for gender diversity in leadership and sustainability outcomes. Demographic information of the leadership was obtained from organizational websites, annual reports, and publicly available corporate governance directories. This approach aligns with recent methodological recommendations emphasizing the triangulation of corporate disclosures with independent ESG data sources to ensure reliability and reduce managerial reporting bias. Contemporary studies examining gender diversity and sustainability performance in Saudi Arabia, the UK, and global markets use similar multi-source validation, combining corporate filings with ESG databases such as Refinitiv, Bloomberg, and CDP to strengthen methodological rigor [1, 3, 18]. The percentage of executive women in senior leadership positions has been confirmed by these sources. However, in order to reduce potential biases related to self-reported data, these figures were triangulated with independent corporate disclosure databases and third-party governance reports [19].

Data on sustainability performance indicators: carbon emissions, energy consumption, waste diversion rates, and water use efficiency were collected from publicly available environmental audits and company released sustainability reports.

### 4.2. Data source verification and triangulation procedures

To ensure methodological transparency and reliability, all sustainability indicators were validated using multiple independent data repositories. Carbon emissions, energy consumption, waste diversion, and water-use efficiency metrics were cross-checked against at least two of the following:

- CDP (Carbon Disclosure Project) Climate and Water Reports
- Refinitiv Eikon ESG Database
- Bloomberg Environmental Performance Dataset
- GRI-aligned corporate sustainability reports
- EPA Greenhouse Gas Reporting Program (GHGRP) for U.S. organizations
- EU Emissions Trading System (EU-ETS) data entries for European firms
- IEA regional environmental statistics for Asia-Pacific entities

Triangulation ensured that organizational self-reported metrics aligned with external regulatory and market-verified disclosures. When discrepancies arose (>10% deviation), independent audit reports or environmental assurance statements were consulted to identify the most reliable data source.

This approach mirrors the methodological standards adopted in recent sustainability studies across Saudi Arabia, Pakistan, and European markets, where publicly available environmental audits and ESG disclosures have been validated as reliable sources for assessing firm-level sustainability performance[1, 6, 14]. These datasets are widely utilized due to their comparability, regulatory alignment, and formal verification processes.

**Table 1.** Sector Representation in the Organizational Sample

| Sector | Number of Organizations | Examples of Activities |
|---|---|---|
| Energy & Utilities | 10 | Power generation, renewable energy operations |
| Manufacturing | 12 | Industrial processing, chemicals, materials production |
| Environmental Services | 8 | Waste management, remediation, environmental consulting |
| Technology & Telecommunications | 10 | ICT infrastructure, software systems, hardware production |
| Logistics & Supply Chain | 10 | Transport operations, distribution networks, warehousing |

This sectoral stratification strengthens the comparability of findings by ensuring representation from industries with varying degrees of environmental intensity and regulatory demands.

These data were then compared with industry norms and third-party regulatory environmental assessments [33]. This selected set of indicators aligns with existing reporting frameworks for sustainability disclosures as per the Global Reporting Initiative (GRI), the Carbon Disclosure Project (CDP) and Sustainability Accounting Standards Board (SASB) [18].

Various sustainability indicators were recorded at different time scales to secure the accuracy of collected data and rate of future updates. Carbon emissions data were reported on a yearly basis while energy consumption, waste diversion rates and water efficiency were measured quarterly to allow more

detailed temporal analysis. All data types were independently validated and cross-checked against national regulatory reports which enhanced the robustness of the data, and an alignment with meaningful international sustainability reporting frameworks [25].

Factors related to policies and institutions affect corporate sustainability practices in the sphere of environmental governance through legal and regulatory frameworks and this was agreed upon in this study. Previous research has highlighted the role of governance structures in steering environmental crises and the heterogeneity of the impact of legal regulations on corporate environmental performance [26]. By utilizing data from both corporate and regulatory resources, this study provides a comprehensive investigation into the link between leadership diversity and sustainability performance, ensuring information is considered from multiple perspectives.

### 4.3. Sample design and stratification

A stratified sampling approach was used to ensure the organization takes into account the heterogeneous aspects regarding objects in terms of size, sector, and geographical representation. The study results evaluated 50 environmental organizations, creating three groups based on the size:


**Figure 1.** Organizational Size Classification Based on Employee Count

To facilitate a more granular analysis, organizations were stratified into quartiles in terms of their female representation in leadership, allowing for a more structured comparison across varying leadership compositions. The geographical outreach included North America, Europe, and Asia-Pacific, indicating a wide range of sustainability practices in regulatory, cultural, and industrial scope.

Organizations were selected using a multi-stage stratified sampling technique. In stage one, the global population of corporations reporting environmental data through CDP, GRI, or regulatory authorities (N ≈ 5,800) was filtered according to two criteria:

1. Availability of gender disaggregated leadership data;
2. Public disclosure of at least three environmental performance indicators.

In stage two, firms were stratified across five sectors (Energy, Manufacturing, Environmental Services, Technology, Logistics) and three macro regions (North America, Europe, Asia-Pacific). A proportionate allocation strategy ensured representation aligned with the global distribution of reporting organizations. The final sample included 50 organizations (10 per sector) with anonymized identifiers (O1–O50) to maintain confidentiality while ensuring transparency of methodology.

To assess variation in gender representation, organizations were further grouped into leadership diversity quartiles, enabling structured comparison across low-, medium-, and high-diversity governance models.

This approach promotes comparability across differing organizational scales while balancing statistical power. Categorization based on quartiles facilitates better identification of trends or causal relationships correlating diversity in leadership with sustainability outcomes.

## 4.4. Data collection techniques and standardization

This study uses a mixed-method approach to explore the relationship between gender-diverse leadership and sustainability performance in detail.

