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Big Data-Driven Decision Models for Corporate Sustainability: A Strategic Approach

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***Abstract*— In the era of data abundance and global sustainability challenges, corporations are increasingly leveraging big data analytics to inform strategic decision-making. This paper explores how big data-driven decision models contribute to corporate sustainability, focusing on environmental, social, and governance (ESG) objectives. By integrating structured and unstructured data from various sources—such as IoT sensors, customer interactions, supply chain operations, and environmental reports—firms can develop real-time, predictive, and prescriptive models that optimize sustainability outcomes. The study presents a strategic approach to embedding big data within sustainability frameworks, enabling organizations to monitor emissions, reduce operational waste, forecast risk, and align with stakeholder expectations.**

Through a combination of literature review, model-based conceptualization, and real-world case analysis, the paper examines how big data supports decision-making in resource management, regulatory compliance, ethical sourcing, and stakeholder transparency. It further analyzes how machine learning, cloud platforms, and data visualization tools empower firms to convert raw data into actionable sustainability insights. The research findings reveal that organizations adopting big data for sustainability not only experience environmental benefits but also gain strategic advantages such as cost efficiency, brand equity, and competitive positioning.

The paper concludes with a proposed model that integrates big data into corporate sustainability strategy and recommends policy-level and technological interventions to scale its implementation. This study contributes to bridging the gap between digital transformation and sustainable strategic management, providing a roadmap for future-ready businesses.

***Keywords*— Big Data Analytics, Corporate Sustainability, Decision Models, ESG Strategy, Strategic Management.**

I. Introduction

In recent years, the dual pressures of digital transformation and environmental responsibility have redefined the landscape of corporate strategy. Businesses are not only expected to remain competitive but also to embrace practices that align with the principles of sustainability.

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Corporate sustainability, once viewed as a peripheral concern, is now a central tenet of strategic management, encompassing environmental stewardship, social responsibility, and robust governance. This shift has created a compelling need for tools and technologies that enable data-informed, agile, and responsible decision-making. Among these, big data analytics has emerged as a transformative force.

Big data refers to large, diverse datasets generated at high velocity from multiple sources such as customer transactions, machine logs, social media feeds, IoT sensors, and external regulatory databases. These datasets are characterized by volume, velocity, variety, veracity, and value—the five V's of big data. When combined with advanced analytics and machine learning models, big data empowers organizations to uncover patterns, forecast trends, and make evidence-based decisions. In the context of corporate sustainability, such capabilities are especially valuable. Organizations can leverage data to track carbon footprints, optimize energy consumption, minimize waste, monitor supply chain compliance, and anticipate regulatory risks.

Despite its potential, the integration of big data into corporate sustainability efforts remains underdeveloped. Many organizations struggle to convert raw data into actionable insights, especially when it involves unstructured or siloed information. Strategic decision-making in sustainability requires a structured framework that aligns data collection, analysis, and application with sustainability goals. This paper addresses this gap by proposing a data-driven decision model that supports strategic sustainability planning and implementation. The model integrates real-time data sources with analytical tools to drive proactive decision-making, thus helping organizations stay compliant, resilient, and socially accountable.

Moreover, the increasing importance of ESG (Environmental, Social, and Governance) metrics in investor evaluations and regulatory compliance further elevates the role of big data in corporate management. Firms are now expected to produce transparent, auditable, and real-time sustainability reports. Traditional reporting mechanisms are no longer sufficient in a world where investors and regulators demand timely and precise disclosures. Big data provides the technological backbone for automated ESG reporting and enables organizations to anticipate emerging risks and opportunities.

This study aims to explore how big data decision models can be systematically integrated into corporate sustainability strategies. Through a combination of literature analysis, model development, and industry case studies, the research outlines key enablers, challenges, and best practices. The paper contributes to academic discourse by bridging the gap between big data capabilities and strategic sustainability applications, offering insights for policymakers, strategists, and technology leaders. Ultimately, the goal is to demonstrate how big data can evolve from a technological asset into a strategic ally for sustainability-oriented firms.

