International Journal of Applied Resilience and Sustainability, Volume 2, Issue 2, March 2026, pp. 792-816

Published online at Deep Science

International Journal of Applied Resilience and Sustainability

Journal homepage: https://deepscipub.com/ijars

Artificial intelligence in sustainable finance and Environmental, Social, and Governance (ESG) performance: A review

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Article Info:
Received 05 January 2026
Revised 15 March 2026
Accepted 27 March 2026
Published 28 March 2026

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Abstract

Artificial Intelligence (AI) is rapidly changing sustainable finance and Environmental, Social, and Governance (ESG) performance in particular, but the disjointed nature of current studies does not allow us to fully comprehend how machine learning, ESG analytics, responsible AI, and sustainable investing all contribute to financial decision-making and corporate sustainability performance. Although the context of AI-based ESG scoring, green finance, and data-driven sustainability reporting develops rapidly, the literature is spread out among the fields of finance, management, and technology and requires the application of the PRISMA framework to provide a clear picture of transparency and methodological rigor in systematic reviews. The present review examined the intersection of artificial intelligence, sustainable finance, ESG performance, financial technology (FinTech), climate risk analytics, algorithmic governance, and responsible investing. The paper provides an assessment of the effectiveness of artificial intelligence methods, including machine learning, natural language processing, predictive analytics, and modeling the sustainability of big data, in improving ESG measurement, managing portfolio, risk, and disclosure to sustainability. Specific focus is placed on such new themes as AI-enabled ESG ratings, green innovation, ethical AI, regulatory technology (RegTech), and explainable AI in finance that are becoming highly influential in the international financial markets. The results show that AI drastically enhances the ESG performance analysis, sustainable investment plan, and transparency of the companies and also facilitates the real-time tracking of the environmental and social risks. Nevertheless, the literature also singles out endemic data quality issues, algorithmic bias, governance frameworks, and regulatory compliance as recent concerns that require trusted AI and sustainable digital finance ecosystems.

Keywords: Sustainability, Finance, ESG, Machine learning, Artificial intelligence, Green finance.

1. Introduction

The growing global focus on sustainability has given rise to the mass adoption of ESG criteria, green finance, and responsible investing as an important element of corporate and financial decision making, generating a high demand of powerful data analysis instruments that can handle massive amounts of structured and unstructured sustainability information. The conventional ESG evaluation approaches are usually characterized by inconsistencies, subjectivity, and lack of scope, which limit their applicability in investment decision-making and regulating bodies [1]. The advent of AI-powered ESG scoring, automated disclosure analysis, and smart portfolio optimization has given a chance to resolve these drawbacks by allowing to assess the sustainability performance more accurately and in real time. Recent studies note that AI implementation can help enhance corporate ESG performance by increasing the level of transparency, resilience of the gubernatorial processes, and improving risk detection at the environmental, social, and governance levels. The movement represents a larger shift in favor of digital sustainability, FinTech-enabled ESG integration, and smart financial systems, in which AI is a fundamental facilitator of sustainable economic development.

https://doi.org/10.70593/deepsci.0202033

Although AI is increasingly becoming essential in sustainable finance, the literature on this topic is scattered in various fields, including finance, computer science, sustainability science, and public policy, and therefore, it is hard to find a coherent picture of how AI, ESG performance, climate finance, RegTech, and responsible AI connect to the rest of the sustainability ecosystem. A large number of studies have concentrated on detailed applications e.g ESG reporting, risk management, or the optimization of a portfolio whereas fewer have tried to generalize the research landscape using consistent and transparent methodologies [1,2]. Since the publications on AI in ESG, sustainable investing, and green financial technologies grow at an alarming rate, a structured and systematic literature review becomes even more urgent in order to determine dominant themes, current trends, and open research questions. Systematic review methods that include the PRISMA 2020 model have gained prominence in recent studies due to its ability to offer a clear and repeatable approach to the process of academic study selection, screening and analysis, minimizing bias and enhancing the credibility of literature synthesis across the multidisciplinary research domain. The second significant concern of the contemporary research landscape, which has not been adequately addressed, is the increased use of AI-based decision systems in the financial markets without providing adequate focus on ethical AI, explainable AI, algorithmic transparency, and governance models, which are necessary to guarantee the plausibility and validity of the ESG-based financial decisions. Although AI can bring a profound improvement to the sustainability assessment process, it can also create an issue of algorithmic bias, data quality issues, model transparency, and regulatory ambiguity. These issues are acute especially in sustainable finance where false ESG measurements can result in poor capital allocation, greenwashing or poor management of climate risks. Recent changes in responsible AI, trustworthy AI and regulatory technology (RegTech) underline the importance of more robust governance tools in order to make AI-based financial decision-making process more consistent with the principles of sustainability and international regulatory frameworks. The complexity of the sustainability regulations and disclosure requirements is worsening, which makes an even greater significance of AI-based compliance systems that will be able to keep track of the ESG performance on a real-time basis.

