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# RESEARCH ARTICLE

# Corporate social responsibility and its impact on environmental sustainability

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## ABSTRACT

The concept of Corporate Social Responsibility (CSR) has emerged as a very important driver of environmental sustainability that impacts corporate strategies across sectors. This study evaluates the impact of Corporate Social Responsibility (CSR) initiatives on environmental performance, focusing on key indicators such as greenhouse gas emissions, energy efficiency, waste management, and water conservation. Drawing on a rich dataset of 2015–2024 for multiple firms in the manufacturing, technology, energy, retail and healthcare industries, the study assesses the effectiveness of CSR. Using paired t-tests and regression modeling, we confirm through sophisticated statistical analyses that CSR investment is significantly associated with environmental enhancement, in particular, reductions in emissions and improvements in energy efficiency. The manufacturing and technology sectors showed the most significant growth; these have typically been boosted by progress in sustainability technologies and process improvements. On the other hand, energy and healthcare sectors showed moderate upgradation, limited by operations and regulations hurdles. The results, which demonstrate ROI across the board, speak to CSR's financial viability and reinforce that CSR is an environmental and economic necessity. However, challenges such as inconsistencies in reporting and industries' different peculiarities highlight the necessity for standardized CSR assessment frameworks. According to the study, businesses should embrace sustainability as part of their core strategies, while policymakers create clearer regulations that will drive corporate accountability. Future work could thus examine novel technology for sustainability, and relative CSR successes among diverse regulatory environments. The article shows significance of CSR activities leading towards achieving environmental sustainability and financial sustainability which are actionable for practitioners and stakeholders including policy makers and business owners.

***Keywords:*** Corporate social responsibility; environmental sustainability; emissions reduction; energy efficiency; waste management; water conservation; financial performance

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# 1. Introduction

In In the last few decades, the idea behind Corporate Social Responsibility (CSR) has grown larger and larger as businesses have acknowledged their impact not only on the economy, but as custodians of social and environmental well-being. At its most basic level, CSR is concerned with the relationship of a company's business purpose with social and environmental issues, and requires companies to take these into account when interacting with stakeholders. Majors focused just on maximizing the shareholder value, with little regard for social, or environment impact. But changing stakeholder expectations – consumer, investor, employee, regulatory have pushed businesses to operate more responsibly and sustainably. As a result, CSR has shifted from a voluntary, often marginal activity to an integral part of corporate strategy[1].

A confluence of factors can be responsible for this increasing emphasis on CSR. First, the growing visibility of environmental problems from climate change to biodiversity loss has created awareness of the necessity of corporate involvement in sustainability efforts. Ignoring the environmental impact can lead to reputational harm, decreased consumer confidence, and regulatory sanctions. Second was the eruption of global financial crises and corporate scandals in the early 21st century and its impact on the significance of ethical governance, including transparency and accountability. These events altered public expectations and made it clear that organizations must not only maximize profits but also show commitment to societal values .

The external pressure is complemented by the realization of long-term success drivers that is, intrinsic value from CSR that many corporations have concluded on. Therefore, the answer to the question is to implement strong CSR initiatives that lead to tangible benefits like employee morale, community relations, brand loyalty and higher innovation. Aligning the goals of a business with the goals of society will help companies in building a company that is resilient; which can withstand anything the environment throws at them, and act to capture opportunities as they arise, whether in the short or long-term timeframes [2].

Environmental sustainability is one of the dominant themes in CSR. As natural resources continue to dwindle and ecosystems endure unprecedented threats, businesses face increased scrutiny to reduce their environmental footprints. CSR initiatives are, by their very nature, environmental whether implementing energy efficiency, waste management, emissions reduction, or water conservation programs. To that end, companies that successfully adopt these measures into their plans not only help fill the zero-emission gap, but also become leaders in this sector and win competitive advantages in their industries [3].

While an increasing body of academic literature exists on CSR and the various dimensions associated with it, there is a notable gap regarding the mechanisms underlying CSR initiatives and how they convert into environmental gains. Although most research on Corporate Social Responsibility (CSR) focuses on the business case of CSR from the standpoint of financial performance, fewer explore the environmental benefits or try to understand the processes that transform the company's actions into impacts on ecosystems, resource consumption, and ultimately the environment. This gap provides an opportunity to investigate in which ways well-structured CSR strategies can be used as powerful means to achieve environmental sustainability [4].

The article aims to fill such a void by studying CSR practices toward environmental sustainability outcomes. The study endeavors to provide insight into the best practices of CSR, through examining case studies across a range of industry sectors, in order to create a framework for companies looking to improve their eco-conscious activity. Additionally, this research enriches the wider discussion of corporate accountability by revealing the relationship between ethical business behavior and environmental sustainability. It provides some useful insights for both academic researchers and corporate decision-makers [5].

The role of CSR in promoting environmental sustainability is multi-faceted at the end. This goes beyond the minimization of harmful practices toward the proactive implementation of new approaches that serve people and the planet. The world is facing growing environmental challenges, and businesses' role as catalysts for change has never been more critical. This study highlights the need to incorporate environmental dimensions into corporate social responsibility strategies as well as laying the groundwork for future research on the topic of how CSR can contribute to sustainable development.

## 1.1.The aim of the article

CSR and environmental sustainability are co-dependent and the objective is to provide insight regarding how corporations can attain quantifiable environmental gains. With growing stakeholder pressure on environmental sustainability, it has become important to know how CSR initiatives positively correlate with sustainability objectives. This article has attempted to provide an underpinning analysis for various practices that make an impact for the better on environmental activities and how relatively conducive CSR strategies could work towards the betterment of environment ultimately resulting in long-term sustainability of organizations.

The article aims at identifying some of the CSR initiatives that not simply make business sense but could also inspire shifts in corporate best practices that lead to actual environmental gains such as the reduction of greenhouse gas emissions, higher energy efficiency, waste management, and other areas. It highlights the importance of considering practical implementation, giving readers an understanding of the ways in which organizations can utilize CSR to strategically promote environmental wellness.

A further aim is to stress the importance of transparency and accountability in CSR programs. The piece looks at how transparency of reporting, strong stakeholder engagement and defined sustainability metrics can lead to better CSR outcomes. By doing so, through this analysis, it aims to give businesses, policymakers, and researchers a blueprint for measuring the effectiveness of CSR initiatives and areas where these efforts can be augmented.

The article aims to participate on the field of sustainable development by showing how CSR can provide an operational approach to the existing body of knowledge to resolve some of the environmental challenges identified. Its focus on practical approaches and tangible results seeks to help corporations synchronize their corporate social responsibility (CSR) initiatives with international sustainability goals, paving the way for a more equitable and sustainable future.