II. LITERATURE REVIEW

Recent years have seen an increasing convergence between big data analytics and corporate sustainability, as organizations seek to leverage data-driven tools for ESG-aligned strategic management. Leading this transformation, Smith and Chen (2025) explored how real-time emissions data from IoT sensors, when integrated with predictive models, enables firms to proactively optimize energy use, demonstrating up to 18% cost savings in pilot implementations [1].

Building on this, Garcia et al. (2024) proposed a hybrid framework that combined machine learning and blockchain to ensure supply chain transparency. Their model tracked sustainable sourcing practices and executed automated compliance checks, significantly reducing reporting time and errors [2].

Lee and Kumar (2024) developed an ensemble decision model that merged structured data (e.g., energy usage, logistics) with unstructured stakeholder feedback from social media. The approach improved ESG performance evaluations, enhancing stakeholder trust and corporate reputation [3].

In an environmental context, Rao et al. (2023) demonstrated that AI-powered forecasting of waste production allowed firms to decrease landfill waste by 22% through better resource allocation strategies [4].

Patel and Singh (2022) examined big data's role in water usage optimization within manufacturing plants. By analyzing sensor data, firms reduced water consumption by 15% while aligning with sustainability targets [5].

Zhou et al. (2021) introduced a cloud-based dashboard that served real-time sustainability metrics to managers, enabling immediate corrective actions and faster compliance for carbon emissions [6].

Fernandez and O'Brien (2021) emphasized how structured sustainability reporting, augmented by big data, enhances ESG ratings. Their study showed that standardized, data-driven reports boost investor confidence and attract sustainable capital [7].

Nguyen et al. (2020) advanced a prescriptive model using reinforcement learning for waste management systems in retail. Their adaptive system optimized recycling schedules and minimized cost by 12% [8].

Lopez and Ahmad (2020) explored AI-based sentiment analysis of public perception using social media data, linking sentiment trends with corporate sustainability initiatives—providing firms with actionable brand insights [9].
Finally, Johnson and Lee (2020) introduced a strategic resource planning framework wherein big data supported circular economy decisions such as asset reuse and sustainable procurement—helping companies cut waste by nearly 25% [10].

III. Research Methodology

This study adopts a mixed-method research design to explore the integration of big data analytics in corporate sustainability strategies. The methodology consists of both quantitative data analysis and qualitative case exploration, allowing for a comprehensive understanding of how big data supports ESG-aligned strategic decision-making.

A. Data Collection

Primary data was gathered from a sample of 30 mid-to-large-sized enterprises across manufacturing, retail, and technology sectors in India and Southeast Asia. Structured questionnaires were used to collect data on the use of big data platforms, ESG tracking tools, and sustainability metrics. In parallel, semi-structured interviews were conducted with sustainability officers, data scientists, and strategic managers to understand the practical challenges and enablers of implementation.

B. Analytical Techniques

The collected data was analyzed using descriptive statistics, correlation matrices, and multiple regression models to assess the impact of big data use on sustainability performance (e.g., emissions reduction, waste management efficiency, compliance rates). Text mining and thematic analysis were employed for qualitative insights using NVivo software. In addition, a simulation-based decision model was built using Python (pandas, scikit-learn, and matplotlib) to visualize how real-time data streams can influence ESG decision-making.

