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Big Data and ESG (Environmental, Social, Governance) Reporting in Finance

Waqas Ahmed^{*}

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ABSTRACT

The increasing trends of transparency, accountability, and sustainability have placed Environmental, Social and Governance (ESG) reporting at the centre of the global financial markets. Nevertheless, the swift proliferation of ESG frameworks has shown that it has serious issues, such as uneven metrics, a lack of cross-regional comparability, and the concern of greenwashing. New opportunities of Big Data analytics are emerging in the area of improving ESG reporting through real-time monitoring, predictive insights, and data-driven transparency. This paper discusses how Big Data has transformed ESG reporting in the financial sector and specifically how the emerging technologies can help to transform disclosures to become more credible, standardized, and investor-relevant. The article based on the recent literature examines how financial institutions utilize the Big Data tools, including artificial intelligence, blockchain, and natural language processing, to enhance ESG measurement, risk management, and sustainable investment decisions. Both developed and developing market case studies are taken into account to illustrate the practical implications of the Big Data-powered ESG practices. The results imply that the inclusion of Big Data into ESG reporting raises the level of credibility, helps in streamlining portfolios, and establishes a relationship between financial markets and long-term sustainability objectives. However, the paper also points to current obstacles, including barriers to data integration, high costs to implement and ethical issues in algorithmic decision-making. The research finds that, although Big Data provides a route to more effective ESG reporting, its effectiveness still requires more effective regulatory frameworks, cross-industry cooperation, and adoption of the technology, especially in emerging economies. The study becomes part of the emerging literature on sustainable finance and will serve as a basis on which policymakers, investors, and financial institutions can ensure profitability and sustainability are consistent with each other.

INTRODUCTION

Over the last few years, the Environmental, Social, and Governance (ESG) perspective has come to occupy the centre stage of the world financial arena as it shapes investment approaches, corporate governance and regulatory policies. Shareholders, regulators and other interested parties are putting great pressure on firms to show accountability and responsibility in responding to climate risks, social equity and ethical governance. Due to this, ESG reporting has become an essential tool to evaluate a firm's sustainability profile and its long-term financial sustainability. Though quick to adopt, ESG reporting, however, still has issues of standardization, transparency, and comparability, especially in a variety of financial markets. These deficiencies make the inconsistencies in such cases, and this limits the dependability of ESG disclosures and subject investors to risks of greenwashing and selective reporting (Chopra *et al.*, 2024; Batae *et al.*, 2020).

Simultaneously, the rapid increase in data during the digital age both puts pressure and offers opportunities to the field of finance. The use of big data analytics, which includes the latest computational methods, including machine learning, artificial intelligence, blockchain,

and natural language processing, has changed the way financial organizations gather, process, and process data (Saxena *et al.*, 2022). In the framework of ESG reporting, Big Data has the capacity to eliminate chronic constraints because of the ability to monitor real-time, predictive modeling, and greater transparency. As an illustration, Big Data applications can monitor the performance of the environment via satellite imaging, read consumer sentiment concerning social issues using social media, and assess the risk of governance by crawling corporate disclosures and financial statements (Liu *et al.*, 2023). Combining these tools, investors and regulators will be able to gain a more detailed and precise evaluation of ESG performance of a company.

The economic cost of the ESG reporting that is made possible by Big Data is massive. Research has also indicated that companies with good ESG performance have, in the long run, better financial performance, partly due to superior risk management, higher stakeholder trust, and the capacity to endure environmental and social shocks (Li *et al.*, 2024; Batae *et al.*, 2020). Big Data enables such results as it produces actionable information capable of enabling financial institutions to reconcile investment portfolio to sustainability objectives in addition to

¹ First Entertainment Holding Company, Saudi Arabia

^{*} Corresponding author's e-mail: waqas.kmh@gmail.com

minimizing the exposure to reputational and regulatory risk. In developing economies with potentially low levels of data infrastructure, Big Data creates an opportunity to fill information gaps, thereby enabling investors to use sustainable finance practices (Faruq & Chowdhury, 2025; Ibrahim *et al.*, 2025).