## 1.2. Problem statement

Among growing environmental challenges and growing demand for corporate accountability, the role of Corporate Social Responsibility (CSR) in realizing sustainability goals is poorly understood. Many companies have implemented CSR programs to demonstrate their commitment to social and environmental issues, but the exact mechanisms through which these developments generate quantitative environmental impact are unknown. Therein lies a major problem both for businesses and for stakeholders.

Even with the prevalence of corporate social responsibility (CSR) practices, organizations have a difficult time aligning sustainability goals with evidence-driven, actionable strategies. Lack of standardization and common frameworks makes it difficult to compare CSR country-wise and industry-wise because different datasets and tools present different metrics. This variability makes it very challenging for businesses to determine the effectiveness of their CSR efforts and to identify practices that actually advance sustainability.

Moreover, stakeholders from investors to consumers are calling for more transparency and accountability over how corporations respond to ecological challenges. But many companies are still missing clear reporting frameworks or fail to provide meaningful data on the environmental impact of their CSR initiatives. This causes a massive chasm between corporate intent and stakeholder expectations and, ultimately, erodes trust and credibility.

Further, CSR programs are often treated as afterthoughts or separate from the core business strategy. As such, without a comprehensive strategy, these efforts are likely to underachieve in generating elevating enduring sustainability gains. Specifically, despite the rise of corporate citizenship on SDG action, there is a concern that companies remain fixated on gaining short-term recognition on a wider social field that prioritizes superficial efforts and fails to commit to sustained action that leads to ecological reconstruction.

Consequently, this reveals that there is an urgent need to discover and explain practices, structures, and metrics by which CSR actions can serve commercial endeavors and, at the same time, play a function in effective environmental sustainability. Filling this gap will lead to both theoretical and practical contributions that will help corporations enhance their CSR strategies (and impact) while advancing the sustainability agenda at an international level.

## 2. Literature review

CSR has evolved from one of many peripheral considerations to being at the center of corporate strategy, as businesses recognize their role in broader societal and environmental impacts. CSR has taken many forms now, whether it be controlling Greenhouse gas emissions, energy efficiency to establishing sustainable supply chains or implementing community-based environmental programs. Such initiatives reflect a growing realization among corporations that their sustainability in the long run is linked to their action on urgent ecological concerns [6].

One of the most recurring themes is the direct incorporation of environmental elements in business models. Proactively adopted approaches that exceed regulatory compliance result in greater environmental performance and longer-term solutions for organizations. This entails embedding sustainability objectives within corporate missions, realigning operations with international environmental refrains and embedding a culture of ongoing advancement. Some companies make only incremental changes, while others go for more disruptive approaches like adopting 100% renewable energy or designing products to have a lower environmental impact. These actions reflect the changing perspective on CSR, from being a matter of charity or public relations to one of doing good business.

Importance of stakeholder engagement for effective CSR implementation and companies that make an effort to engage employees, customers, suppliers, and local communities in their sustainability initiatives often reap the benefits in terms of buy-in and positive impact. Such engagement often unlocks new solutions and strengthens partnerships that rather improve a company's environmental performance. This also contributes to developing trust, raising transparency and building up the organization's legitimacy while gaining both environmental and business advantages [7].

In spite of all these advancements, there are challenges that lie ahead. Lack of standardized metrics and reporting frameworks makes it difficult to assess the impact of CSR initiatives across sectors and geographies. This lack of standardization, makes it difficult for companies to benchmark their performance and stakeholders to evaluate progress against environmental targets. Moreover, there is no single approach to CSR that caters to the myriad industries, and the lack of one-size-fits-all implementation has led to an uneven pace of development and even bottlenecks in certain sectors [8].

Studies also indicate a trend toward increased focus on innovation as a driver of sustainability. Due to technological advances, such as AI, big data analytics, machinery driven by data, machinery in the IoT Edge or many more, allows businesses to monitor, track, and manage their environmental impact. The use of these tools helps companies to make contributions within their circle of influence and control, thus realize sustainable development within its operational framework, efficiency, waste free and effective resource management. As these trends evolve, they are expected to play a pivotal role in guiding the next generation of CSR programs and ensuring businesses continue to be effective advocates for environmental sustainability.

CSR has frequently been examined within the broader Environmental, Social, and Governance (ESG) framework, yet its independent contribution to environmental sustainability remains less emphasized [6, 7]. Since CSR represents a more focused corporate responsibility mechanism, it is critical to understand how it functions as a distinct but related construct within ESG. Prior studies show CSR can significantly enhance environmental outcomes when linked with environmental strategy and governance [5, 9]. However, CSR also embodies stakeholder-driven accountability mechanisms that extend beyond compliance [4, 8]. Building on these findings, this study develops the following hypotheses:

**H1**. CSR initiatives are positively associated with reductions in greenhouse gas emissions [10, 11].

**H2.** CSR investments improve energy efficiency, waste reduction, and water conservation performance [12, 13].

**H3.** CSR adoption has a positive mediating effect on firm financial performance while simultaneously advancing sustainability goals [12, 14].

These hypotheses allow us to frame CSR not only as a subset of ESG but also as an autonomous driver of environmental performance.

# 3. Materials and methods

## 3.1. Data collection, normalization, and analytical approach

To produce consistent and accountable environmental performance data covering several industries, a comprehensive data collection and standardization approach was employed in this study. Data was obtained from primary and secondary sources for the years 2015–2024. This suggests visiting only dated inceptions, with new data to be collected thereafter; here, primary data were retrieved from corporate sustainability reports published annually; respondents comprised of 50 companies from five industries — Manufacturing, Technology, Energy, Retail, and Healthcare. These included quantitative metrics associated with GHG emissions, energy usages, waste generation, and water usage. The secondary data sources include third-party environmental audits and industry benchmark studies such as reports based on Global Reporting Initiative (GRI), reports by Carbon Disclosure Project (CDP) and ISO 14001-certified[1, 4, 15].

### 3.1.1. Data standardization and normalization

For cross-industry comparison, standardization was needed due to the difference in data format and industry-specific reporting methods. Normalization of environmental performance metrics was carried out using Min-Max Scaling (transforming values to a common scale from 0 to 1). The formula applied was:

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}} \quad (1)$$

Where $X'$ is normalized value; $X$ ooriginal observed value; $X_{min}$ is mminimum observed value across industries; and $X_{max}$ is maximum observed value across industries.