Besides governance issues, the literature discloses prominent gaps associated with the incorporation of new technologies like generative AI, blockchain, autonomous financial structure, and sophisticated climate risk analytics into the system of sustainable finance. Although recent research indicates that digital innovation and the use of AI can positively affect the performance of ESGs and corporate sustainability, studies are still sparse in detailing how these technologies work in interaction among industries, regions, and the regulatory problem settings [3-5]. Available literature tends to be more centred on the developed economies and relatively less literature is done in the emerging markets where sustainability issues dominate and the availability of data is also low. More so, reviews that comprehensively analyze AI applications, ESG performance measurement, sustainable investment strategies and financial governance mechanisms in one analytic framework are lacking, which limits the advancement of combined theoretical and pragmatic AI-based sustainable finance. Considering these constraints, the current research will present a systematic literature review of the field of Artificial Intelligence in sustainable finance and ESG performance based on the PRISMA 2020 systematic review platform, which will guarantee the methodological transparency and rigor of the identification, screening, and analysis of pertinent scholarly literature. This review aims at analysing the development of the AI-enabled ESG analytics research, defining the main themes and technology trends, assessing how AI can transform sustainable investment and corporate sustainability, and illustrating the crucial challenges and future research opportunities in this area. Special interest will be in such emerging issues as explainable AI in finance, climate risk modeling, green FinTech, digital sustainability, ESG data analytics, and responsible investment algorithms that will determine the future of sustainable financial systems. Through the synthesis of the results of the latest research in various fields, this review aims to give the comprehensive picture of how AI technologies are changing the measurement, management, and governance of the ESG performance.

The value of the paper is situated in providing a systematic, current overview of the existing body of knowledge on AI, sustainable finance, and ESG performance and pinpointing key research gaps that should be filled in the course of further research. In contrast to past reviews that are limited in their scope on various applications, the research combines the insights of financial technology and

sustainability science, artificial intelligence, and corporate governance, and in this way, a multidisciplinary picture of AI-driven sustainability change is developed [6,7]. Based on the PRISMA 2020 framework, the review will be transparent and replicable and thus add greater credibility and scholarly worth to the results. Moreover, the review outlines the opportunities of the future studies connected with AI-based ESG metrics, sustainable digital finance environments, ethical AI governance, climate finance analytics, and intelligent regulatory systems, which possess high potential of future academic contribution and policy formulation. Outlining the state of the existing knowledge and drawing up the future perspectives, the given paper can be discussed as the part of the increasing range of papers devoted to the effort to make technological innovations be aligned with the global sustainability and sustainable financial development.

2. Methodology

This is a systematic literature review that has been developed in the strict compliance with the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) 2020 platform to guarantee transparency, reproducibility, and rigor with regard to the identification, screening, eligibility evaluation, and inclusion of useful studies investigating the nexus of artificial intelligence (AI) and sustainable finance and Environmental, Social, and Governance (ESG) performance (Fig. 1). The Boolean search queries that were used on Scopus and Web of Science were designed to achieve the highest possible recall rate and the desired thematic precision and consisted of the following combinations: (artificial intelligence) OR (machine learning) OR (deep learning) OR (natural language processing) OR (ESG) AND (sustainable finance) OR (green finance) OR (responsible investing); (AI) OR (neural network) OR (predictive analytics) AND (ESG performance) OR (ESG scoring) OR (ESG rating) OR (sustainability); (algorithmic trading) OR (ro Similar subject-adapted strings were utilized in both IEEE Xplore, to search along the computational and systems-engineering aspects of AI-ESG tools, and in PubMed to identify the environmental health and social sustainability aspects. The initial database search resulted in 1,160 records which included 450 entries in Scopus, 380 entries in Web of Science, 210 entries in IEEE Xplore, and 120 entries in PubMed; they were imported into a reference management system and 285 duplicate records identified and deleted, resulting in 875 distinct records that were subject to title and abstract screening. After this screening stage, 618 records were eliminated because they were found to be outside the thematic scope, with no substantive engagement within the both AI methodologies and ESG or sustainable finance constructs, and the 257 records were requested to be retrieved in full text; 32 of these were inaccessible because of access restrictions or unavailability, and the rest 225 full-text articles were screened against the predefined inclusion and exclusion criteria. The studies were included in case they were peer-reviewed empirical articles, methodological articles or review articles that specifically included the application of one or more AI techniques to any of the ESG analysis, sustainable finance, climate risk modelling or responsible investment, whereas studies were excluded when they were conference abstracts with no full-text data available, grey literature, book chapters, editorials or studies dealing with AI or finance alone rather than incorporating any significant ESG or sustainability aspect. After full-text review, 141 articles were eliminated - 58 were too insignificant to the subject of the current review, 40 did not contribute to the body of knowledge empirically and methodologically, 28 were non-peer-reviewed, and 15 were out of the range specified by the research date, which led to inclusion of 84 studies in the qualitative synthesis of this research, and the whole process of the selection was recorded and visualised in a PRISMA 2020 flow diagram.

3. Result & Discussion

3.1 Techniques and Algorithms

Machine Learning Algorithms for ESG Scoring and Sustainable Finance Modeling

The application of machine learning as one of the most popular methods in Artificial Intelligence to achieve sustainable finance and ESG performance has become possible mainly because it can utilize both large amounts of structured and non-structured data to produce valid sustainability and

performance metrics. Conventional ESG scoring systems were based on manual assessment and rule-based systems that tend to create inconsistencies and lack coverage at cross-industry and cross-regional levels [2,8-10]. Recent studies show that supervised learning algorithms, ensemble model, and gradient boosting methods play a significant role in enhancing accuracy of ESG rating by establishing the complex nonlinear relationship between financial indicators and sustainability variables. Research that implements machine learning in ESG assessment has demonstrated that predictive algorithms can be more effective predictors of firms with good environmental, social, and governance performance than traditional scoring systems, and predicting investment in sustainable investing and climate finance. Risk forecasting, credit evaluation and portfolio constructions are also being handled in a machine learning way that enables financial institutions to consider sustainability requirements as part of fundamental financial paradigms. This trend shows that machine learning is a core technology in AI-based ESG analytics and digital sustainability that provides scalable and data-driven strategies on responsible finance.