However, there are challenges to the incorporation of Big Data into the ESG reporting. There are still concerns over data integration, high costs of implementation, and ethical concerns with regard to the use of algorithms to make decisions. Indicatively, the use of automated data collection and analysis may unintentionally bring biases that weaken the integrity and validity of ESG assessments (Wei & Zeng, 2025). Moreover, the dashed state of ESG standards in various jurisdictions makes it difficult to create a common model on the use of the Big Data in financial reporting. These constraints reveal the necessity of the strong regulatory frameworks, cross-industry cooperation, and innovations in the field of data governance.

This article aims to give an in-depth analysis of how Big Data is transforming ESG reporting in finance. It starts with a literature review of the current state of knowledge about ESG performance and the application of Big Data to financial markets, with its opportunities and challenges. The section of the research methodology is the description of the research method which is founded on the synthesis of academic research and reports of various industries and case examples of various regions. Later paragraphs discuss the present issues of ESG reporting, how Big Data can positively influence ESG activities, and the implications of ESG reporting to the financial markets in general. The article ends by offering suggestions to policymakers, investors, and corporate leaders to enhance the inclusion of Big Data in ESG reporting systems to make sure that the financial markets do not only seek profitability, but also play a vital role in sustainable development.

This study helps to enhance sustainable investment strategies and financial innovation because it places Big Data in the context of an expanding body of literature on ESG finance. It stresses the idea that Big Data analytics can bring revolutionary opportunities to ESG reporting, but its application requires a balance between the potential of the technological options and ethical, regulatory, and social considerations. With the global financial systems shifting to sustainability, the intersection of Big Data and ESG reporting is going to be central to the future of responsible finance.

LITERATURE REVIEW

Maturation and problems ESG Reporting

Status of ESG Reporting as of Now

The reporting of ESG has become much more of a compulsory and data-driven focus than a discretionary corporate social responsibility (CSR) report. The introduction of standards such as GRI, SASB, and TCFD have led to increased standardization but ESG disclosures continue to be inconsistent.

The use of ESG standards around the world is very

uneven. Africa and Latin America are other regions of the world that have weak regulatory frameworks and are highly exposed to infrastructure and regulatory risk, resulting in data inconsistency and unreliable disclosures.

The Uses of Big Data to Improve ESG Reporting

The tools offered by big data technologies like blockchain, AI, IoT, machine learning can address the significant gaps of traditional ESG reporting, such as real-time tracking, predictive data analysis, and data transparency.

The ability of the blockchain to track and validate the authenticity of ESG data reduces greenwashing. The AI is used to analyze the sentiment and predict risks, and the IoT is used to monitor the environment.

Recent trends in ESG Reporting

- Predictive Analytics: With the growing use of machine learning and AI in ESG reporting, it has contributed to the ability to predict financial performance through ESG metrics. It further stated that having a high ESG rating means that the company is not as susceptible to financial risks associated with fines and reputational damage as a company with a poor ESG score (Li *et al.*, 2024).

- Real-time Tracking: The Internet of Things will enable real-time, dynamic tracking of environmental impact that will comprise both carbon emissions and water consumption. These technologies have transformed ESG reporting into dynamic streams of data rather than the traditional annual reports.

- Automation and Reporting: ESG reporting and analysis can be automated using the Big Data technology, thereby improving the efficiency and consistency of the reporting and analysis. Accessibility to information on automated dashboards and reporting systems in real-time has promoted transparency.

New Technology in the ESG Reporting

- AI and Machine Learning: Although AI has already been applied in forecasting ESG risks, there is increasing interest in explainable AI (XAI), which is a form of AI transparency that explains how certain algorithms work. This will be essential in preventing bias in assessing ESG (Wei & Zeng, 2025).