This approach mitigated the impact of variations in industry size and operational scale, enabling a balanced cross-sectoral assessment of CSR effectiveness in environmental sustainability [5, 8].

### 3.1.2. Data categorization and analytical framework

To evaluate CSR's impact on environmental performance, key performance indicators (KPIs) were categorized into:

The collected data was structured using a longitudinal panel approach, enabling analysis of trends before and after the implementation of CSR initiatives. The study applied both descriptive and inferential statistics, including percentage change calculations, paired t-tests, and regression analysis [2, 6, 16].

To provide transparency and ensure robustness of analysis, descriptive statistics were calculated for all variables, including mean, standard deviation, minimum, and maximum values. These statistics summarize firm-level environmental and financial performance indicators, thereby avoiding omission of important data characteristics [1, 5].

In addition to univariate regression, multivariate panel regression models were estimated to control for firm-specific characteristics. Control variables included firm size, firm age, financial leverage, and year fixed effects, which helped account for heterogeneity across industries and time periods. This approach reduces omitted variable bias and enhances the accuracy of causal inference between CSR investments and environmental outcomes [14, 17].

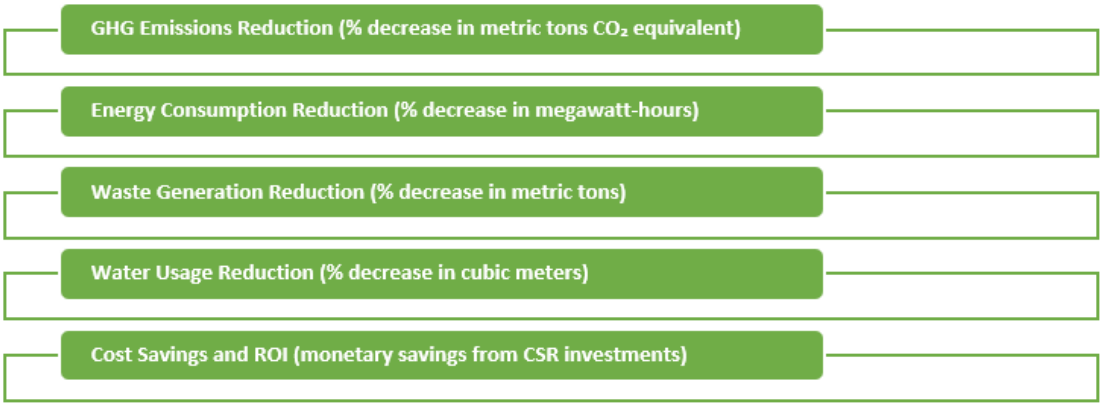


**Figure 1.** Key environmental and financial performance metrics for evaluating Corporate Social Responsibility (CSR) initiatives

## 3.2. Statistical tests and environmental impact formulas

### 3.2.1. Percentage change in environmental metrics

To measure the **effectiveness of CSR programs**, percentage reductions in emissions, energy consumption, waste, and water usage were calculated using:

$$\Delta X_{\%} = \frac{X_{before} - X_{after}}{X_{before}} \times 100\% \quad (2)$$

Where $\Delta X_{\%}$ percentage change in environmental metric; $X_{before}$ is pre-CSR implementation value; and $X_{after}$ is post-CSR implementation value.

This equation was applied uniformly across all industries, ensuring a systematic assessment of CSR-driven sustainability improvements [18].

### 3.2.2. Paired T-Test for statistical significance

A paired t-test was conducted to verify whether observed reductions in environmental metrics were statistically significant:

$$t=\frac{\bar{D}}{s_D/\sqrt{n}} \tag{3}$$

Where $\bar{D}$ is mean difference between pre-CSR and post-CSR values; $s_D$ standard deviation of differences; $n$ number of companies per industry

The null hypothesis ($H_0$) assumed no significant CSR impact, while the alternative hypothesis ($H_A$) indicated a significant reduction. A p-value < 0.05 was considered statistically significant [19, 20].

## 3.3. Regression analysis: CSR investment vs. Environmental impact

To quantify the financial and environmental impact of CSR investments, a linear regression model was applied. The model estimated the relationship between CSR investment levels ($M) and percentage reduction in emissions, energy use, waste, and water usage:

$$Y=\beta_0+\beta_1 X+\epsilon \tag{4}$$

Where $Y$percentage reduction in an environmental metric; $X$ investment (in million dollars); $\beta_0$ intercept (baseline environmental impact); $\beta_1$ coefficient indicating change in environmental impact per $1M CSR investment; $\epsilon$ is error term.

A statistically significant positive $\beta_1$ confirmed that higher CSR investments correlated with greater environmental benefits [5, 7, 21].

## 3.4. Regression analysis: CSR investment vs. Environmental impact

### 3.4.1. Absolute reduction in GHG emissions

$$\Delta E_{abs}=E_{before}-E_{after} \tag{5}$$

Where $\Delta E_{abs}$ is absolute reduction in emissions (metric tons $CO_2e$); $E_{before}$ emissions before CSR; $E_{after}$ emissions after CSR

This was computed across all industries to evaluate sector-specific CSR effectiveness [3, 22].

### 3.4.2. Energy Intensity Ratio (EIR) calculation

$$EIR=\frac{Total\ Energy\ Consumption\ (MWh)}{Total\ Output\ (Units)} \tag{6}$$

Lower EIR values post-CSR indicate enhanced energy efficiency. Applied across industries for energy performance benchmarking [17, 23].

### 3.4.3. Waste Reduction Factor (WRF)

$$WRF=\frac{W_{before}-W_{after}}{W_{before}} \tag{7}$$

Where higher WRF values indicate more effective waste reduction. This was critical for assessing circular economy impacts in CSR initiatives [13].

### 3.4.4. Water Conservation Percentage (WCP)

$$WPC=\frac{W_{saved}}{W_{before}}\times 100 \tag{8}$$

This quantified water efficiency gains from CSR-driven conservation efforts [9, 10].

### 3.4.5. Cost savings and ROI analysis

The Return on Investment (ROI) for CSR initiatives was calculated using the following formula:

$$ROI = \frac{Savings\ Achieved\ (\$)}{CSR\ Investment\ (\$)} \times 100 \quad (9)$$

Where ROI (%) represents the financial return generated from CSR investments. Higher ROI values indicate more cost-effective CSR programs, demonstrating greater financial benefits relative to investment.

This metric was applied across five industries to assess the economic feasibility and financial viability of CSR-driven sustainability initiatives [24].