### 4.4.1. Quantitative data collection

This quantitative dataset, comprising measurable sustainability performance indicators, had been systematically compiled from company sustainability reports, regulatory disclosures, and industry sources of proven reliability [39]. To ensure data standardization and comparability [27], key indicators were computed using standardized formulas:

1. Carbon Emissions Calculation

$$CO_2^{org} = \sum_{t-1}^{T} \left( \frac{E_t \times EF}{P_t} \right) \quad (1)$$

Where $CO_2^{org}$ total organizational carbon emissions (tons $CO_2$), $E_t$ energy consumed (mwh) at time $t$, $EF$ carbon emission factor per unit energy (tons $CO_2$/MWh), $P_t$ total production output at time $t$.

2. Water Use Efficiency Calculation

$$WUE = \frac{W_{used}}{Q_{output}} \quad (2)$$

Where $W_{used}$ total water used (liters), and $Q_{output}$ total production output.

These standardized calculations allow for consistent measurement across organizations, ensuring accurate cross-sectional comparisons.

### 4.4.2. Qualitative data collection

To complement quantitative findings, semi-structured interviews were conducted with senior executives from 10 selected organizations. Comparable research emphasizes that qualitative methods are essential for uncovering leadership behaviors and decision-making logics that cannot be captured through quantitative indicators alone. Recent studies have shown that women leaders influence sustainability through relational leadership styles, transformational behaviors, and the embedding of environmental values into organizational culture [2, 16]. These qualitative insights help contextualize observed differences in performance metrics, strengthening the overall validity of the mixed-method design.

Semi-structured interviews were conducted between March and May 2024 with senior executives from 10 organizations across North America, Europe, and Asia-Pacific. Participants were selected using purposive sampling to ensure representation of diverse sectors and leadership structures. Interviewees included CEOs, sustainability directors, and senior environmental managers, each with at least five years of experience in sustainability oversight. Interviews lasted between 45 and 70 minutes and were conducted via secure videoconferencing. The interview guide included questions on leadership decision-making, sustainability integration, gender-inclusive governance practices, and organizational challenges. Interviews were transcribed verbatim, coded independently by two researchers, and cross-validated to ensure inter-coder reliability (Cohen's $\kappa = 0.82$).

These interviews explored:

- Leadership decision-making processes concerning sustainability initiatives
- Strategies for gender-inclusive environmental governance
- Challenges in integrating sustainability goals within corporate structures

A thematic analysis was applied to identify recurring leadership behaviors that contribute to sustainability performance improvements. This qualitative approach enriches the quantitative results, providing contextual depth [24]. To prevent elite bias, participants represented CEOs, sustainability directors, and environmental managers with a minimum of five years of experience.

## 4.5. Analytical framework and model specification

To empirically assess the impact of gender diversity in leadership on sustainability outcomes, a combination of descriptive statistics, correlation analysis, and multiple regression models was applied.

**Table 2.** Operationalization of Variables

| Construct | Type | Operational Definition | Unit |
|---|---|---|---|
| Female leadership representation | Independent variable | Percentage of women in senior leadership roles (board + C-suite) | % |
| Carbon emissions | Dependent variable | Annual $CO_2$-equivalent emissions | tons/year |
| Energy consumption | Dependent variable | Total annual energy use | MWh/year |
| Waste diversion | Dependent variable | % of waste diverted from landfill | % |
| Water-use efficiency | Dependent variable | Liters of water per unit output | liters/unit |
| Organizational size | Control variable | Employee count (small, medium, large) | categorical |
| Sector | Control variable | Sector classification (Table X) | categorical |
| Region | Control variable | World region | categorical |

### 4.5.1. Independent variable: leadership gender diversity

Leadership gender diversity was operationalized as:

$$Female\ Leadership\ = \frac{Number\ of\ women\ in\ board + C{-}suite\ roles}{Total\ number\ of\ board + C{-}suite\ members} \times 100 \quad (4)$$

Data were extracted from annual reports, governance disclosures, and Refinitiv leadership profiles. To address intersectionality limitations, a binary categorization was used due to lack of publicly available non-binary leadership data.

Each metric was standardized using industry-accepted formulas, ensuring comparability:

- **Carbon Emissions:** Scope 1 + Scope 2 verified emissions.
- **Energy Consumption:** Total electricity and fuel use converted to MWh via IEA conversion rates.

$$Waste\ Diversion = \frac{Recycled + Reused + Recovered\ Waste}{Total\ Waste\ Generated} \times 100 \quad (5)$$

- **Water-Use Efficiency:** Standardized using production-normalized indicators consistent with SASB (Sustainability Accounting Standards Board) guidance.

To ensure cross-sector comparability, all continuous variables were normalized using Z-scores.

### 4.5.2. Descriptive and inferential statistical analysis

The study employed Pearson's correlation coefficients to measure the relationship between female leadership representation and sustainability indicators:

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 (Y_i - \bar{Y})^2}} \quad (6)$$

Where $X$ proportion of female leaders, $Y$ sustainability performance metric and $\bar{X}$, $\bar{Y}$ are mean values of $X$ and $Y$.

#### 4.5.3. Multiple regression model

A multiple linear regression model was constructed to quantify the causal impact of female leadership (%) on sustainability outcomes, controlling for organizational size, industry, and region:

$$Y = \beta_0 + \beta_1 FL + \beta_2 Size + \beta_3 Industry + \beta_4 Region + \epsilon \quad (7)$$

Where $Y$sustainability outcome, such as carbon emissions, energy use, waste diversion, water efficiency, $FL$ is percentage of female leaders, $Size$ is organizational size (small, medium, large), $Industry$ is industry classification, $Region$ is geographic region, $\epsilon$ is error term.

The significance of leadership diversity was evaluated using hypothesis tests, assessing whether quartiles with higher female representation exhibited statistically superior sustainability outcomes.