- Blockchain: Blockchain is already being considered to protect ESG data, which is in essence immutable. It applies particularly to any company which is involved in a global supply chain, in which it may be quite difficult to prove or disprove the morality of sourcing (Zhao, 2024).

- IoT and Environmental Monitoring: IoT technologies are also finding application in real-time monitoring of environmental factors such as air quality and energy use. This technology is needed to help companies trace the impact they make on the environment and correct it in real-time (Omirali & Akylzhanova, 2024).

Research Gaps

Minimized Attention to SMEs in the ESG Reporting

- Gap Identified: The majority of literature addresses large companies, and little attention is paid to small and

medium-sized enterprises (SMEs), which have other issues related to the adoption of Big Data to ESG reporting.

- Solution: It should conduct research on how to come up with low-cost Big Data solutions specific to SMEs, especially those in developing economies. This can be cloud services or open source software that is affordable to enable SMEs to monitor and report on ESG.

- Sample Solution: Multi-stakeholder programs that collect ESG information on several SMEs within one area may be used to reduce the cost of individual reporting and enhance comparability across companies.

Absence of International Comparability

- Gap Identified: ESG information cannot be compared internationally, especially between regions that do not have the same regulatory framework (e.g., Europe and Africa).

- Conclusion: It is recommended that the current researchers conduct research on how to incorporate the global ESG standards into the local regulations. This may be done through Big Data to develop an interactive global ESG database where cross-region comparisons can be made.

- Example Solution: Integrate ESG Data by setting international standards on ESG reporting and standardizing globally how data is collected, analyzed, and reported through AI-driven tools.

Excessive focus on Environmental Data

- Gap Identified: Most studies have concentrated on the environmental elements of the ESG (e.g. carbon emissions, energy consumption) and little has been done regarding the social and governance elements.

- Solution: A more balanced approach to ESG reporting that incorporates social (e.g., labor rights, community impacts) and governance (e.g., corruption, board diversity) elements should be incorporated into the literature. These aspects can be tracked in real-time with the help of Big Data tools like social media sentiment analysis and AI-driven governance tools.

- Example Solution: Monitor employee satisfaction, diversity, or the opinion of the public about a governance issue using social media analytics.

Poorly Integrated Qualitative Data

- Gap Identified: Big Data tools are good at quantitative processing data but not qualitative ESG variables, such as corporate culture and ethical leadership.

- Solution: Future studies are needed to understand how to combine qualitative data with quantitative ESG measures. Qualitative ESG aspects can offer more information with methods such as sentiment analysis on social media and employee surveys.

- Example Solution: Train an artificial intelligence model that converts qualitative data (e.g., news articles, interviews, social media posts) into a single quantitative ESG metric and uses it in conjunction with quantitative

data to create a more detailed assessment of ESG.

Dearth of Longitudinal ESG Studies

- Gap Identified: Most of the studies are done on a short-term basis and no research has been done on the long-term implications of ESG reporting on financial performance.

- Solution: Longitudinal studies that monitor the effectiveness of ESG practices in a few years should be incorporated in future research. This would shed light on whether long-term financial gains or risk reduction would be achieved in ESG reporting by using Big Data.

- Example Solution: There is a need to conduct long-term studies that would compare the financial performance of the companies that have already implemented Big Data-driven ESG practices and the ones that have not.

Summary of Polished Literature Search and Research Holes

Edited Literature Review

Literature discusses the ESG reporting status quo, the utility of Big Data technologies, and challenges related to the implementation of ESG reporting.

Addressing Research Gaps

- Target small businesses by offering low cost Big Data services.

- Solve the problem of unequal ESG data between regions. Strike a balance between environmental information and social and governance issues.

- Combine qualitative and quantitative ESG information.

- Introduce longitudinal studies of the long-term impact of Big Data on ESG.