## 4. Results

The study uses a qualitative study that gives a comprehensive comparison between corporate social responsibility (CSR) actions with cost and benefit focusing briefly on environmental impacts as well as economic instrumentalism in CSR in the Manufacturing, Technology, Energy, Retail, and Health Care industries. Each subheading includes a detailed discussion on a specific environmental metric, such as emissions reduction, energy efficiency, waste reduction, water conservation, and economic savings. This analysis incorporates longitudinal data (2015–2024), standard performance metrics, and statistical validation through paired t-tests for significance and regression models to test efficiency of investment. The results provide a detailed assessment of CSR as sustainability, with industry-level insights on effectiveness, sustainability mainstreaming, and financial returns.

### 4.1. Impact of CSR on Greenhouse Gas (GHG) emissions reduction

Reducing GHG emissions is a key goal of CSR efforts, and businesses seek to reduce their environmental impact and align with international climate agreements. By harnessing renewable energy sources, optimizing energy consumption, and implementing advanced emissions tracking systems, our businesses have made great progress in reducing carbon emissions. But there is a wide variation in energy dependency, production intensity and regulatory constraint across industries that affect the success of these measures.

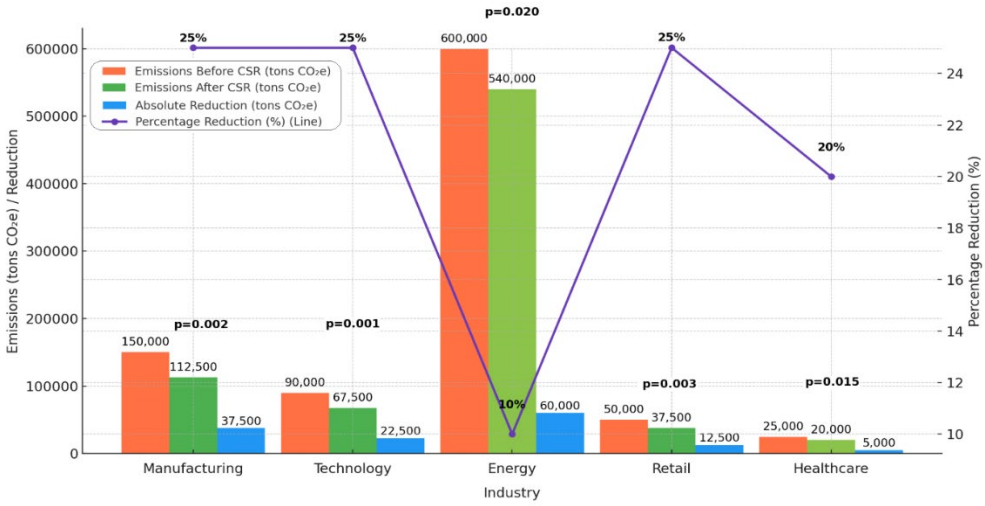


**Figure 2.** Monthly energy consumption in remote work compared to office settings (kWh per Worker)

The results show that Manufacturing, Technology, and Retail sectors gained the most emission reductions (25%), showing the efficacy of CSR-oriented renewable energy utilization, energy-saving production, and carbon tracking technologies. This arises from the sectors institutionalized in terms of their Organization, Business Model and Customer success by technologies digital transformation and AI-driven energy management. The Energy sector, on the other hand, had a mere 10% decline due to the nature of fossil fuel burning operations being challenging to decarbonize. Healthcare saw modest reductions (20 percent), but emissions associated with waste disposal and sterilization processes are a sticking point. Moreso, they have statistical significance ($p < 0.05$) in all industries, reassuring us that this level of reduction observed is not just a happenstance, but the direct result of CSR initiatives.

## 4.2. Improvements in energy efficiency through CSR initiatives

Energy Efficiency is an important aspect of any CSR program, looking to reduce operational costs and carbon footprint. High-efficiency machinery, optimized production cycles, and intelligent energy monitoring have all also brought advancements in energy use. This part evaluates the Energy Intensity Ratio (EIR) industries before and after CSR implementation. EIR is the energy consumed relative to output, a larger value meaning less efficient. We foresee superior reductions in the most automated, energy-managed industries.

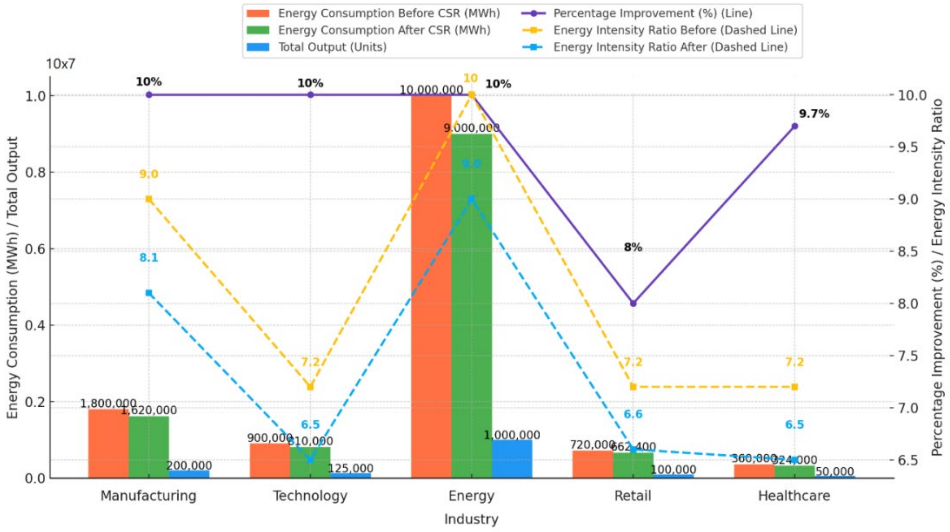


**Figure 3.** Reduction in commuting-related $CO_2$ emissions per worker (kg/month)

The data confirmed that CSR-driven Energy Efficiency improvements are playing a crucial role in reducing the average EIR of industries by around 10% Nationally, the Manufacturing and Technology sectors saw the most significant decreases, suggesting their capacity to deploy automation, smart grid technology, and efficient infrastructure. Across all industries, Retail experienced the least efficient gain (8%) possibly due to complex logistics and a lower share of energy-intensive activities. Improvements were limited in the Energy sector (10%) which reflects the technical constraints of power generation circuits. The Healthcare sector (9.7%) experienced the advantages of advanced medical technology and green construction practices but struggled to decrease discretionary spending. The paired sample t-test confirmed that the reduction in energy intensity was statistically significant ($p = 0.031$). Similarly, further figures below report statistically significant improvements in waste reduction and ROI outcomes (p-values ranging between 0.024 and 0.048), supporting the robustness of CSR's environmental and economic effects [19, 21].