### 4.6. Statistical modeling and robustness diagnostics

Multiple regression models were estimated using heteroskedasticity-robust standard errors. The analytical framework included:

- Multicollinearity test: VIF < 2.0 for all predictors
- Normality: Shapiro-Wilk p > 0.05
- Heteroskedasticity: Breusch–Pagan test (p > 0.10)
- Influential observations: Cook's distance < 1.0
- Model stability: Sensitivity analysis using ±20% alternative weighting scenarios for CSI

Additionally, quantile regressions were tested as a robustness check, consistent with methods used in contemporary gender-diversity studies[19, 28].

### 4.7. Validation procedures

Data validation procedures were implemented to ensure the accuracy, consistency, and methodological rigor of the data, covering a wide range of validation procedures to ensure the reliability and credibility of the data. This was to verify data integrity, assess the robustness of statistical models and minimize potential biases in both qualitative and quantitative analyses. This is achieved through stringent validation to ensure that all the findings represent true trends in sustainability performance and sustainability leadership in the real world [22].

The data collected were also cross-verified with industry benchmarks and third-party sustainability reports. Using this method ensured that the meaningful sustainability measures used in the analysis were consistent with global reporting standards and matched the frameworks of the Global Reporting Initiative (GRI) and the Carbon Disclosure Project (CDP) [31]. This validation was supplemented with external regulatory assessments and independent audits validating data consistency and accuracy across information sources [23].

To make sure of the validity of thematic analysis of leadership interviews, an inter-coder agreement procedure and guidelines were followed for qualitative data. One independent researcher transcribed a subset of these data and we compared results to adjudicate coding consistency. This facilitated systematic

classification of qualitative information[18] and decreased the likelihood that subjective interpretation bias would arise.

Since regression models are sensitive to the presence of multicollinearity, we employed the Variance Inflation Factor (VIF) test to assess correlations between independent variables to improve the robustness of regression models. The analysis verified that the levels of collinearity did not exceed intolerable levels and therefore model coefficients were not corrupted by the labeled variable dependency[33].

Setio et al. also performed a sensitivity analysis to observe the robustness of the regression models in which they adjusted parameter weight proportions and utilized new weight scenarios for the sustainability indicators. Multiple testing confirmed the stability of results obtained across approaches [19].

**Table 3.** Multicollinearity and Sensitivity Diagnostics

| Indicator | Result | Interpretation |
|---|---|---|
| VIF range | 1.27–1.51 | No multicollinearity concerns |
| Sensitivity analysis (weight shifts ±20%) | CSI variation = 3.4% | Model stable |
| Residual normality (Shapiro–Wilk) | p = 0.12 | Normal distribution not violated |

It is this establishment of how things relevant for the study were done in practice which adds both scientific robustness and credibility to the data which is what helps the conclusion you come to stand up to scrutiny based on verifiable, statistical means with a high level of methodological rigor.

**Table 4.** Validation Steps and Methods for Ensuring Data Reliability

| Validation Step | Description | Result | Verification Method |
|---|---|---|---|
| Cross-Verification | Comparison of collected data with industry benchmarks | Data consistency confirmed | Third-party verification and independent audits [3][4] |
| Inter-Coder Agreement | Recoding of qualitative data by an independent researcher | Reliability confirmed | Thematic analysis cross-check [5] |
| Multicollinearity Testing | Assessment of variable correlations in regression models | No collinearity detected | Variance Inflation Factor (VIF) test [6] |
| Sensitivity Analysis | Adjustment of model parameters and alternative weighting scenarios | Stable and consistent results | Comparative analysis of alternative weight configurations [7] |

These validation measures ensure that the study's findings are methodologically sound, replicable, and reflective of actual corporate sustainability performance under gender-diverse leadership models.

# 5. Results

## 5.1. Leadership gender diversity and carbon emissions

Carbon emissions remain a critical environmental concern, with organizations under increasing pressure to adopt sustainable measures that reduce their carbon footprint. The analysis examines whether gender-diverse leadership teams are more likely to implement effective carbon reduction strategies. Carbon emissions, measured in tons of $CO_2$-equivalent per year, were analyzed across organizations categorized into four quartiles based on their proportion of female leadership representation. The findings indicate that organizations with higher gender diversity in leadership roles consistently reported lower carbon emissions, suggesting that diverse leadership teams may be more proactive in adopting carbon reduction policies and environmentally friendly technologies. Comparable reductions in carbon intensity have been observed in multiple studies across the UK, EU, and Asian markets, where firms with gender-diverse boards adopt stricter emission control policies and invest more aggressively in decarbonization technologies. These

findings confirm that the association observed in this study aligns with global evidence linking gender diversity to proactive climate mitigation behavior.

**Table 5.** Carbon Emissions by Leadership Diversity Quartile

| Leadership Diversity Quartile | Average Carbon Emissions (tons $CO_2$) | Standard Deviation (SD) | Median Emissions | Interquartile Range (IQR) |
|---|---|---|---|---|
| **Q1 (≤ 15% Female Leadership)** | 25,000 | 3,500 | 24,700 | 2,900 |
| **Q2 (16-30% Female Leadership)** | 20,500 | 2,800 | 20,400 | 2,400 |
| **Q3 (31-45% Female Leadership)** | 17,200 | 2,500 | 17,000 | 2,100 |
| **Q4 (≥ 46% Female Leadership)** | 14,800 | 2,200 | 14,600 | 1,900 |

The data shows an unambiguous correlation between carbon emissions in a given jurisdiction and the representation of female leaders. Organizations in Q1, where female representation is the lowest (≤15%), emit 25,000 tons of $CO_2$ on average per year, significantly higher than the 14,800 tons that organizations report (e.g. Q4 ≥46% female leadership). The difference of 10,200 tons $CO_2$ between these two sets of leaders' accounts for a 40.8% decline in emissions, further supporting the notion that gender-diverse leadership teams favor carbon-efficiency. So, in Q4 for example, the SD is lower (2,200) than in Q1 (3,500) which speaks to more stability and consistency of emissions' control measures of organizations with a larger fraction of female leaders.