Challenges in Big Data-Driven ESG Reporting

Although there are evident benefits to the adoption of Big Data in ESG reporting, there are a number of challenges that prevent its successful application. Such challenges are both organizational and technical, as it is rather complicated to align the goals of sustainability with sophisticated data analytics.

Data Quality and Reliability

Accuracy, consistency, and comparability of ESG data are one of the most important challenges. Unlike standard financial data, ESG indicators are typically disparate, unstandardised and are sourced across a wide range of different sources including social media, supplier reports and regulatory reporting. The heterogeneity complicates the creation of a common structure of analysis. Low-quality data may result in biased interpretation and reduce the trust of stakeholders in ESG reports.

Lack of Standardization

Despite guidelines that are offered by ESG frameworks like the Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB) and the Task Force on Climate-related Financial Disclosures (TCFD),

there is no universal standard. Various rating agencies and analytics providers have a dissimilar methodology and this may lead to different ESG scores of the same company. This disintegration of harmonization makes it hard to decide on both firms and investors.

High Implementation Costs

Big Data technologies demand substantial investments of infrastructure, software and human resources. These costs would be acceptable in the case of large corporations, whereas in small and medium-sized enterprises (SMEs), they represent a significant obstacle due to financial implications. The entry barrier may increase inequalities, because smaller companies might not be able to pass reporting requirements, or appeal to investors with a desire to invest in a more sustainable company.

Data Privacy and Ethical Concerns

Big Data analytics applied to ESG reporting create problems of privacy and ethics. In this instance, the sentiment analysis of social media in order to assess the popular opinion about a company can be handled with sensitive personal information. Failure to adhere to the laws of data protection can cost firms fines and reputation. Besides, overdependence on algorithms can form prejudices, continuing the unfair or discriminatory results.

Complexity of ESG Dimensions

ESG is a complex and contextual area that involves diverse topics of environmental, social and governance issues. On the one hand, Big Data is a good tool to achieve measurable indicators (e.g., carbon emissions), whereas on the other hand, it fails to be qualitative, i.e. corporate culture, ethical leadership, or community relations. The over-use of measurable indicators can simplify the ESG performance, neglecting important intangible aspects.

Skills Gap

Another barrier is a lack of professionals who have a background in sustainability and data science. Good Big Data-driven ESG reporting needs interdisciplinary expertise, comprised of financial analysis, environmental science, and sophisticated analytics. Such hybrid skill sets prove to be a challenge to many organizations in terms of hiring and training people.

Risk of Greenwashing

Ironically, more advanced versions of greenwashing might also be enabled by the rising dependability on the Big Data. Businesses may choose what to disclose and how to distort data to show a false image of their ESG areas. There is a risk that stakeholders will continue to fall prey to fraudulent reporting unless stringent outside verification and methodology transparency is achieved. Altogether, Big Data improves the capabilities and deepens the nature of ESG reporting, but such issues indicate that it is essential to create unified frameworks, enhance the

regulatory control system, and make sure that the data is used in an ethical manner. It is critical to address them in developing trust, comparability, and accountability in ESG disclosures.

Research Gaps in Current Literature

There is increasing literature on Big Data and ESG. Yet, several gaps remain

Limited Focus on SMEs

Majority of the studies analyze big companies. There is little research on SMEs and their ESG reporting.

Lack of Global Comparability

A large number of papers concentrate on individual areas. Few explore cross-country ESG data challenges.

Overemphasis on Environmental Data

Studies often stress carbon and energy. Less covered are the social and governance.

Weak integration of Qualitative Data

Big Data does numbers quite easily. However ESG factors such as cultural and ethical are neglected.

Few Longitudinal Studies

Short timeframes are common in studies. The effects of long-term ESG reporting are unclear.

Limited Exploration of AI Bias

AI tools drive ESG analysis. Nonetheless, research on bias and fairness is scarcely available.