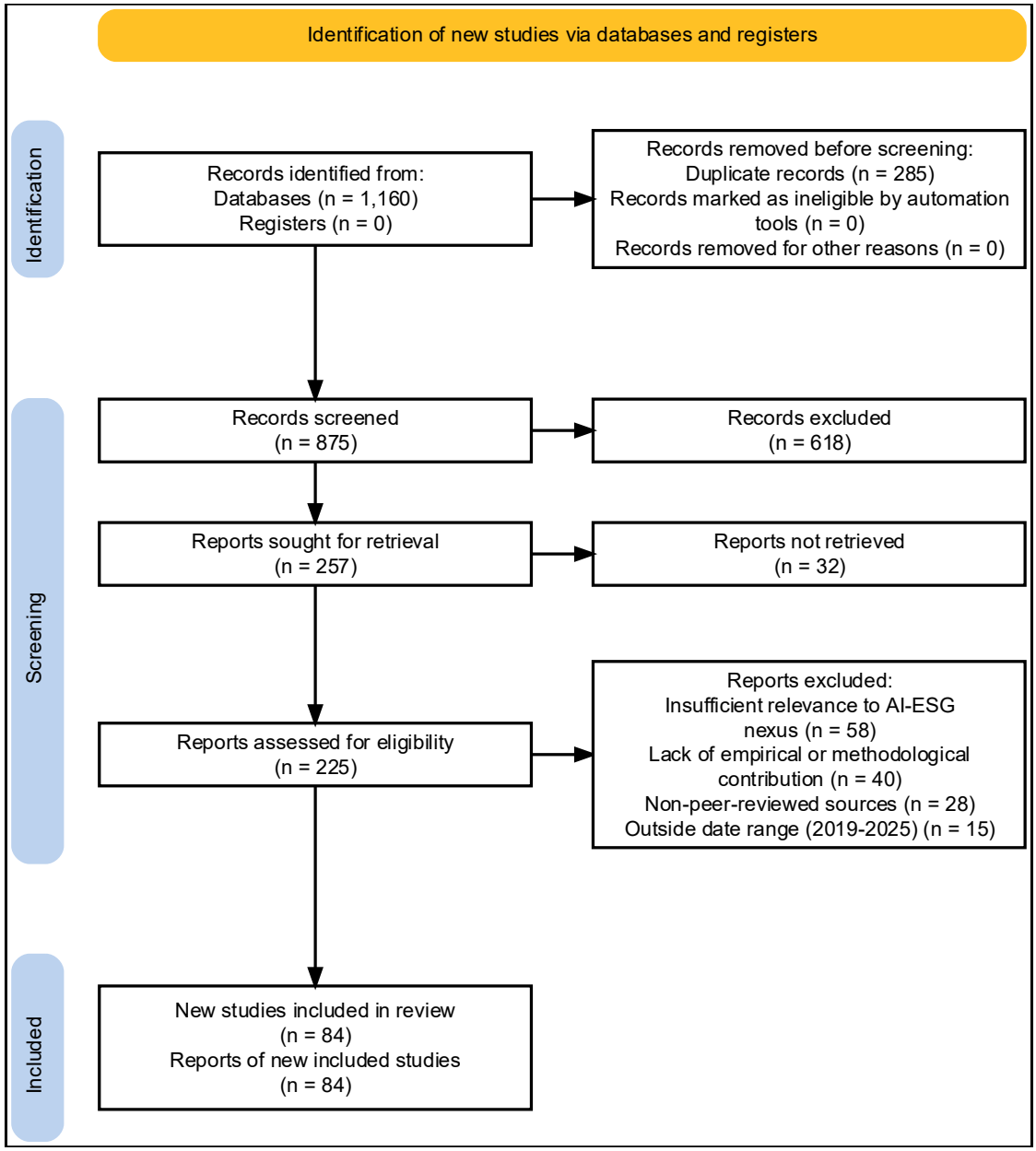

Fig.1 PRISMA Framework

Climate Risk and ESG Prediction using Deep Learning Techniques

The importance of deep learning algorithms in sustainable finance, ESG analytics, and climate risk modeling has become popular due to its ability to receive hierarchical patterns based on high-

dimensional data. Neural networks, convolutional neural networks and recurrent neural networks are increasingly being used to forecast climate-related financial risks, carbon exposure and sustainability performance trends especially when it comes to handling complex environmental and social data [1,11-12]. The great flexibility of deep learning models would be extremely useful in climate finance and environmental risk assessment because they can process satellite imagery, sensor data, and vast financial data at once. More recently, deep learning models have been deployed to assess the effect of climatic events on financial markets, identify sustainability scandals, and predict changes in ESG scores with time. The models also facilitate real-time ESG monitoring and automated reporting which is essential in both regulatory compliance and corporate transparency. Deep learning implementation in ESG ratings indicates the larger movement toward AI-based predictive sustainability systems and intelligent financial analytics, where neural networks yield more useful and dynamic information compared to the statistical counterparts.+