## 5.2. Energy consumption and leadership composition

One of the key metrics for corporate sustainability is the amount of Energy that the enterprise consumes, which firms want to optimize to limit their reliance on non-renewables. This research explores the impact of leadership gender diversity on the energy consumption patterns. The energy is measured in megawatt-hours (MWh) per year and looks at how organizations with varying levels of female representation are actively optimizing their energy efficiency. The results suggest that organizations with higher gender diversity in leadership tend to use energy more efficiently, reflecting strategic decision-making that aligns with sustainable energy policies and investments in energy-saving technologies.

Recent analyses of female-led sustainability initiatives reinforce this observation, showing that women executives are more likely to champion energy-efficiency programs, introduce clean production technologies, and strengthen internal environmental management systems. This consistent pattern across industries underscores the strategic importance of gender-inclusive leadership in reducing energy intensity.

**Table 6.** Energy Consumption by Leadership Diversity Quartile

| **Leadership Diversity Quartile** | **Average Energy Consumption (MWh)** | **Standard Deviation (SD)** | **Median Consumption** | **Interquartile Range (IQR)** |
|---|---|---|---|---|
| Q1 (≤ 15% Female Leadership) | 140,000 | 15,000 | 138,500 | 14,200 |
| Q2 (16-30% Female Leadership) | 125,000 | 12,000 | 124,000 | 10,500 |
| Q3 (31-45% Female Leadership) | 115,000 | 10,000 | 113,900 | 8,900 |
| Q4 (≥ 46% Female Leadership) | 100,000 | 8,000 | 99,500 | 7,500 |

The findings reveal a strong inverse relationship between energy consumption and gender diversity in leadership. Organizations in Q1 (≤15% female leadership) reported an average annual energy consumption of 140,000 MWh, while organizations in Q4 (≥46% female leadership) consumed 100,000 MWh—a 28.6% decrease. The difference of 40,000 MWh highlights the role of inclusive leadership in energy efficiency. Notably, the standard deviation decreases progressively across quartiles, with Q4 organizations showing the lowest variation, suggesting greater consistency in energy management practices among gender-diverse leadership teams. These results align with previous studies on corporate sustainability, where energy-conscious decision-making is often more prevalent in organizations with diverse executive teams.

## 5.3. Waste diversion rates and gender Diversity

Efficient waste management is a crucial aspect of corporate sustainability, as organizations seek to reduce landfill contributions and enhance recycling efforts. This study assesses whether higher female leadership representation is linked to improved waste diversion rates—the percentage of waste materials diverted from landfills through recycling, composting, or reuse initiatives. The results indicates that organizations that have more gender diversity in their leadership positions tend to have better waste management, as they develop more defined and detailed sustainability policies.

**Table 7.** Waste Diversion Rates by Leadership Diversity Quartile

| Leadership Diversity Quartile | Average Waste Diversion Rate (%) | Standard Deviation (SD) |
|---|---|---|
| Q1 (≤ 15% Female Leadership) | 60% | 5.0 |
| Q2 (16-30% Female Leadership) | 67% | 4.0 |
| Q3 (31-45% Female Leadership) | 71% | 3.0 |
| Q4 (≥ 46% Female Leadership) | 72% | 2.0 |

Table 7 indicate a positive association between female leadership and waste diversion rates. Q1 organizations (15% female leadership) have an average waste diversion rate of 60% and Q4 organizations (46% female leadership) at 72%—a 20% difference. It indicates that diversified leadership teams are better positioned to implement formal waste reduction policies, work with recycling partners, and apply circular economy principles. The values of standard deviation further decrease across the quartiles, confirming the higher consistency of waste diversion rates among organizations with higher diversity in leadership. These findings underline the need for all stakeholder groups to have their views represented in corporate sustainability decision-making.

## 5.4. Water use efficiency and leadership diversity

Water use efficiency is an important sustainability measure, as companies look to reduce water used, improve production processes, and adopt conservation technologies. We explore the relationship between leadership diversity and corporate water efficiency policies. This is measured in liters of water used per unit of production, and the findings show that organizations with a higher proportion of female leaders have better water-saving records. These organizations implement sustainability features that prevent over-extraction of water, for instance, closed-loop water recycling systems or low-water processes, enhance existing management frameworks.

**Table 8.** Water Use Efficiency by Leadership Diversity Quartile

| Leadership Diversity Quartile | Water Use Efficiency (liters/unit production) | Standard Deviation (SD) |
|---|---|---|
| Q1 (≤ 15% Female Leadership) | 14.5 | 2.0 |
| Q2 (16-30% Female Leadership) | 13.0 | 1.8 |
| Q3 (31-45% Female Leadership) | 12.0 | 1.5 |
| Q4 (≥ 46% Female Leadership) | 11.0 | 1.2 |

As the proportion of female leadership increases, the data show a steady decrease in water used per unit of production. Organizations in Q1 (15% female leadership) consume an average of 14.5 liters/unit as opposed to Q4 46% female leadership which consumes a significantly lower 11.0 liters/unit, representing a 24.1% reduction in water consumption. The lower standard deviation (1.2) in Q4 compared to 2.0 in Q1 suggests that organizations with gender-diverse leadership apply more consistent and structured water conservation practices. These findings reinforce the positive role of diverse leadership in resource efficiency, aligning with global sustainability goals focused on water conservation and responsible consumption.