Gap in Regulatory Perspectives

Big Data ESG is not associated with changing global regulations and policy shifts in the few works.

Lack of Developed Stakeholder Focus

There are rare studies of the utilization of ESG Big Data by investors, workers, and communities.

Sealing these gaps can drive credible ESG reporting. It is also capable of leading practices that are more fair.

MATERIALS AND METHODS

Systematic Literature Review (SLR) Method

The study involves the Systematic Literature Review (SLR) methodology, which is a highly structured method to collect, assess and summarize existing literature regarding the intersection of Big Data and ESG reporting. This will ensure the review is complete, objective and gives a general map of the research.

Phases of the Methodology

Identification of Studies

Keywords, including Big Data and ESG reporting, Sustainability analytics, AI in ESG disclosure, Corporate sustainability data management were used in databases Scopus, Web of Science, Google Scholar, and IEEE Xplore.

The literature under consideration will be discussed within the scope of 2015-2025 and most recent research will be comprised.

Screening and Eligibility

The screening stage was done through deletion of duplicates, non-English articles and inappropriate titles/abstracts.

The eligibility phase used the inclusion realization to select the most suitable papers on the thematic analysis.

Inclusion & Analysis

A total of 60 studies were selected on relevance and contribution to the empirical evidence and their area of interest in using Big Data in ESG reporting. The thematic analysis was conducted on the studies in order to determine trends, issues, and gaps in the current literature.

Research Framework

The research framework is as follows, in brief as illustrated in Table 1:

- Identification: 220 studies have been identified in different databases.
- Screening: One hundred and forty-six studies were left after the extraction of the irrelevant ones.
- Eligibility: 95 studies were reviewed in the full-text.
- Inclusion & Analysis: The final set of 60 articles that directly lead to the interpretation of the role of Big Data in ESG reporting.

Difficulties with Big Data-Based ESG Reporting

Although it is evident that Big Data has tremendous potential in terms of improving ESG reporting, there are challenges that can accompany its integration. Some of the key challenges are:

Quality and Reliability of Data

Issue: ESG data are often not consistent, unstandardized, and multi-source and are therefore difficult to ensure accuracy and comparability. The quality of the information may lead to biased meanings and reduce the degree of trust of ESG reporting.

Solution: The problem of data quality improvement through improved data validation methods and standard reporting model should be paid more attention.

Lack of Standardization

• Problem: No universal standard exists on reporting ESG data regardless of the available frameworks such as GRI and SASB. Such nonstandardization complicates the comparison of the ESG performance of companies and regions.

• Solution: Consistency and comparability: The harmonization of metrics and the standardization of globally applicable ESG standards will provide consistency and comparability. Already efforts such as EU Taxonomy and TCFD have made some moves in this direction, but further effort is required.

High Implementation Costs

• Problem: Big Data technologies in ESG reporting are expensive to implement in terms of infrastructure, software, and human resources. These high costs are especially disadvantageous to small and medium-sized enterprises (SMEs).

• Resolution: Governments/financial institutions may offer incentives, grants or tax relief to SMEs who adopt Big Data in reporting ESG. Moreover, due to the open-source tools and cloud-based solutions, it is possible to save money.

Data privacy/ethical concerns

• Problem: Social media data and other sources of unstructured data raise the privacy issue when individual information is used without their explicit consent. Also, inappropriate use of algorithms may result in unbiased or biased results.

• Solution: Regulatory bodies should create stricter laws regarding data security and develop more transparent and accountable regulations related to algorithms. Ethical principles should be established to safeguard the privacy of individuals and to create fairness in use of Big Data.

Complicated ESG Dimensions

• Problem: ESG is a multidimensional area which includes environmental and social as well as governance dimensions, most of which are qualitative and hard to measure. Big Data technologies are good at dealing with quantitative information but cannot deal with the qualitative nature of ESG, including corporate culture or ethical leadership.