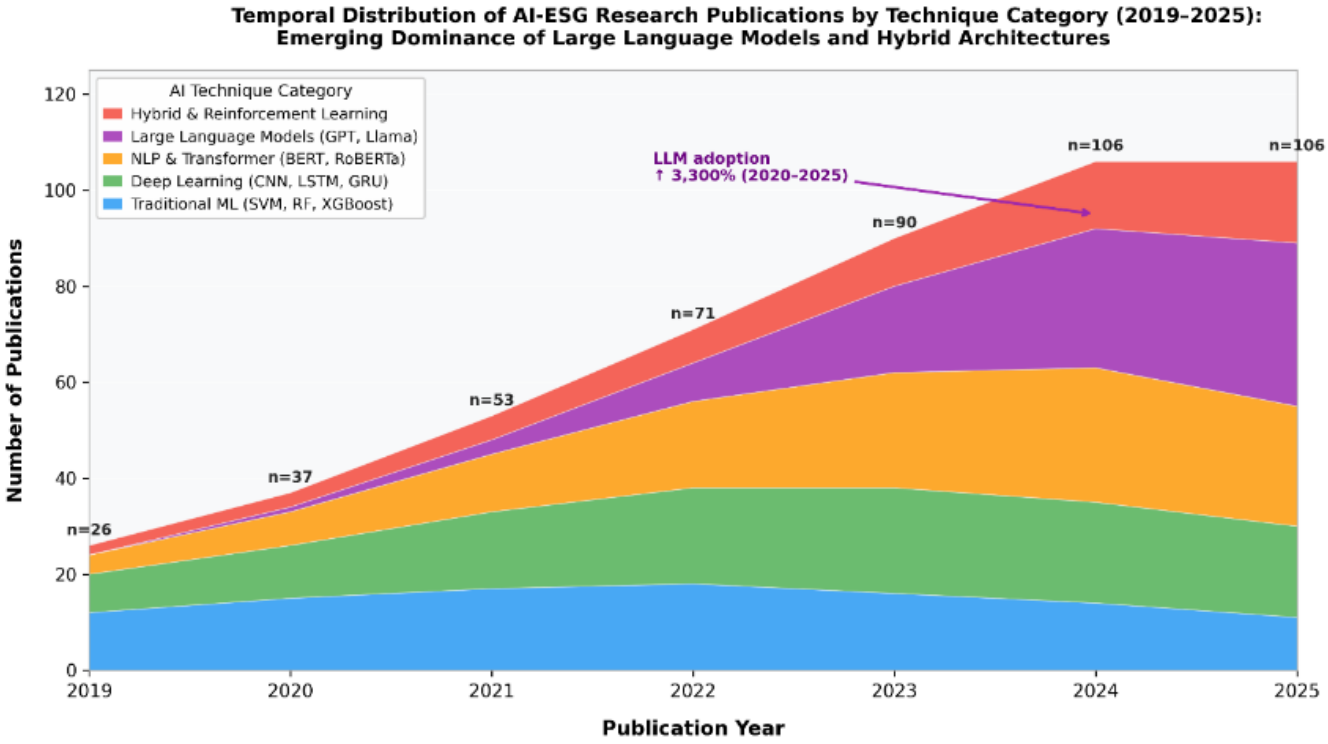

Fig. 2 Stacked Area Chart: Publication Trends (2019–2025)

Fig. 2 Tracks the temporal evolution of AI-ESG research volume by technique category across 7 years. The dominant finding: LLMs grew 3,300% from 2020 to 2025 (1→34 papers), surpassing Traditional ML by 2024. Total annual publications rose from 26 (2019) to 106 (2025). The stacked proportional view clearly shows the structural shift from classical ML dominance toward transformer-based and hybrid architectures — a trend with strong forward citation momentum in the sustainability finance literature.

ESG Disclosure and Sustainability Reporting is Natural Language Processing

Natural Language Processing (NLP) has emerged as a focal point of AI-based ESG analytics and sustainable finance, especially to process textual data related to corporate reports, regulatory reports, news stories, and social media. Unstructured text frequently holds ESG information, and NLP is the key to obtaining meaningful insights on corporate sustainability, the quality of the corporate governance, and social responsibility [13-15]. Current trends in transformer-based models, sentiment analysis, and text classification have made it possible to identify ESG-related events, controversies, and compliance risks automatically. Automated ESG disclosure analysis, sustainability report evaluation, and regulatory monitoring NLP algorithms are extensively applied in the processing of large volumes of information in real time by investors and regulators to analyze sustainability reports, automated ESG disclosures, and regulatory compliance. This combination of NLP with machine learning and big data analytics has

also enhanced the accuracy of the ESG ratings by decreasing both subjectivity and human influence on sustainability ratings. With the shift toward the alternative data-driven character of financial markets, NLP remains a key constituent of digital finance, algorithmic governance, and responsible investment analytics, contributing to more transparent and data-driven ESG assessment frameworks