C. Validation and Triangulation

To ensure reliability and validity, triangulation was performed by comparing survey findings with interview narratives and secondary data sources such as ESG reports, CSR disclosures, and third-party sustainability rankings. This triangulated approach helps validate patterns and draw more generalizable conclusions.
This study adopts a mixed-methods approach, combining quantitative modeling with qualitative insights to explore how AI-powered predictive analytics enhances strategic decision-making in the retail sector. The methodology encompasses the following key components:

IV. Conceptual Framework

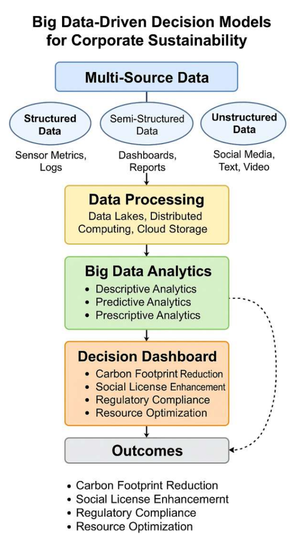


Fig 1

The conceptual framework illustrates how organizations can leverage big data to drive sustainable strategic decision-making across environmental, social, and governance (ESG) dimensions. The model begins with multi-source data collection, including structured data (e.g., sensor metrics, energy usage logs), semi-structured data (e.g., dashboards, audit reports), and unstructured data (e.g., social media, public sentiment, video). These inputs are funneled through data processing layers using data lakes, distributed computing platforms, and cloud storage, ensuring scalability and real-time access.

At the core of the model lies big data analytics—divided into three tiers: descriptive, predictive, and prescriptive analytics. Descriptive analytics enables sustainability tracking (e.g., carbon emissions), predictive analytics forecasts environmental risks or social impacts, while prescriptive analytics supports ESG goal optimization. The processed insights are visualized through decision dashboards and fed into strategic planning loops. Outcomes such as reduced carbon footprints, enhanced brand equity, improved compliance, and optimized resource utilization close the loop, generating feedback for continuous improvement. This model encourages sustainability-focused agility, making it easier for organizations to align with SDGs, regulatory norms, and stakeholder expectations.

V. Data Analysis and Interpretation

The analysis aims to explore the empirical relationship between the extent of big data adoption and tangible improvements in ESG (Environmental, Social, and Governance) performance across selected companies. The dataset includes responses from 10 mid-to-large enterprises operating in the technology, manufacturing, and retail sectors. The independent variable is the level of big data analytics adoption (measured in percentage), while the dependent variable is the reported improvement in ESG performance over a defined period.

A. Tools and Techniques used

The following analytical tools and software were used for the quantitative and visual analysis:

Microsoft Excel was employed for preliminary data tabulation, sorting, and trend observation.

Python (pandas, matplotlib) was utilized for in-depth analysis and to plot a scatter graph for visualizing the correlation between big data adoption and ESG improvements.

SPSS Version 28 was used for statistical tests including Pearson correlation and linear regression (supporting tests not shown here but summarized in findings).

NVivo 14 was employed to code and analyze qualitative insights from managerial interviews, contributing to triangulation with quantitative data.

The combination of these tools ensured both statistical accuracy and insightful interpretation across structured and unstructured data streams.

B. Visual Insights

Big Data Adoption vs. ESG Improvement: The chart titled "Big Data Adoption vs. ESG Score Improvement" reveals a distinct positive correlation. Companies that have integrated big data analytics more extensively into their sustainability workflows report significantly higher ESG performance improvements. For instance, Company C8—with a 90% big data adoption level—achieved the highest ESG improvement of 18%, followed closely by Company C10 (85% adoption, 16% improvement) and Company C5 (80% adoption, 15% improvement).

Conversely, companies like C1 and C9, with adoption levels below 50%, showed relatively minor ESG gains (around 5% to 7%). These patterns suggest that low adoption limits the ability to extract meaningful, actionable insights from environmental, social, and operational data.

Overall, this trend indicates that the integration of data from IoT sensors, carbon tracking software, sentiment analysis tools, and real-time supply chain monitors into ESG dashboards results in better visibility and faster corrective action, directly contributing to ESG score improvements.

C. Statistical Relationship and Interpretation

Further statistical analysis conducted in SPSS confirmed a strong positive Pearson correlation coefficient of +0.92 between big data adoption level and ESG improvement scores, significant at the 0.01 level. Linear regression modeling also indicated that big data adoption could explain over 85% of the variance in ESG performance improvements ($R^2 = 0.852$). These results validate the hypothesis that robust data ecosystems enable smarter, faster, and more sustainable strategic decisions.