## 5.5. Composite sustainability performance index and leadership diversity

To evaluate overall corporate sustainability performance, a composite sustainability index (CSI) was developed, integrating key environmental metrics—carbon emissions, energy consumption, waste diversion rates, and water use efficiency. The index is calculated using a weighted summation model, ensuring balanced representation of all indicators.

$$CSI = w_1(E) + w_2(C) + w_3(WD) + w_4() \quad (6)$$

Where $CSI$ is Composite Sustainability Index, $E$ is energy consumption (MWh), $C$ is carbon emissions (tons $CO_2$), $WD$ is waste diversion rate (%), $WUE$ is water use efficiency (liters/unit), $w$ is weighting factors, set to equal values for balanced assessment.

**Table 9.** Composite Sustainability Scores by Leadership Diversity Quartile

| Leadership Diversity Quartile | Composite Sustainability Score (0-100 scale) | Standard Deviation (SD) |
|---|---|---|
| Q1 (≤ 15% Female Leadership) | 65 | 5.0 |
| Q2 (16-30% Female Leadership) | 72 | 4.2 |
| Q3 (31-45% Female Leadership) | 78 | 3.5 |
| Q4 (≥ 46% Female Leadership) | 84 | 2.8 |

The Composite Sustainability Index (CSI) increases progressively as gender diversity in leadership improves. Organizations in Q1 (≤15% female leadership) score an average of 65, while those in Q4 (≥46% female leadership) achieve a significantly higher score of 84, representing a 29.2% improvement in overall sustainability performance. The decreasing standard deviation (from 5.0 in Q1 to 2.8 in Q4) suggests that organizations with gender-diverse leadership teams consistently implement well-structured, effective sustainability strategies. This finding underscores the strategic importance of inclusive leadership in driving environmental excellence across multiple domains.

## 5.6. Correlation between leadership diversity and sustainability indicators

To quantify the strength of associations between female leadership representation and sustainability outcomes, Pearson's correlation coefficients were calculated. A strong negative correlation between female leadership percentage and carbon emissions (-0.68) and energy consumption (-0.65) suggests that as the proportion of women in leadership increases, both environmental footprints decline. Conversely, a strong

positive correlation is observed for waste diversion rates (0.71) and water use efficiency (0.63), confirming the role of inclusive leadership in enhancing resource efficiency and sustainability policies.

**Table 10.** Pearson's Correlation Coefficients Between Female Leadership and Sustainability Metrics

| Sustainability Metric | Correlation Coefficient (r-value) | Statistical Significance (p-value) |
|---|---|---|
| Carbon Emissions | -0.68 | < 0.001 |
| Energy Consumption | -0.65 | 0.002 |
| Waste Diversion Rates | 0.71 | < 0.001 |
| Water Use Efficiency | 0.63 | 0.003 |

The negative correlation between leadership diversity and carbon emissions (-0.68) and energy consumption (-0.65) tends to only re-confirm that organizations with more female leaders are more likely to have carbon (energy) conscious strategies. It is well established that more gender-diverse teams lead more effective sustainability policies (or at least adopt sustainability policies that align more with circular economy principles and resource conservation), as evidenced by the strong positive correlations with waste diversion rates (0.71) and water efficiency (0.63). These relationships are statistically significant, as demonstrated by the p-values (<0.01 for every metric), further strengthening the causal relationship we identify between inclusive leadership and improved sustainability outcomes.

To complement the descriptive and correlational findings, a multiple regression model was estimated to assess whether female leadership representation predicts sustainability outcomes after adjusting for sector, size, and region.

**Table 11.** Multiple Regression Results for Composite Sustainability Index (CSI)

| Variable | β | Std. Error | t-value | p-value | VIF |
|---|---|---|---|---|---|
| Female leadership (%) | 0.43 | 0.11 | 3.96 | <0.001 | 1.42 |
| Organizational size | 0.18 | 0.09 | 2.04 | 0.046 | 1.33 |
| Sector (dummy) | 0.22 | 0.10 | 2.19 | 0.033 | 1.51 |
| Region (dummy) | 0.14 | 0.08 | 1.78 | 0.082 | 1.27 |
| Model fit: | | | | | |
| $R^2 = 0.61$ | Adj $R^2 = 0.57$ | $F(4,45) = 17.58$, $p < 0.001$ | | | |

Female leadership remains a statistically significant predictor of sustainability performance even after controlling for confounding factors, explaining 61% of variance in CSI. However, the results indicate association—not causation.

The data reveal that trends suggest sustainability measures improve in organizations more often when projects are championed by female rather than male executives and directors. The findings reveal clear statistical relationships between the diversity of leadership teams and the environmental performance of their corporations, offering strong reasons to promote the inclusivity of organizational leadership as a normative objective that breadth is necessary for long-term sustainability.

# 6. Discussion

The results indicate that organizations with higher levels of leadership gender diversity consistently outperform less diverse organizations across multiple environmental performance indicators. These findings align with Babiker et al. [1] and Celik [40] report that female representation strengthens environmental

disclosure quality and strategic sustainability integration. Similarly, the association between women's leadership and improved ESG outcomes mirrors evidence from UK-listed companies analyzed by EmadEldeen et al. [3] and the broader patterns synthesized in the review by Fernández-Torres et al. [4].

The qualitative insights complement empirical trends highlighted in research on eco-innovation capabilities and sustainability-oriented culture building [11, 14, 15]. Executives in this study described enhanced internal accountability, long-term strategic thinking, and greater stakeholder orientation in gender-diverse leadership teams—mechanisms consistent with operational sustainability effects documented by Cole et al. [2] and leadership-driven environmental practices observed in Australasian and Asian markets [32, 38]. However, consistent with concerns raised in cross-country institutional studies [17, 18], our results should not be interpreted as causal. Instead, they reflect robust correlations that point toward organizational patterns requiring deeper longitudinal and policy-sensitive investigation.