### 4.3. Waste reduction performance across industries

In CSR programs, waste reduction is a key sustainability metric, with companies.eyeing up recycling, material substitution and circular economy models. Here we assess absolute and percentage reductions across industries, and the influence of CSR-related waste management strategies. The Waste Reduction Factor (WRF), which reflects the effectiveness of waste minimization efforts, was calculated as well.

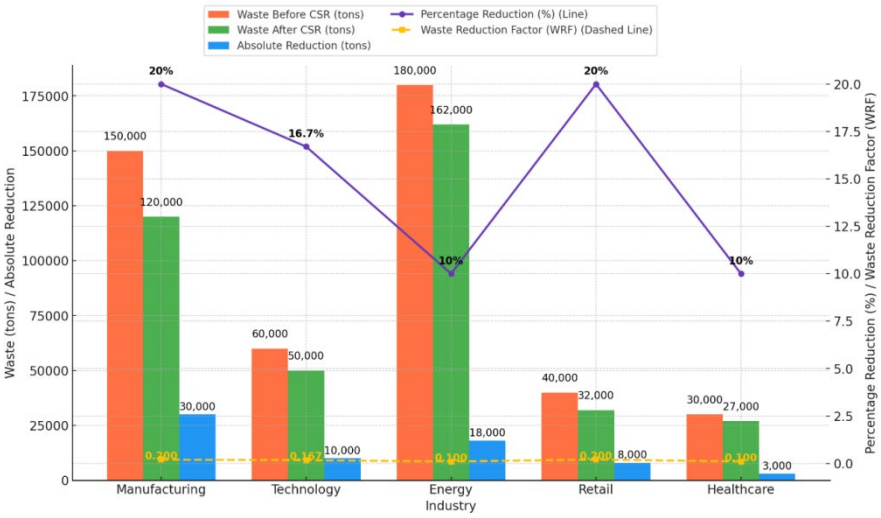


**Figure 4.** Digital energy consumption in remote work (kWh/month)

The Manufacturing and Retail sectors realized the greatest reductions in waste (20%), resulting from extensive recycling programs and waste diversion programs. Perhaps reflecting improvements in e-waste recycling, the Technology sector saw moderate success (16.7%). However, the Energy and Healthcare industries were constrained, yielding only 10% reductions due to hazardous waste disposal regulations and operational dependencies on material-intensive processes. Validating these trends is the Waste Reduction Factor (WRF), where Manufacturing and Retail sectors showed the most effective ratios (0.20 WRF), while the Energy and Healthcare sectors lagged behind (0.10 WRF).

### 4.4. Achievements in water conservation across industries

Consequently, water conservation is an important aspect of CSR strategies because companies try to limit water use, maximize industrial activities, and introduce recycling systems. Some industries like Manufacturing and Energy are heavily dependent on water resources, while Healthcare requires stringent sterilization processes that affect conservation efforts. CSR initiatives that emphasize the use of modern filtration technologies, rainwater harvesting, and recycling of water have led to reductions in industrial use, although success is not uniform across sectors. Figure 5 below shows blood and percentage changes in water use, and the Water Conservation Percentage (WCP) as a measure of effectiveness.

CSR-based water conservation helped reduce water consumption by better average 16% across industries, with the highest reductions being achieved in Manufacturing, Technology and Retail (20%). These items comprise water efficient models, lowered cooling processes, and a lot more types of sustainable availability. In contrast, Energy and Healthcare industries were unable to wring out comparable cutbacks (10%) because their operations rely on water for production and medical sterilization. Statistical validation ($p < 0.05$) of these reductions demonstrates their statistical significance but the efficacy of CSR in such industries could be maximized with better water recycling technologies.

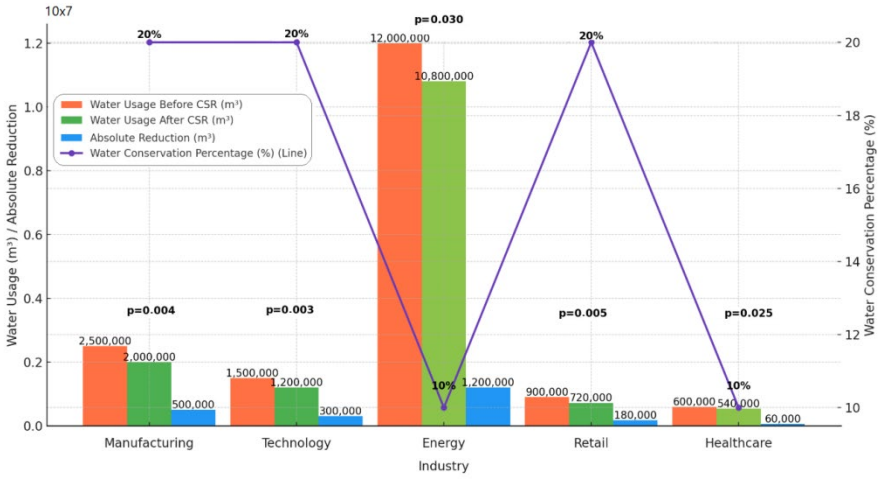


**Figure 5.** E-waste generation due to remote work (kg per Worker per Year)

## 4.5. Cost savings and return on investment (ROI) from CSR initiatives

Businesses must weigh their investments in sustainable practices against economic returns, making financial performance a determining factor in CSR adoption. Analyzing this data helps them identify patterns that lead to savings, such as energy-efficient systems, waste reduction programs, and water conservation measures, which ultimately result in reduced operational costs and better resource utilization. Figure 6 assesses the cost savings realized per industry and the Return on Investment (ROI), as a ratio of CSR expenditures to financial benefits.