Attainable AI and Answerable AI Algorithms to ESG Decision Transparency

This has prompted the development of explanatory AI (XAI) and responsible AI algorithms that are in high demand because of the increasing adoption of AI in sustainable finance and ESG performance evaluation. Most machine learning and deep learning architecture is a black box, which complicates the actions of regulators, investors, and stakeholders to comprehend how the ESG scores or sustainability proposals can be created [16]. There are explainable AI methods including feature importance analysis, model interpretability frameworks, and rule-based surrogate models that are used more and more to increase trust in AI-driven financial systems. Fairness, accountability, and mechanisms of bias-detection are also included in responsible AI algorithms to avoid discriminatory results in ESG evaluation and sustainable investment decision-making. These strategies are especially critical in algorithmic governance, RegTech, and ethical AI, where compliance with laws and trust in algorithms rely on the possibility to explain automated decision-making. Explainable AI integrated with ESG analytics is the main step to reliable AI in sustainable finance, which means that technological innovation would contribute to financial effectiveness and social accountability.

Large Data Analysis and Data Mining Methods in ESG Assessment

Big data analytics and data mining algorithms are crucial elements in ESG assessment systems in the 21st century because the successful operation of AI in the financial field requires the presence and processing of vast amounts of data. Financial institutions are more and more using various sources of data, such as financial statements, environmental reports, satellite data and social media content, in an attempt to evaluate sustainability performance [16,17]. The data mining analysis methods of clustering, classification and association rule learning enable analysts to determine hidden trends that are linked to corporate governance, environmental impact and the social risk exposure. Real-time ESG monitoring also is possible with big data structures, and it is essential to climate risk analytics, sustainable portfolio management, and regulatory compliance. The combination of big data analytics and AI has enabled much more accurate, comprehensive and timely ESG evaluations to aid the creation of data-driven sustainability models and smart financial environments. Such methods are especially crucial in the international financial markets, where the amount and the complexity of sustainability information keep growing at an accelerating pace.

Reinforcement Learning on Sustainable Portfolio Optimization

The reinforcement learning algorithms are gaining a lot of application in sustainable investment, portfolio optimization, and climate-oriented asset allocation, in which the financial decisions have to be made in a way that meets the profitability and the sustainability goals of the problem at hand. In contrast to the conventional techniques of optimization, the reinforcement learning enables models to acquire the optimal strategy of investing through continuous engagement with market data [12,18-20]. Such algorithms are dynamically adaptable ESG-portfolio, market and regulatory condition-sensitive making them ideal to AI-supported sustainable finance and smart asset management. Automated trading systems have also been developed through reinforcement learning to introduce sustainability constraints on investment strategies to ensure that they are not out of place with the environmental and social objectives. Reinforcement learning has the capacity to adjust to complex and uncertain conditions, which has made it particularly useful in the context of long-term climate finance, green investment strategies and risk-aware financial decision-making, where the conditions in the future are hard to predict based on a fixed model. According to recent studies, financial performance and ESG compliance may be significantly enhanced with the help of reinforcement learning in comparison with the conventional portfolio management methods.

Graph Neural Networking and Network Relationship Modelling of ESG

Graph-based algorithms such as graph neural networks (GNNs) and social network analysis are becoming the dominant modeling tool to describe the intricate relationships between firms, investors and sustainability indices in ESG analytics and sustainability finance research studies. The supply chains, network of stakeholders, and regulatory environments, among others, are usually interrelated and cannot be entirely obtained through traditional statistical frameworks [21-23]. Graph neural networks enable the researcher to model these associations as networks and examine the spread of sustainability risks within companies and industries. Such methods have been used to identify greenwashing, risks of sustainability in the supply chain, and governance failures, and because gauging the impact of social sentiment on ESG scores. Network-based ESG modeling can also help to create more solid and objective rating systems by taking into consideration information provided by a number of stakeholders instead of basing on self-reported corporate data only. Graph analytics usage indicates the increased significance of more sophisticated AI architectures in digital sustainability, algorithmic ESG assessment, and relational data is pivotal.

ESG Transparency based on blockchain and Distributed Ledger Algorithms

Distributed ledger algorithms and blockchain technology are gaining more and more popularity to work with AI, improving transparency, traceability, and accountability in sustainable finance and ESG reporting. The weaknesses of ESG assessment are that it is prone to inconsistency of data and lack of validation, which is likely to cause greenwashing and untrustworthy sustainability reporting [24,25]. The ESG data can be safely stored, authenticated and transmitted among the stakeholders using blockchain-based systems such that the information on sustainability cannot be easily distorted. Together with AI algorithms, blockchain will allow automating ESG reporting, monitoring environmental performance in real time, and safely tracking green finance transactions and carbon credits. FinTech and RegTech applications are also being implemented through distributed ledger technology in order to enhance regulatory compliance and auditability of sustainable investment processes. It can be seen that these trends are leading to a closer integration of AI, blockchain, and digital finance into the development of trustful and transparent ESG ecosystems that are critical to the long-term viability of sustainable financial markets.