The findings also resonate with recent evidence showing that female leadership enhances firms' environmental capabilities by improving ESG transparency, strengthening sustainability governance structures, and promoting employee-level pro-environmental behavior [5, 16]. Furthermore, gender-diverse boards have been found to facilitate eco-innovation, particularly in high-tech and resource-intensive sectors, thereby contributing to long-term competitiveness and environmental performance [14]. These converging results underscore the multifaceted pathways through which gender-inclusive leadership contributes to sustainability outcomes. Similar findings have been documented in earlier research, though with varying emphasis. For instance, Ramos et al.[15] investigated family-owned firms and gender dynamics, finding that female leaders developed stronger environmental policies, typically driven by a desire to be ethical and create long-term value rather than short-term financials. The study found improvements in both energy efficiency and waste diversion, thus lending credence to the argument that teams of diverse leadership by gender are likely to encourage sustainability-minded corporate cultures

According to Bouaddi et al.[28], it was found that board gender diversity impacted firm performance and carbon emissions where firms with a higher proportion of women on board had lower $CO_2$ emissions while simultaneously serving a significantly improved CSR. This study adds to this literature by quantifying the magnitude of emissions reductions that we identify across leadership quartiles, indicating a 40.8% lower carbon output for firms that have more women on managerial teams. And, most interestingly, this sharp decline suggests that gay-friendly leadership teams not only make environmental sustainability commitments to the public, but they also implement policies that lead to measurable change in areas like emission controls.

Furthermore, Uyar et al.[20] studying the relationship between board composition and renewable energy policies, found that various leadership structures are associated with investments in energy efficiency technologies when financial slack is plentiful. In the current study, results reinforce this finding as organizations with a higher percentage of female leaders show a 28.6% increase in energy efficiency. These findings reflect the importance of gender-inclusive decision-making in prioritizing energy native investments, and suggest that projects led by women may be more prone than projects led by men to integrate renewables within their operations. Another important aspect when it comes to gender diversity in leadership is its effect on the larger community. Hence, corporate governance through gender mainstreaming resulted in sustainability through embedding multidimensional decision processes as per Caywood & Darmstadt [29]. They found that gender-diverse boards are more likely to prompt companies to adopt wider-reaching policies that unify environmental and social sustainability. This is in line with the finding of the current study that companies with better representation of female leadership tend to show more robust waste diversion,

similar to water conservation, suggesting a more integrated approach to sustainability governance. However, the current study also builds on the previous literature by providing a formal empirical examination of a number of environment indicators across a range of organizational types. While Galdiero et al.[26] proposed that gender diversity aids human resource management and social sustainability along with environmental aspects, but they did not quantify the benefits of diversity on environmental metrics. The results from this study, by contrast, provide a quantitative basis for thinking about ways female leadership directly translates into sustainability improved, thus, filling an important hole in the literature.

While this study is well-grounded in empirical data, it has limitations that need to be clarified. First, although the data offers a rich cross-section of organizations in diverse sectors and geographies, it does not normalize for sector-related environmental issues. Gavana et al.[34] demonstrate that there is substantial heterogeneity in the influence of gender diversity on sustainability between family-oriented and non-family firms. Lu & Herremans [21], thus, also found that some industries such as manufacturing and energy production are inherently resource intensive and that there may be a need for further regulatory mechanisms in place in those settings to facilitate sustainability performance. Future research could analyze how gender diversity influences the environmental output of particular industries rather than to consider companies as one homogeneous group[36]. Second, though the study uses several regression models to isolate the effect of gender diversity in corporate leadership from measures of sustainability, the study does not entirely account for external regulatory parties that may also encourage corporate sustainability efforts. Kassinis et al.[37] point out that corporate environmental performance is heavily molded by government policies and industries' regulations for firms to at least establish effective minimum compliance, irrespective of the leadership's makeup. Research in the future may also explore how different regions have different regulatory mechanisms in place that mediate the relationship between leadership diversity and environmental performance. Another limitation is that this study solely addresses board-level and higher senior leadership gender diversity, dismissing the contributions of mid-level female management and employee-fueled sustainability efforts. Buchy et al.[30] underlined that women professionals encounter systemic obstacles to leadership in various sustainability-focused professions such as water, energy, and environmental management. Approaching the topic of gender diversity in sustainable decision-making in this manner could offer more holistic insights into the impact of gender diversity on environmental governance, taking into account the influences of women in non-executive positions on sustainability-related outcomes.

These study results are significant for policymakers, corporate leaders, and sustainability strategists. Indeed, since evidence to date suggests that gender-diverse leadership leads to better environmental performance, organizations could benefit from designing well-targeted policies and programs that promote leadership inclusivity. Such initiatives may include gender-sensitive corporate governance policies that promote the meaningful representation of women in leadership positions, sustainability-linked executive compensation frameworks to make sure that leaders are rewarded for meeting (or penalized for failing to meet) long-term environmental targets, and sector-specific research to customize diversity and sustainability strategies for the needs of particular industries[9]. Future studies should just add longitudinal effects of gender diversity on sustainability performance. Wang et al.[41] noted that corporate environmental responsibility must be recognized as a long-run evolutionary process bounded by the turnover of leadership that alters sustainability priorities. Researchers would be able to ascertain, through longitudinal analysis, whether or not gender-diverse leadership teams sustained environmental improvements over time or if shifts in executive composition correlated with inconsistent sustainability results. This study could be extended to emerging economies to provide more robust findings on how the interplay between gender and sustainability can vary in different contexts due to cultural or regulatory differences. Gavana et al.[34] as well as many

previous studies, primarily focus on developed economies while sustainability governance may operate differently in regions with more fragile regulatory enforcement and less strong gender inclusivity frameworks. One issue may be to the study of the interaction effect between board tenure, leadership diversity and sustainability performance. Studies such as Uyar et al.[20] argue that corporate sustainability commitments are affected by board tenure but can experience inertia as longer-serving boards can become resistant to transformation. But understanding whether newly diverse leadership teams will force more aggressive sustainability reforms in such cases compared with long-embedded boards would enrich extant literature on this subject.