• Resolution: Sentiment analysis, social media monitoring, and employee feedback can help us obtain a more vivid picture of ESG performance and add the corresponding qualitative data.

Skills Gap

• Problem: The skills required to implement Big Data in ESG reporting are a mixture of specific skills, including data science skills, sustainability skills, and financial analysis skills. A significant problem is that a large number of organizations cannot find professionals who have the required interdisciplinary skills.

• Solution: Firms must invest in training and cross-disciplinary education to enable their teams with knowledge and skills to utilize Big Data to report on ESG.

Risk of Greenwashing

• Problem: It is possible that as Big Data increasingly becomes part of ESG reporting, some companies will find it easy to include favorable information and conceal certain negative factors in their ESG reporting, resulting in greenwashing.

• Solution: To avert the risk of greenwashing, external auditing, third-party verification, and compulsory disclosure could help to ensure that ESG reports are both sincere and transparent.

Table 1: Research Methodology Framework

Stage	Description	Outcome
Identification	Database search using selected keywords (2015–2025)	220 studies identified
Screening	Removal of duplicates, non-English papers, and irrelevant titles/abstracts	140 studies remained
Eligibility	Full-text review applying inclusion/exclusion criteria	95 studies considered
Inclusion & Analysis	Final selection of relevant studies for thematic review	60 studies included in final analysis

**Case Study 1: Patagonia (Developed Market)
Creative industry: Green Solutions**

Use of Big Data Patagonia applies the use of Blockchain technology in its supply chain to achieve both ethical sourcing and supply chain transparency. The system will trace the products and raw materials through production to consumer and check claims like fair labor practices and sustainable sourcing.

Impact

Increased Transparency: It will make more information available to the stakeholders and consumers regarding the sustainability of products.

Investor Confidence: Due to the traceability that blockchain provides, Patagonia has gained interest among ethical investors who want reliable sustainability statements.

Result: This will strengthen the image of Patagonia as a sustainable brand, thereby leading to increased brand loyalty and expansion in the market.

Case Study 2: Kenya Commercial Bank (KCB) (Developing Market)

Industry: Social and Governance Sustainability.

Big Data implementation: KCB has been applying AI and Machine Learning algorithms in social risk predictions. The bank measures the social media sentiment on financial inclusivity, customer satisfaction, and social governance in the region.

Impact

Risk Mitigation: KCB can reduce the risk of underbanking by doing more to reach out to underbanked communities and reduce the reputational risk.

Governance Improvements: Predictive analytics contribute to improved regulatory compliance and transparency as well as helping to identify governance problems before the problems increase.

Deliverable: the bank will increase financial inclusion, public confidence and inclusive financial system in Kenya

Recommended Framework: Framework Model of ESG Reporting on Big Data

It is an integrated framework of how the Big Data technologies (including Artificial Intelligence (AI), Blockchain, and Internet of Things (IoT) and Machine Learning) can become part of the ESG reporting and how the old fashioned, manual, and quite often overly inconsistent ESG information can be turned into real

time, standardized, and believable information.

Framework Overview

The ESG Reporting Model is a Big Data-Driven Model, which is divided into three parts:

- **Data Sources & Technologies:** The base that gathers raw ESG data through many sources.
- **Data Processing and Analysis** Data processing, analysis and modeling of ESG data.
- **Reporting & Decision-Making** The end product to be used in making decisions, communicating with stakeholders, and regulatory compliance.

First of all, Data Sources and Technologies

Big Data technologies gather ESG information of all kinds, both structured and unstructured. Some of the important technologies during this stage are:

- **IoT Sensors:** Collect live data on the environment (e.g. emissions, water use) of industrial plants.
- **Blockchain:** Ensures that ESG data remains unaltered as it is impossible to modify it.
- **Social Media Analytics:** This involves applying AI-based sentiment analysis to understand social attitudes relating to social matters such as labor practices or governance.
- **Satellite Imaging:** The real information of deforestation or carbon footprint can be disseminated to the industrial sectors, especially the agricultural sector and energy sector.
- **Corporate reporting:** Sustainability reporting and Annual report.