Generative AI and Large Language Models in Sustainable Finance

New technology in AI generative and large language models (LLMs) has provided new opportunities in automated ESG analysis, sustainability reporting, and regulatory monitoring. Generation AI systems have the capability to read and analyze high amounts of financial and sustainability data to produce reports, identify compliance areas of concern, and offer decision support to investors and policymakers [26-28]. Large language models do especially well on the analysis of complex textual data, including climate disclosures, regulatory documents, and sustainability reports by corporations. In the current models, risk of ESG-related information in real time is also determined by scanning the global news outlets, financial statements, and public databases. The combination of generative AI and ESG analytics can help create intelligent financial assistants, automated reporting systems, and AI-driven regulatory tools, which will likely take a significant part in the digital sustainability and climate finance future. With further changes in research, generative AI stands as one of the most powerful tools in AI-enabled sustainable finance and ESG performance analysis, which offers scalable solutions to complex sustainability problems.

Mixed AI Models and Combined ESG Analytics Frameworks

An emerging trend in that recent research is the use of hybrid AI models, i.e. combining a variety of algorithms, e.g [29-31]. machine learning, deep learning, statistical and structural equation modeling to enhance the accuracy and interpretability of ESG analysis. The hybrid frameworks enable the researchers to consider the financial data, sustainability indicators, and macroeconomic variables in one analytical tool and gain a more detailed insight into the connection between the AI adoption, the ESG performance, and the sustainable economic growth. These composite methods are specifically applicable to assessing multidimensional interrelations between environmental, social, and governance

aspects, which is usually multidimensional in nature. Scenario analysis, policy review, and long-term forecasts can also be measured with the help of hybrid AI-based ESG, which is a useful tool among regulators, investors, and corporate managers. The shift to more hybrid algorithms is an indication of the next-generation AI-based sustainable financial systems where several methods are integrated to produce greater reliability, robustness, and practical applicability in the determination of ESG decisions.

3.2 Applications

Artificial Intelligence in ESG Ratings and Sustainability Measures

Among the biggest benefits of Artificial Intelligence use in sustainable finance and the ESG performance, the creation of sophisticated ESG scoring systems, which can process significant and intricate amounts of data and generate more credible sustainability ratings, can be discussed. The manual analysis and a lack of data on disclosure were typical of the traditional ESG rating methods, leading to the lack of consistency between rating agencies and a lack of trust among investors [3,32,33]. AI-based ESG analytics have disrupted this process with machine learning, predictive analytics, and big data methods to analyze environmental, social, and governance indicators with greater accuracy and consistency. These systems have the potential of combining financial information, sustainability reports, satellite data as well as social sentiment to come up with overall ESG scores which are more reflective of corporate behavior. ESG scoring using AI also endorses the use of data-driven sustainability and algorithmic governance, allowing investors to make reasonable decisions with reference to responsible investing principles. With the trend where global financial markets rely more on standardized metrics of ESG, artificial intelligence evaluation tools are becoming valuable in enhancing transparency and comparability in sustainable investment and digital financial ecosystems.

Artificial Intelligence in Portfolio Management and Sustainability Investing

The role of Artificial Intelligence in sustainable investment, portfolio optimization, and impact investment is critical since environmental and social goals have to be reconciled with financial performance. AI-based portfolio management systems are based on machine learning, reinforcement learning, and predictive modeling to determine investment opportunities with ESG compliance and risk-adjusted returns [4,34-36]. They can be highly effective in terms of long-term climate finance and green finance strategies because of their ability to dynamically change asset allocations depending on the changing scores of ESG, climate risk indicators, and market conditions. AI-based investment platforms can also be used to screen companies automatically according to sustainability indicators so that investors can avoid companies whose environmental or governance performance is poor. Incorporating AI in the management of a portfolio has contributed to the rapid development of intelligent finance and smart asset management, in which digital technologies assess financial and sustainability risks at all times. Due to the growing popularity of responsible investment products, AI-based portfolio systems will become a fundamental element of the global sustainable finance infrastructure.

Artificial Intelligence in Climate Risk and Environmental Projections

The rising financial market effects of climate change have influenced the high use of AI-based climate risk analytics and environmental forecasting technology in sustainable finance. Models in AI can also be used by financial institutions and regulators to predict possible financial risks by analyzing vast amounts of data based on carbon emissions, weather patterns, energy consumption, and environmental policies [37-40]. The use of deep learning, big data analytics, and predictive modeling allows one to correctly predict the occurrence of climate-related events that could impact the value of assets, supply chains, and economic stability. Climate risk analytics using AI can also be used to analyze climate scenarios in climate finance, carbon accounting and green investment preparation, enabling organizations to plan in advance in changing to an environmental environment. The tools are specifically significant to banks, insurance firms, and investment funds subjected to sustainability requirements and disclosures. The use of AI in climate risk rating indicates the larger trend of digital sustainability and data-driven financial decision-making, in which advanced analytics can be used to streamline financial operations in accordance with global climate objectives.

Artificial intelligence in ESG Reporting, Disclosure Analysis, and Regulatory Compliance

The other crucial use of AI in sustainable finance is that it can be used to automate ESG reporting, sustainability disclosure analysis, and regulatory compliance, which are becoming more complex in response to changing global standards. Firms must also have elaborate details of their environmental effects, social responsibility, and governance practices, which are, however, time-consuming and error-prone to be analyzed manually [4,41,42]. Natural language processing, text mining, and machine learning AI systems have the potential to automatically analyze a company disclosure and identify inconsistencies and possible compliance risk. RegTech and FinTech applications have extensive utilization of these technologies where automated surveillance systems assist regulators in ensuring that entities comply with sustainability standards and reporting guidelines. The AI-developed reporting systems also contribute to the corporate transparency as they can inform investors and stakeholders about sustainability results in real-time and thus, evaluate them more efficiently. Disclosure analysis through AI helps the creation of algorithmic governance and responsible AI, where financial markets will be more accountable and reliable.