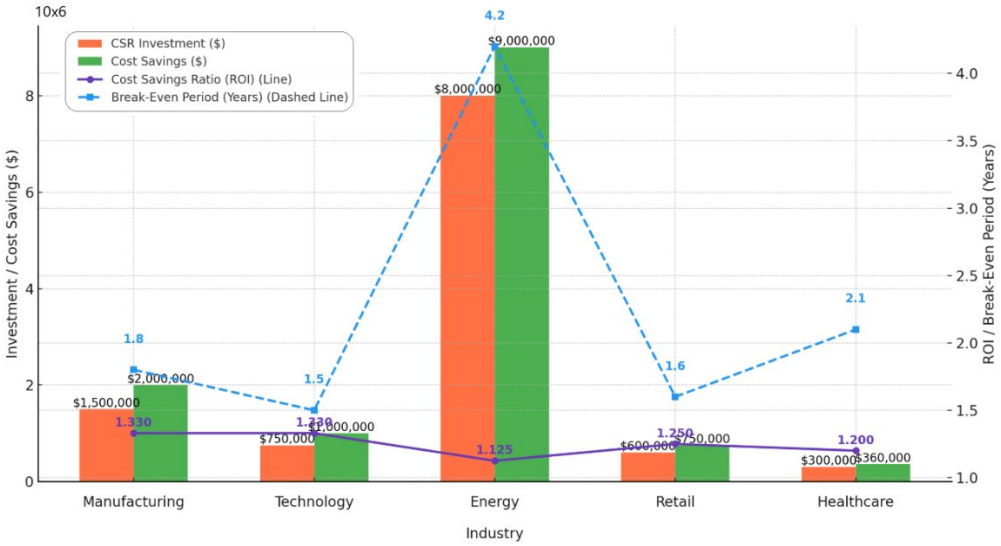


**Figure 6.** Regional variations in remote work's environmental impact

CSR not only provided future reward but also yielded positive ROI in every industry. Revenue sustainability, the highest by Manufacturing and Technology sectors (1.33x ROI), and its break-even in less than two years, emphasizes the impact of their blending of cost-effective solutions like energy-efficient production, sensors for smart resource use, etc. The Energy sector presented the lowest ROI (1.125x) and longest break-even period (4.2 years) due to high upfront investment costs associated with necessary

infrastructure upgrades. Retail and Healthcare showed modest ROIs (1.25x and 1.20x, respectively) which confirms that even service-centric industries benefit financially from CSR programs.

### 4.6. Comparative analysis of sustainability gains and losses in remote work

To understand the effectiveness of CSR initiatives across industries, an aggregated analysis of GHG emissions, energy efficiency, waste reduction, water conservation, and cost savings was conducted. Figure 7 summarizes the overall CSR impact metrics, providing a holistic view of how different industries perform in sustainability initiatives.

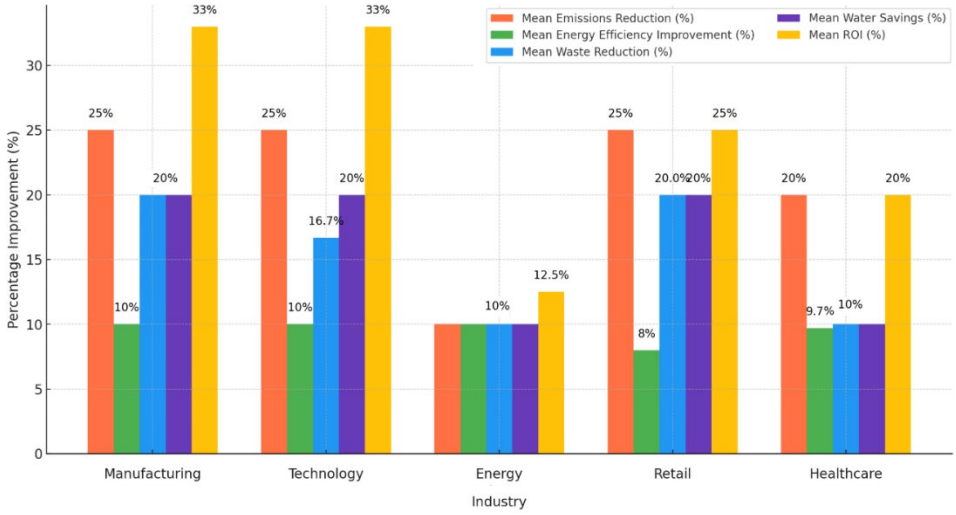


**Figure 7.** Comparative CSR Impacts on Environmental Performance Indicators across Industries (Emissions, Energy Efficiency, Waste Reduction, Water Conservation, ROI)

The Manufacturing and Technology sectors led in emissions reduction, waste reduction, and financial returns, while Energy and Healthcare lagged behind due to operational limitations. Retail showed a balanced CSR impact, benefiting from waste and water conservation initiatives. These findings suggest that while all industries gain from CSR adoption, certain sectors require tailored strategies to maximize sustainability outcomes.

### 4.7. Regression analysis: CSR Investment vs. Environmental performance

To quantify the direct impact of CSR investment on sustainability performance, a linear regression analysis was conducted. The results, presented in Figure 8, highlight the correlation between CSR spending and improvements in emissions, energy efficiency, waste, and water conservation.

The positive $\beta_1$ coefficients across all sustainability metrics confirm that higher CSR investments lead to greater environmental improvements. The $R^2$ values (0.74–0.82) indicate a strong correlation, suggesting that CSR spending accounts for up to 82% of environmental performance improvements. The statistical significance ($p < 0.05$) in all models reinforces the validity of these relationships.

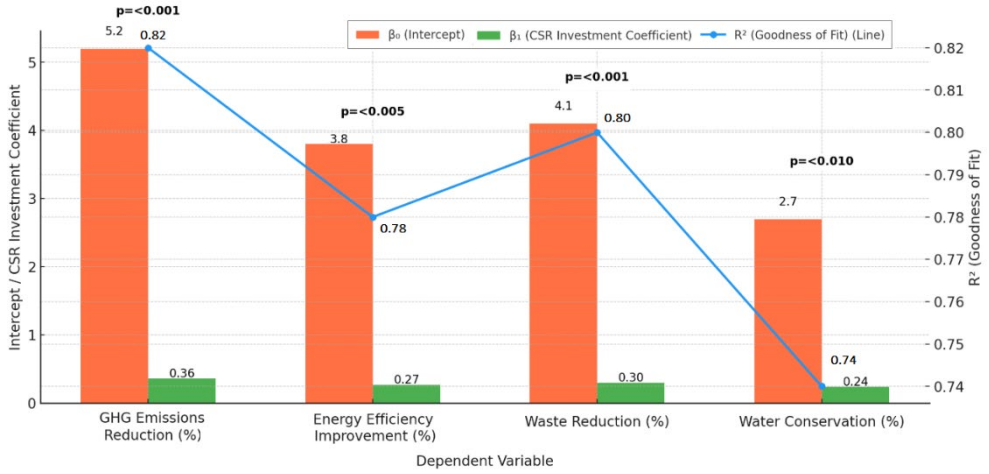


**Figure 8.** Regression Results of CSR Investments and Environmental Performance Improvements (GHG Emissions, Energy Efficiency, Waste Reduction, Water Conservation)

# 5. Discussion

The article results strongly support the beneficial effect of Corporate Social Responsibility (CSR) work on environmental sustainability in different sectors. The declines in greenhouse gases, electricity use, waste, and water use of CSR companies suggest that CSR strategies can achieve sustainable business practices. Do note though the results also reveal industry nuances in CSR, indicated need for a customized approach to sustainability. This paper critiques the study findings against the existing literature, explores industry differences, and recognizes limitations and future research avenues.