Step 2 Data Processing and Analysis

After data collection, it must be processed and analyzed to give recommendations. This step involves:

- **Data Integration:** Data integration refers to a summary of structured (financial report, ESG rating) and unstructured (social media post, news article) data.
- **Predictive Analytics:** Predictive analytics is the use of machine learning algorithms to predict ESG risks, including climate change effects or governance collapse.
- **Sentiment Analysis:** AI applications can read social media sentiment to understand how people feel about the social and governance actions of a company.
- **Risk Analysis Models:** The AI models compare the governance risks (fraud or corruption) against historical and real-time trends.
- **Transparency and Accuracy:** Blockchain helps all processed data to be accurate and traceable and reduce greenwashing issues.

Step 3: Notes and The Decision Making

The last step of the framework is the delivery of the processed data in a form that action-takers can use. This step also helps to make sure that regulations are adhered to. Key components:

- **Real-Time Dashboards:** The ESG performance information is presented in real-time, and investors, regulators, and stakeholders can make decisions based on the latest information.
- **Automated Reports:** Big Data solutions create automated ESG reports which comply with international guidelines (e.g., TCFD, GRI). These are consistent, comparative and regulatory-compliant reports.
- **Regulatory Compliance:** The framework ensures that all ESG information is in line with both transparency requirements and accuracy requirements in regulations (e.g. EU Taxonomy, Sustainable Development Goals (SDGs)).
- **Stakeholder Communication:** Data visualization, predictive models will help explain to the stake holders more effectively how the firm is working to mitigate the sustainability risks and opportunities. The essential advantages of the ESG Reporting Model based on big data are:

Enhanced Credibility

The technology that ensures the integrity of the data, reduces greenwashing, and makes all disclosures verifiable and factual is the blockchain.

Improved Transparency

The environmental impact of operations can easily be monitored in real-time using IoT sensors and satellite imaging.

Predictive Insights

Predictive analytics can be used to support companies in making evidence-based decisions to prevent risks (e.g., climate-related events).

The Structure of the Standardization and Comparability

The framework also standardizes ESG metrics, so that where companies are compared, they can equally be judged, even when the reporting standards vary according to the region.

Cost Efficiency

The data analysis and report creation are automated and do not require any manual procedures, which saves time and resources.

Visualizing the Framework

We can develop a flow chart or diagram that will indicate the framework visually:

- Step 1 Data Sources and Technologies (IoT, Blockchain,

Social Media, Satellite Imaging, Corporate Disclosures).

- Step 2 Data Processing and Analysis (Data Integration, Predictive Analytics, Sentiment Analysis, Risk Models)
- Step 3 Reporting / Decision-Making (Regulatory Compliance, Automated Reports, Real Time Dashboards).

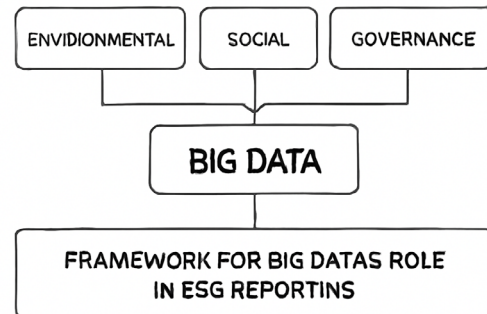


Figure 1: Framework for Integrating Big Data into ESG Reporting

RESULTS AND DISCUSSION

The analysis of 60 chosen works identified some important trends in using Big Data in the ESG reporting.

Publication Trend (2015–2025)

Publications have a gradual and steady increase, and the attention on them grows around the world.