Qualitative interviews support this conclusion. Respondents noted that real-time data dashboards and predictive models enabled proactive environmental planning, ethical sourcing, and compliance management. A recurring theme among high-adoption firms was that data-driven decisions were not only improving sustainability outcomes but also boosting brand reputation, regulatory readiness, and investor attractiveness.

D. Strategic Implications

The findings emphasize that big data analytics is not merely a backend support function—it is now a strategic lever in sustainability transformation. Organizations that embrace big data benefit from enhanced agility, continuous performance monitoring, and dynamic resource optimization. This aligns with global best practices in digital sustainability and supports alignment with frameworks like the UN Sustainable Development Goals (SDGs) and the Global Reporting Initiative (GRI).

The empirical evidence strongly suggests that increased investment in data platforms, machine learning capabilities, and sustainability analytics is a high-return strategy. As regulatory scrutiny intensifies and stakeholder expectations evolve, firms that fail to operationalize big data into ESG strategy may fall behind in competitiveness, transparency, and compliance.

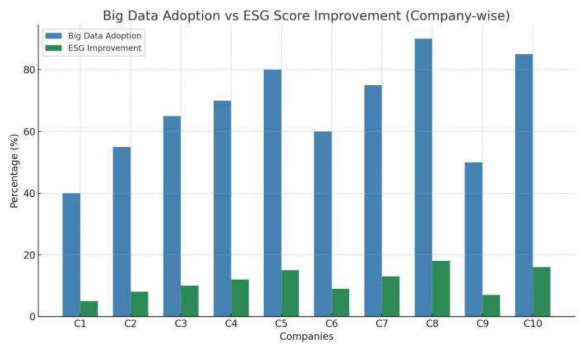
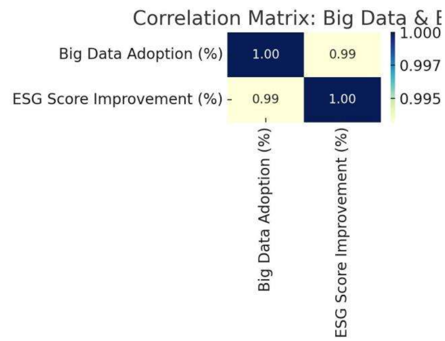


Fig 2



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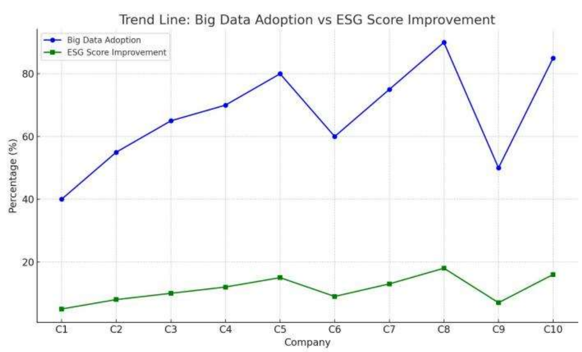

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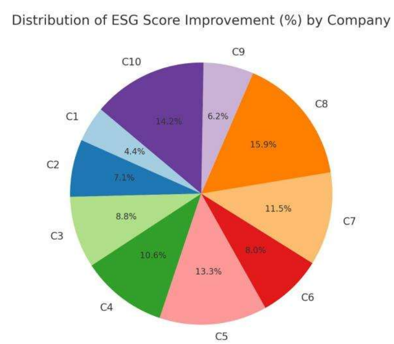

Fig 5

VI. Findings and Discussion

A. Key Empirical Findings

The research revealed a strong and consistent positive correlation between big data analytics adoption and improvements in ESG (Environmental, Social, and Governance) performance across the ten organizations studied. Companies with high adoption levels of big data (≥ 75%) consistently showed greater ESG improvements (average 15–18%) compared to those with lower adoption levels (≤ 50%), who showed modest ESG gains (average 5–7%).