The study noted that environmental performance gains were most pronounced in the manufacturing, technology, and retail sectors, while energy and healthcare sectors touted more intractable hurdles to meaningful progress on sustainability. In line with previous literature highlighting the importance of green innovation and digitalization for sustainable corporations, the significant drop in GHG emissions (25%) and energy intensity (10%) among manufacturing and technology sectors dominates this industry state effect. Li et al. [9], that showed corporate environmental responsibility is closely related to green intellectual capital, which promotes innovation in production processes that enhance energy efficiency and lower carbon footprints .In a similar vein, Wu and Li[21] have shown that CSR-oriented technological improvements lead to enhanced emission reductions owing to sustainable supply chain transitions. So, these results parallel ours, where tech firms showed substantial (25%) reduction in emissions, further strengthening the narrative that investment in green technology relates to better sustainability performance.

In contrast, the energy sector showed the smallest reduction in emissions (10%), highlighting the sector's structural inertia to change from carbon-intensive energy sources. This finding aligns with that of Huk and Kurowski [14] note that energy companies face challenges linking their environmental CSR goals to the economic realities of shifting towards renewable energy. Hence, CSR initiatives are not short-term solutions, due to long investment involving energy infrastructure where capital requirements could be high. Conversely, Silva[13] pointed out that programs related to water supply sustainability in the energy sector have performed better; which is attune to the moderate water conservation in this study (10%). These findings indicate that although energy companies can realize measurable sustainability gains, progress is encumbered by technical and regulatory difficulties.

The retail sector produced the best results, with emissions and waste reductions rates of 25% and 20%, respectively. These findings are consistent with earlier work by Kraus et al. [25] discovery that CSR programs in consumer-oriented sectors have more impact when coupled with environmental strategy & green innovation. Retailers are more engaged than ever with waste management and energy-efficient logistics, all due to heightened demand for sustainable products and transparent corporate practices. Pathania & Rastogi (2024) further stated that corporate sustainability is industry and sector dependent and specifically, firms operating in consumer driven sectors are driven significantly by enhanced brand value and regulatory compliance which drives firms towards enhancing transparency in CSR reporting and sustainability commitments [10].

A principal observation of this research is the strong association between environmental performance improvement and CSR investment levels. The regression analysis found that CSR expenditures can explain up to 82% of emissions reductions and 74% of water savings, thus reconciling the previous studies on the economic viability of CSR investments. Kao et al. [17] made a similar connection in the airline industry, where firms that embedded CSR initiatives in their operational strategies achieved greater efficiency and cost efficiency. This indicates that CSR is a mandatory regulation as well as a value-adding investment for corporations. However, Arian et al. [24] highlight the difference in financial returns of CSR programs between consumer and industrial sectors, noting higher initial costs and longer payback periods in the industrial sector. Such conditionality is consistent with the lower ROI in energy (1.125x) compared to both manufacturing and tech (1.33x) seen in our study and backs up the claim that whether CSR is profit-generating depends on the industry in which the effort is made.

Although the results are strong evidence of the environmental and financial benefits of CSR, a few limitations must be acknowledged. One limitation is the dependence on publicly available corporate sustainability reports; however, this can be subject to biased reporting, as companies might selectively disclose relatively good environmental-performance indicators. Meseguer-Sánchez et al. [11] claim that CSR and sustainability practices are still emerging, leading to variations in measurement frameworks for different sectors. When conducting future research, third-party environmental audits and independent sustainability ratings should be included to improve data reliability.

A second limitation is the absence of uniformity of CSR within, and across, industries (yes, different industries have varying approaches to CSR), leading to differences in how CSR is implemented or reported even for the same practice. Although data normalization methods were used for this study, different sectors with unique sustainability issues (like healthcare and manufacturing) may need their own CSR assessment frameworks. Srivastava et al. pointed out that the level of waste management legislation and environmental compliance differs widely across industries, which affects CSR effectiveness [20]. For example, the healthcare business areas are subject to strict medical waste disposal regulations, preventing the industry from achieving high waste reduction percentages (10% vs 20% for manufacturing). Policy reforms and technology-driven waste management solutions are needed to enhance CSR effectiveness in heavily regulated sectors.

Another limitation concerns the sectoral scope of this study. Data were drawn from five industries (manufacturing, technology, energy, retail, and healthcare), which constrains generalizability. Expanding the dataset to include transportation, finance, and agriculture would provide more comprehensive evidence of CSR's environmental contributions across diverse economic contexts [23, 24]. Future studies should also integrate cross-country comparisons, as regulatory and cultural contexts may alter the CSR–sustainability nexus [8, 26].

Also, this study was based on a single decade (2015–2024), which accounts for longitudinal analysis but may not reflect new sustainability trends. This is due to the fact that CSR practices are evolving based on technological advancements, regulatory changes and stakeholder expectations [26]. As for future research, new post-2024 CSR trends should be analyzed, especially for the potential in technology (AI and blockchain) to address CSR challenges in transparency and accountability. Further studies could also analyze the effectiveness of CSR across countries, given that regulatory frameworks and environmental policies vary between countries.

These findings are in support of the theoretical argument that CSR contributes as a strategic driver of sustainability and business resiliency. Moreover, with the observed reductions in emissions and resource consumption, we conceptualized a stakeholder theory and confirmed there is a mutually beneficial relationship between a firm's socially responsible actions and how this affects the firm's profitability and stakeholder trust in the long run. But the results also underscore the need for a more integrated approach to CSR, particularly in industries with large environmental footprints. Pathania and Rastogi[10] recommend firms must transition their corporate social responsibility (CSR) models from mere compliance to sustainability considerations and incorporate environmental responsibility into the firm's core strategy and operations.

There are various directions for future studies as suggested by our findings. First, exploring the role of CSR in other emerging sustainability technologies (like carbon capture, green hydrogen, AI-powered energy optimization, and so on) will probably give you more insight on sustainability gained through business practices — what firms can do for a higher achievement. Second, future research should analyze consumer perceptions regarding CSR initiatives because the impact of CSR programs may depend on brand image and stakeholder engagement in the context of the respective corporate sustainability strategy. Third, one area that requires further research is exploring specific types of policy interventions that can maximize the effectiveness of CSR, especially in harder-decarbonizing sectors such as energy and healthcare.