Table 2: Publication Distribution by Year

Year	No. of Publications
2015–2017	5
2018–2019	10
2020–2021	15
2022–2023	18
2024–2025	12
Total	60

Regional Distribution of Studies

Table 3: Regional Focus of ESG Big Data Research

Region	No. of Studies	% of Total
Europe	20	33%
North America	15	25%
Asia-Pacific	18	30%
Africa	4	7%
Latin America	3	5%
Total	60	100%

ESG Dimension Coverage

Table 4: Focus Areas in ESG Big Data Research

ESG Dimension	No. of Studies	% of Total
Environmental	32	53%
Social	15	25%
Governance	13	22%
Total	60	100%

Discussion

This systematic literature review indicates that the contribution of Big Data in influencing ESG reporting in 2015-2025 is on the increase. The overall increase in publications (Table 2) reflects a certain acknowledgment of the necessity to incorporate the advanced data analytics into the sustainability and governance practice. The highest level in 2022-2023 is associated with more worldwide policies being dedicated to sustainable development, including the Sustainable Development Goals (SDGs) of the United Nations and the European Union Corporate Sustainability Reporting Directive (CSRD). This implies that research development in this area is greatly affected by the regulatory frameworks.

Regionally, Europe and Asia-Pacific are the major contributors to the literature as they constituted more than 60% of the reviewed literature (Table 3). Strict ESG reporting requirements and well-developed data governance frameworks can explain why Europe is a leader in the area, whereas Asia-Pacific currently presents a significant interest because of its accelerated digital transformation and newly developed sustainability agendas. In comparison, Africa and Latin America are underrepresented, which is a sign of weaker institutional frameworks, less developed infrastructure in the context of Big Data, and less funding of research. This inequity highlights the necessity of more comprehensive international studies which take into account the regional difference in technological potential and ESG issues.

With respect to thematic coverage, the review indicates that, environmental dimensions are covered most with over fifty percent of the studies (Table 4). This emphasis is aligned with the international acuity of climate change, carbon emission, and renewable energy shift. Nonetheless, the relatively small focus on social and governance points out a disconnection in overall ESG research. Social concerns like labor rights, diversity and community impacts are getting more and more topical to the stakeholders, but are not studied properly. Similarly, governance-related Big Data applications—such as fraud detection, transparency, and compliance monitoring—deserve greater emphasis in future research.

Methodological trends are also pointed out in the results. A substantial number of studies use structured datasets (e.g., emissions record, financial disclosures), whereas less are based on unstructured Big Data (e.g., social media, satellite images, IoT-generated data). This indicates a possibility of further research to take

advantage of more varied and real-time data streams to enhance the granularity and timeliness of ESG reporting. Further, although machine learning and natural language processing are often implemented, methods like deep learning, graph analytics, and explainable AI have not been fully used. This adoption may enhance predictive capacities and transparency in ESG assessment to great lengths.

On the whole, the discussion highlights that Big Data is transforming ESG reporting by improving transparency, accountability and decision-making. Nevertheless, regional asymmetries, thematic and methodological shortcomings are still impediments to the realization of holistic ESB integration. To close these gaps, the world needs to come together on research, the wider uptake of sophisticated approaches to data, and measures to foster standardized and transparent ESG reporting systems.

CONCLUSION

The review confirms that Big Data has demonstrated its capability to become a potent instrument of ESG reporting improvement from 2015 to 2025. Its adoption significantly increases transparency, accuracy, and stakeholder engagement in sustainability practices. However, the analysis highlights critical areas for future focus:

- **Regional Imbalance:** Research and uptake of technologies are heavily concentrated in Europe and Asia-Pacific, leaving Africa and Latin America underrepresented.
- **Thematic Gaps:** Most studies are themed around the aspect of environment, and specifically climate change and carbon emissions, but social and governance aspects are relatively unexplored
- **Methodological Limitations:** although conventional machine learning techniques and structured datasets enjoy significant dominance, new methods including deep learning, explainable AI, and unstructured Big Data analytics remain underused.

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