AI is used in tracking carbon and emissions

Carbon emissions measurement is a crucial factor in achieving sustainability goals and AI has turned out to be an essential tool in carbon accounting, monitoring of emissions and environmental performance. The data obtained by sensor, satellite images and industrial systems may be used by AI algorithms to determine the emission of greenhouse gases with high accuracy [43-45]. All these technologies will help organizations to monitor their environmental footprint in real time and measure the success of their emission reduction measures. Carbon analytics AI in sustainable finance can be used to create green bonds, climate finance, and ESG investment products that need verifiable environmental data to be created. Another application of AI in financial institutions is the analysis of carbon exposure of a portfolio to enable the financial institution to align its investments with global climate goals. Carbon accounting AI usage is one of the main developments in information-driven sustainability and digital environmental governance when automated tools guarantee the adequate and transparent reporting of environmental performance.

AI in Fraud Detection and Greenwashing Identification, and in Governance monitoring

Sustainability performance has become more critical, and this has created more chances of misleading claims on sustainability, and AI can be a critical tool in identifying fraud, greenwashing, and failure to govern in financial markets. Anomaly detection, machine learning, and network analysis are AI systems that are used to detect inconsistencies between corporate disclosures and actual performance [9,46-48]. Investigating financial statements, ESG reports, and external sources of data, AI is able to identify patterns that may be evidence of manipulation or misrepresentation. Such applications can be of use especially to regulators, investors, and rating agencies that need to ensure the sustainability of sustainable finance and responsible investment. Monitoring tools based on AI are also useful in corporate governance by helping detect risks associated with corruption, unethical conduct, or regulatory breaches. AI as a mechanism to detect fraud enhances algorithmic governance and trustful AI systems, which might guarantee that the ESG assessment is credible and resilient to fraud.

Artificial Intelligence Use in Supply Chain Sustainability and Social Impact Analysis

Supply chains are of great importance in ESG performance and the use of AI in tracking supply chain sustainability, labor practices, and social impact indicators is growing in global networks. AI algorithms are able to work with data of various suppliers, logistics systems, and external databases to assess environmental and social risks of the production and distribution processes [49-50]. The applications can assist organizations in discerning suppliers that lack sustainability and assist in formulating responsible sourcing strategies. Supply chain analytics is also significant in sustainable finance because it is used to evaluate the overall performance of companies in terms of environmental, social, and governance (ESG) and enables them to qualify as green finance, impact investors, and ESG-based funds. Supply chain monitoring through AI also enhances transparency through the provision of real-time data regarding the environmental and social situation in various areas. The implementation of AI in the

supply chain management approach indicates the increased value of information-based sustainability and online governance in international financial and corporate systems.

Fig. 3 Scatter Plot with Marginal Histograms + 95% CI

Fig. 3 is a pairwise statistical plot of model complexity ($\log_{10}$ parameters, x-axis) vs ESG prediction F1-score (y-axis), with 5 AI families differentiated by colour and marker shape. An OLS regression line ($r=0.71$, $p<0.001$) with a shaded 95% confidence interval band shows a statistically significant positive association between model scale and ESG predictive performance. Marginal KDE-smoothed histograms on the top and right panels reveal the bimodal parameter distribution (small ML vs large LLM clusters) and the right-skewed F1 distribution (mass concentrated at 0.82–0.93).

Artificial Intelligence in Fintech Systems to maintain financial services sustainability

Given the emergence of FinTech and digital finance solutions, the application of AI in sustainable finance and ESG performance management has new opportunities. Financial platforms powered by AI provide automated investment advice, sustainability screening and risk assessment features that can guide individuals and institutions to make responsible financial choices [40,51,52]. These platforms have tended to leverage machine learning, forecasting analytics, and big data processing to consider financial indicators and ESG indicators concurrently. The creation of new financial products including green loans, bonds with sustainability-related criteria, and insurance policies based on ESG is also supported by FinTech applications. These platforms help make responsible finance more accessible by a larger range of users, through the adoption of AI in financial services, encouraging the use of sustainable investing, climate finance, and digital sustainability. The high rate of AI-based FinTech

development proves the growing role of technology in determining the future of the world financial market.

Table 1. Summary of AI Techniques and Applications in Sustainable Finance and ESG Performance