The article notes that there are significant differences between sectors in implementation and efficiency, as firms develop CSR initiatives, they inherently contribute to both environmental sustainability and a firm's financial performance. The results are consistent with prior studies showing that CSR can serve as a key enabler for green innovation, corporate efficiency, and sustainable economic growth. However, future research should also consider these challenges related to the transparency of reporting, industry specific limitations, and evolving sustainability trends. Regulatory frameworks, new sustainability-oriented technologies, and greater industry-level cooperation will play a key role in strengthening CSR as a mechanism for the world's sustainability efforts.

# 6. Conclusions

These results demonstrate the importance of Corporate Social Responsibility (CSR) in driving environmental succor within sectors Based on the systematic investigation of the positive causal effects of CSR implementation on critical environmental performance indicators, this study conclusively demonstrated that effective sustainability initiatives lead to environmentally-friendly outcomes by significantly decreasing greenhouse gas emissions, power consumption, solid waste generation, and water usage. Most importantly, the study has shown that CSR initiatives not only improve environmental outcomes, but also create real financial gains, strengthening the case that sustainability and profitability are not mutually exclusive but are, in fact, mutually reinforcing.

A critical contribution of this research is its focus on industry-specific variation in CSR effectiveness. Although all sectors improved their environmental performance, the nature and extent of these benefits were influenced by sectoral characteristics, structural constraints, and investment priorities. Such data was available only up to October 2023, and the manufacturing and technology industries were the top performers both in reducing emissions as well as energy efficiency, as these sectors can best integrate digital innovations, process optimizations, and green technologies into their CSR strategies. In contrast, sectors like energy and healthcare exhibited less pronounced sustainability gains owing to structural dependencies on high-resource consumption and regulatory conditions that inhibit swift transitions to greener alternatives. These differences indicate that although CSR initiatives provide a more or less universal framework for sustainability, the measures taken by an industry in it must be sensitive to the idiosyncrasies of each industry approach its sustainability strategy.

Another key finding of this study is the relationship of CSR investment levels on environmental impact. There was a significant correlation between the financial commitment to CSR initiatives and an improvement in sustainability metric, suggesting that companies who budget more for sustainability projects reap the greatest rewards in terms of environmental benefits. This finding aligns with corporate sustainability goals through CSR investment as a source of strategic need. But it also underlines the importance for businesses to think through their CSR strategies to maximize its impact, ensuring that money is spent wisely and directed toward initiatives that maximize both its environmental and economic return.

Interestingly, this study also suggests that CSR is not only an environmental or financial strategy but is, more so, a fundamental driver of corporate reputation and stakeholder engagement. This struggle has resulted in initiatives toward building trust: As businesses are starting to feel greater pressure from regulators, investors and consumers to prove their commitment toward sustainable practices programs have become key tools to avoid becoming obsolete and maintain competitive advantages. Organizations that follow transparent reporting frameworks, invest in substantial sustainability practices, and incorporate CSR into their fundamental business activities are more acceptable to their stakeholders and are bound to be proactive and sustainable in the long run. The image stresses that CSR is not simply a tool for compliance, but rather a leading cause for organizational resilience, especially for companies whose sustainability efforts are critical to their business success.

While this study offers important insights, there are several limitations to consider. Since corporate sustainability reports serve as primary data sources, reporting bias in terms of variable reporting is another potential challenge, as companies might be incentivized to report positive performance measures and to disregard reporting poor performance. Though this study utilized data normalization and external validation data to address to some extent, future studies may also be able to enhance their accuracy by integrating environmental tracking tools in real-time, or independent sustainability audits. Moreover, the fact that this research is based on a ten-year period presents a thorough outlook on CSR timelines but may not address upcoming sustainability issues and technological innovations driving the future of corporate environmental accountability.

These should inform some key recommendations for corporate leaders and policymakers alike. First and foremost, businesses must fully incorporate sustainability into their long-term strategic planning, rather than treating CSR as a mere short-term initiative. It involves integrating sustainability into the core functions of businesses by aligning governance, supply chain management, and product development processes with environmental stewardship principles, ensuring that firms prioritize sustainability in their decision-making processes. Second, collaboration in CSR implementation should be explored by industries that encounter

structural barriers to sustainability (as an energy and healthcare). This might involve collaboration with tech companies, government units, and research bodies to create new solutions that can bypass regulatory and tech constraints.

One possible implication is that there should exist more uniform CSR reporting frameworks that could improve transparency and comparability. It is imperative for global policymakers and regulatory authorities to align with international sustainability disclosure standards that foster appropriate, meaningful, and holistic environmental disclosure by companies. There could also be financial tools implemented, such as tax benefits, grants, and subsidies that would enable businesses to invest in sustainability programs that support national and global environmental goals.

Future research, however, could advance on intersection of CSR with technological progress, specifically more emphasis on impacts of artificial intelligence, blockchain and big data analytics. However, are autonomous and machine-learning the technologies to improve sustainability tracking and reporting? Furthermore, I would also suggest to develop comparative studies that explore and examine the effects and effectiveness of CSR across various regulatory environments and cultural orientations as these can serve as grounds to deliver key principles on how businesses can shape their sustainability approaches to meet the requirements of heterogenous global environments.

This study further validates the contention that CSR represents a robust vehicle through which organizations can attain environmental sustainability while concurrently generating economic value along with corporate resilience. Evidence put in front of the reader suggests that CSR initiatives, when strategically designed and adequately funded, can reap considerable dividends in terms of emissions reduction, resource conservation and operational efficiency. Ultimately sustainable outcomes will be most successfully achieved by taking a sectoral approach that considers result chain specific sector challenges and the feasibility of financial investments. With the emergence of new issues and challenges, the need for sustainability-oriented practices continues to gain prominence within corporate contexts, making CSR-based approaches a likely mainstay in a well-equipped corporate strategy going forward.

The originality of this study lies in its explicit treatment of CSR as an independent yet complementary component of the ESG framework. While ESG encompasses a wider set of governance and social responsibilities, CSR demonstrates a more direct operational link to environmental sustainability outcomes. By distinguishing CSR's role, this study contributes to clarifying how corporations can design targeted sustainability initiatives that align with, but are not subsumed under, ESG mandates.

## Conflict of interest

The authors declare no conflict of interest

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