This study has several limitations that should be considered when interpreting the results. First, although the sample includes multiple sectors, it does not fully account for industry-specific environmental intensity, which may influence baseline sustainability metrics [5, 6, 13]. Second, gender diversity was operationalized using a binary classification due to data availability; however, contemporary research highlights the importance of broader gender identities, including non-binary and LGBTQ+ groups—in shaping leadership dynamics and sustainability governance [7, 8, 17]. Third, the cross-sectional design limits causal inference. Despite statistical controls, unobserved variables such as regulatory pressure, organizational maturity, and internal training systems may affect sustainability performance [10], [20]. Fourth, the qualitative sample, while diverse, was limited to ten executives and may not fully capture the heterogeneity of leadership experiences across global contexts. Future research should employ longitudinal designs, incorporate more granular regulatory data, analyze mid-level leadership effects, and examine how expanded gender diversity frameworks influence sustainability performance across varied institutional environments.

The article demonstrates that gender-diverse leadership teams significantly improve corporate sustainability performance — companies with more women in top management ranks emit less carbon, reduce energy intake, divert waste from landfills, and extract water more efficiently. These findings corroborate and extend earlier work, highlighting the significance of inclusive decision-making in corporate environmental governance. The consideration of differences between sectors, the impact of regulation or the state, and even the presence of a mid-level female management, are all important for a nuanced understanding of this relationship. Future research could focus on long-term effects, industry specificity, and regional differences to further deepen our knowledge of how gender diversity contributes to environmental sustainability.

# 7. Conclusions

This study contributes to the growing literature establishing links between leadership gender diversity and environmental sustainability performance. By integrating quantitative analysis with qualitative perspectives, it provides a multidimensional assessment absent in many single-indicator studies. The results indicate that organizations with more gender-diverse leadership teams exhibit stronger sustainability outcomes, a pattern consistent with findings from high-tech SMEs, family firms, and international governance contexts.

Contributions:

1. This is one of the few cross-sector empirical studies to simultaneously assess four environmental indicators.
2. It triangulates environmental performance data with leadership composition, supporting theoretical propositions in recent sustainability and governance scholarship.

3. It provides qualitative evidence on internal organizational mechanisms that may explain performance differences.

Limitations:

- Gender diversity was measured in binary terms, constrained by available data sources.
- Environmental performance may reflect contextual factors, such as policy environments or market shocks—not captured in this dataset.
- The study's design is observational; therefore, results indicate associations, not causal relationships.

Future Research:

- Longitudinal analysis to test temporal sequencing.
- Inclusion of non-binary and LGBTI+ identities in leadership datasets.
- Comparative studies across regulatory regimes and cultural contexts.
- Integration of experimental or quasi-experimental methods to explore causal pathways.

## Conflict of interest

The authors declare no conflict of interest

## References

1. Babiker, I., et al., The Effect of Female Representation on Boards on Environmental, Social, and Governance Disclosure: Empirical Evidence from Saudi Highly Polluting Industries. Sustainability, 2025.
2. Cole, D., E. Rosca, and K. Taylor, From social good to operational good? How women influence sustainable operations. International Journal of Operations & Production Management, 2025.
3. EmadEldeen, R., et al., Does Board Diversity Drive Sustainability? Evidence from UK-Listed Companies. Sustainability, 2025.
4. Fernández-Torres, Y., C. Gallego-Sosa, and M. Gutiérrez-Fernández, Do women board members contribute to companies' superior environmental performance? A literature review. Review of Managerial Science, 2024.
5. Sandretto, D., A. Rizzi, and G. Esposito, Gender Diversity Leadership and ESG Performance: The Influence of Women on Boards and in Management. Business Strategy and the Environment, 2025.
6. Fernández-Méndez, C., R. Arrondo-García, and A.R. Fonseca-Díaz, Sustainability practices, board's gender diversity and quota regulations in European markets. Review of Managerial Science, 2025.
7. Kalbarczyk, A., et al., A scoping review on the impact of women's global leadership: evidence to inform health leadership. BMJ Global Health, 2025. **10**.
8. Kopytsia, I. and N. Slobodian, Women's leadership in environmental peacebuilding: converging nature, climate, and peace. Journal of the British Academy, 2025.
9. Celik, B., The impact of board gender diversity on environmental sustainability, . Journal of Economics, Finance and Accounting (JEFA), 2024. **11**(4): p. 27-34.
10. Guedes, M. and A.S. Grübler, Balanced gender boards and environmental, social, and governance performance. Risk Governance and Control: Financial Markets & Institutions, 2025.
11. Kapse, M., et al., The Influence of Women's Leadership on Organizational Alignment with Sustainable Development Goals: A Discriminant Analysis Approach. JWEE, 2024.
12. Lucas, B., How Women's Empowerment Contributes to Climate Change and Natural Resource Management Outcomes. 2024.
13. Montero, J.-M., M.V. Martínez, and J. Santos-Jaén, The impact of board gender diversity on green building practices: Moving beyond traditional linear and logistic specifications. Corporate Social Responsibility and Environmental Management, 2024.
14. Niamat, R. and F. Qureshi, Dynamic Capabilities and Environmental Performance of High-Tech SMEs in Pakistan – The Role of Eco-Innovation and Female Executives. Organizacija, 2025. **58**: p. 158-174.
15. Ramos, A., S. Jayantilal, and F. Sardo, Exploring Gender Dynamics and Environmental Sustainability in Family Firms. International Conference on Gender Research, 2024. **7**: p. 331-338.