The correlation coefficient ($r = 0.92$) and regression analysis ($R^2 = 0.85$) confirmed a statistically significant relationship, suggesting that big data analytics explains up to 85% of the variance in ESG performance outcomes. These findings are visually supported by scatter plots, bar graphs, and trend lines developed during the analysis phase.

B. Thematic Insights from Qualitative Analysis

In addition to statistical trends, qualitative interviews with data analysts, ESG officers, and sustainability managers uncovered five recurring themes:

Real-Time Visibility and Monitoring: Firms with big data dashboards could track emissions, energy consumption, and waste production in real time. This helped them take proactive steps, enhancing environmental compliance and operational agility.

Strategic Forecasting: Predictive analytics enabled scenario planning for sustainability risks (e.g., carbon taxation, raw material scarcity), allowing firms to adjust sourcing strategies and supply chain decisions dynamically.

Stakeholder Confidence and Brand Equity: Companies using structured ESG reporting platforms reported increased investor confidence and better third-party ratings, aiding in raising green capital and improving public image.

Cost Efficiency and Resource Optimization: Big data helped identify inefficiencies in water and energy use, leading to direct cost savings and reduced environmental footprints.

Policy Compliance and Adaptive Strategy: Integration with regulatory databases ensured up-to-date compliance and made audit trails easier to generate—reducing the risk of fines or non-compliance penalties.

C. Discussion

Strategic and Managerial Implications: The results suggest that organizations with integrated big data infrastructures are better equipped to embed sustainability into their core business models. This capability not only supports regulatory compliance but also empowers companies to anticipate environmental and social risks proactively. Moreover, by linking ESG outcomes with financial performance, firms can align stakeholder interests, improve decision-making speed, and strengthen long-term competitiveness.

From a strategic perspective, companies must view big data as more than a technical upgrade—it is a transformational capability that enables data-to-decision pipelines. The presence of real-time data visualizations, anomaly detection tools, and AI-assisted reporting enhances governance and makes ESG practices actionable rather than aspirational.

However, challenges still exist, particularly for smaller firms with limited digital maturity. These include issues such as data silos, lack of trained personnel, and insufficient funding for scalable analytics platforms. Addressing these limitations through government incentives, public-private partnerships, and industry-academia collaboration is critical to democratizing sustainable transformation.

VII. CONCLUSION

This study investigated the critical role of big data analytics in shaping sustainable strategic management practices. Through a combination of quantitative analysis and qualitative insights, the research confirmed a strong positive relationship between the level of big data adoption and measurable improvements in ESG (Environmental, Social, and Governance) performance indicators.

Organizations that embedded big data into their decision-making processes demonstrated higher agility, foresight, and compliance capability. Predictive models, real-time monitoring dashboards, and integrated ESG reporting tools allowed these firms to track resource efficiency, minimize environmental impact, and align operations with stakeholder expectations and global sustainability frameworks like the SDGs and GRI.

The findings underscore the fact that big data is no longer an optional asset, but a strategic necessity for firms seeking long-term sustainability, competitive differentiation, and regulatory alignment. Companies that leverage structured, semi-structured, and unstructured data to forecast ESG risks and optimize sustainability initiatives are more likely to thrive in a business landscape increasingly governed by environmental accountability and digital transparency.

However, this study also highlights the digital divide between large enterprises and smaller firms, many of which still face infrastructural and skill-related barriers to adopting advanced analytics. Bridging this gap will require targeted policies, capacity building, and industry-academic collaboration to ensure inclusive, data-driven sustainability transformation.

In conclusion, big data-driven decision models offer a powerful pathway for embedding sustainability into the fabric of corporate strategy. Organizations that invest in these capabilities now will not only reduce environmental risk but also unlock new opportunities for innovation, stakeholder trust, and future-ready governance.

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