16. Ren, Q., W. Li, and C. Mavros Transformational Leadership and Sustainable Practices: How Leadership Style Shapes Employee Pro-Environmental Behavior. Sustainability, 2024. **16**, DOI: 10.3390/su16156499.
17. Saenz, C., et al., Advancing Gender Equality in Executive Leadership: The Role of Cultural Norms and Organizational Practices in Sustainable Development—A Case Study of Taiwan and Guatemala. Sustainability, 2025.
18. Trireksani, T., et al. The Impact of Country Characteristics on Board Gender Diversity and Sustainability Performance: A Global Perspective. Sustainability, 2024. **16**, DOI: 10.3390/su16073057.
19. Muhammad, H. and S. Migliori, Effects of board gender diversity and sustainability committees on environmental performance: a quantile regression approach. Journal of Management & Organization, 2023. **29**(6): p. 1051-1076.
20. Uyar, A., et al., Renewable energy use, slack financial resources, and board attributes: Does energy efficiency policy matter? Business Strategy and the Environment, 2024. **33**(5): p. 4935-4957.
21. Lu, J. and I.M. Herremans, Board Gender Diversity and Environmental Performance: An Industries Perspective. SRPN: Environmental Finance (Topic), 2019.
22. Liu, Z., L. Cai, and Y. Zhang Gender Diversity and Environmental Performance: New Evidence from China. Sustainability, 2022. **14**, DOI: 10.3390/su142113775.
23. Nyamae, P.S., Relationship between Gender Diversity in Leadership and Corporate Social Responsibility Practices. . American Journal of Leadership and Governance, 2024. **9**(1): p. 56–67.
24. Huang, C.J., W.N. Wan Ahmad, and R.A.J. Saad, Can female CEOs improve corporate environmental, social and governance performance? Gender in Management: An International Journal, 2025. **40**(1): p. 91-113.
25. Issa, A. and M. In'airat, From words to action: unpacking the real impact of sustainability initiatives on carbon emissions reduction. Social Responsibility Journal, 2024. **20**(3): p. 585-604.
26. Galdiero, C., et al. Gender Diversity: An Opportunity for Socially Inclusive Human Resource Management Policies for Organizational Sustainability. Social Sciences, 2024. **13**, DOI: 10.3390/socsci13030173.
27. Salzano, R., et al., Community Validation as a Method to Establish Trustworthiness in Qualitative LIS Research. Proceedings of the Association for Information Science and Technology, 2023. **60**(1): p. 1110-1112.
28. Bouaddi, M., M.A.K. Basuony, and N. Noureldin The Heterogenous Effects of Carbon Emissions and Board Gender Diversity on a Firm's Performance. Sustainability, 2023. **15**, DOI: 10.3390/su151914642.
29. Caywood, K. and G.L. Darmstadt, Gender mainstreaming at 25 years: Toward an inclusive, collaborative, and structured research agenda. Journal of Global Health, 2024. **14**.
30. Buchy, M., M. Elias, and M. Khadka, Invisible women: barriers for women professionals in the water, energy, food, and environment sectors in Nepal. Frontiers in Sustainable Food Systems, 2023. **7**.
31. Lin, X., et al. Board Gender Diversity and Corporate Green Innovation: Evidence from China. Sustainability, 2022. **14**, DOI: 10.3390/su142215020.
32. Waheduzzaman, W., N. Pathiranage, and C. Jubb, Women in the workforce and climate change performance: the moderating role of environmental management training. Australasian Journal of Environmental Management, 2024. **31**: p. 470-491.
33. Sraieb, M.M. and L. Labadze A Dynamic Perspective on the Gender Diversity–Firms' Environmental Performances Nexus: Evidence from the Energy Industry. Sustainability, 2022. **14**, DOI: 10.3390/su14127346.
34. Gavana, G., P. Gottardo, and A.M. Moisello, The effect of board diversity and tenure on environmental performance. Evidence from family and non-family firms. Journal of Family Business Management, 2024. **14**(3): p. 534-561.
35. Muktadir-Al-Mukit, D. and F.H. Bhaiyat, Impact of corporate governance diversity on carbon emission under environmental policy via the mandatory nonfinancial reporting regulation. Business Strategy and the Environment, 2024. **33**(2): p. 1397-1417.
36. de Klerk, K. and F. Singh Does Gender and Cultural Diversity Matter for Sustainability in Healthcare? Evidence from Global Organizations. Sustainability, 2023. **15**, DOI: 10.3390/su151511695.
37. Kassinis, G.I., et al., Gender and Environmental Sustainability: A Longitudinal Analysis. Corporate Social Responsibility and Environmental Management, 2016. **23**: p. 399-412.
38. Khan, M.H., et al., Climate Change Initiatives, Environmental Management Training, and Firm Performance: The Trickle-Down Effect of Board-Level Gender Diversity on Gender Diversity in the top Management Team. Business Strategy and the Environment, 2025.
39. Donkor, A., T. Trireksani, and H.G. Djajadikerta Board Diversity and Corporate Sustainability Performance: Do CEO Power and Firm Environmental Sensitivity Matter? Sustainability, 2023. **15**, DOI: 10.3390/su152316142.
40. Celik, B., THE IMPACT OF BOARD GENDER DIVERSITY ON ENVIRONMENTAL SUSTAINABILITY. Pressacademia, 2024.
41. Wang, Y., C. Wilson, and Y. Li, Gender attitudes and the effect of board gender diversity on corporate environmental responsibility. Emerging Markets Review, 2020: p. 100744.