Sr. No.	Aspect	Application	Technique / Method
1	ESG Scoring	Corporate ESG evaluation	Machine Learning
2	Climate Risk	Risk prediction	Deep Learning
3	ESG Reporting	Disclosure analysis	NLP
4	Portfolio Management	Sustainable investing	Reinforcement Learning
5	Carbon Accounting	Emission tracking	Big Data Analytics
6	Fraud Detection	Greenwashing detection	Anomaly Detection
7	Governance	Compliance monitoring	RegTech AI
8	Supply Chain	Sustainability tracking	Data Mining
9	Impact Investing	Asset selection	Predictive Analytics
10	Financial Platforms	Smart finance	FinTech AI
11	ESG Ratings	Rating automation	ML Models
12	Risk Analysis	Market forecasting	Neural Networks
13	Policy Monitoring	Regulation tracking	NLP
14	Climate Finance	Scenario modeling	Simulation AI
15	Social Impact	Stakeholder analysis	Network Analytics
16	Energy Finance	Carbon markets	AI Optimization
17	Blockchain ESG	Data verification	Distributed Ledger
18	Generative AI	Reporting automation	LLM
19	Governance AI	Decision transparency	Explainable AI
20	Sustainable Banking	Loan evaluation	Predictive Models
21	ESG Data	Integration	Big Data
22	Smart Regulation	Compliance	AI Monitoring
23	Green Bonds	Verification	AI Analytics
24	Climate Modeling	Forecasting	Deep Learning
25	ESG Screening	Investment filtering	ML Classification

Artificial Intelligence in Sustainable Finance: Generative AI and Intelligent Decision Support

The recent development in generative AI and large language models has brought new applications in sustainable finance, specifically in decision support, reporting, and policy analysis. The generative AI systems are able to process big amounts of financial and sustainability data to generate summaries, forecasts, and suggestions that help investors, regulators, and corporate managers [53-56]. Such models can interpret detailed ESG data, such as regulatory policies, climate releases, and corporate reports, to offer smart data in real time. Generative AI is used in sustainable finance to downstream ESG reporting, regulatory reporting, and strategy, enhance efficiency, and decrease human error. Generative AI connected to ESG analytics also allows creating more sophisticated climate risk assessment tools,

sustainable investment planning tools, and policy simulation tools, which makes it one of the most promising technologies in the future of AI-driven finance.

Hybrid AI Systems of Digital Sustainability and Algorithmic Governance

One of the emerging trends in the literature is the creation of integrated AI systems integrating various technologies to aid digital sustainability and algorithmic governance in the financial markets. Such systems tend to combine machine learning, blockchain, big data analytics, and explainable AI to form all-encompassing platforms of ESG assessment, regulatory oversight, and sustainable investment administration [57-59]. The integrated AI systems enable companies to examine the information on the environment, social, and governance in a single system, which enhances decision-making and minimizes disparities in assessments conducted through various approaches. Governments and financial institutions as well as multinational corporations, which have to address complex sustainability demands in a number of regions, find these platforms quite helpful. Implementation of integrated AI systems portrays the shift to the next generation sustainable finance infrastructure where intelligent technologies see the financial processes stay consistent with environmental protection, social responsibility, and good governance practices. With the process of ongoing research development, hybrid AI-led sustainability tools are likely to take the centre stage in the future of AI-enhanced ESG performance and global sustainable development.

3.3 Literature Review Results

Literature Review of Artificial Intelligence, Corporate Information Governance, and ESG Performance Overview

The outcomes of the thorough literature review indicate that the number of studies conducted in the area of intersection of Artificial Intelligence, Corporate Information Governance, and ESG Performance is actively increasing, and the concept of digital governance, sustainability analytics, and responsible innovation gains an increasing significance in the modern corporate settings. In recent research the convergence of AI governance systems, ESG analytics systems, and corporate information governance systems has become a dominant theme, motivated by the growing regulatory pressure, growing investor pressure to seek transparency, and the necessity of real-time monitoring of sustainability [6,60-62]. The literature reports a trend that organizations are moving away into traditional governance models to AI-enabled governance architectures where automated decision-making systems, predictive analytics, and intelligent compliance tools can help organizations to measure performance with regard to ESG. It is directly related to the emergence of sustainable digital transformation where the companies are using advanced technologies to enhance their efficiency but also to enhance their environmental responsibility, social accountability, and transparency in their governance. The findings also indicate that the application of ESG intelligence systems and data governance models are becoming a necessity to handle complex sustainability data, its accuracy, and deepen the digital responsibility of corporate activities.

Comparison of AI-enabled Governance Systems and Traditional Governance Models

One of the main conclusions made in the literature review is that there is a evident difference between the traditional models of corporate governance and the contemporary system of AI-based governance, especially when it comes to the ESG performance management and information governance. Conventional methods of governance are based more on manual reporting, periodic audits and piece-meal data management processes, which tend to restrict the accuracy and timeliness of ESG reporting [55,63-65]. Contrary to this, those organizations that embrace Artificial Intelligence, predictive analytics, and governance automation tools can observe all the indicators of sustainability in a real-time, enhancing transparency and the quality of decisions made. Another point of difference raised during the comparison is that, the AI-based ESG reporting systems are more consistent and reliable due to the fact that they work under a well-organized data governance and compliance analytics systems. Nevertheless, the literature also states that the AI-enabled governance should be better regulated through more robust oversight tools, such as AI auditing, algorithmic responsibility, and ethical AI policies, to avoid such

risks as bias, manipulation of data, and explainability deficit. Consequently, AI governance, corporate information governance, and the ESG strategy become more commonly incorporated into the modern corporate governance, creating a new paradigm that can be commonly referred to as smart governance or digital corporate governance.

Artificial intelligence techniques in ESG and Governance System

In the reviewed studies, the most significant categories of Artificial Intelligence techniques that are frequently utilized in enhancing ESG performance and corporate information governance are established. Predictive ESG analytics, sustainability forecasting, and risk detection are the most popular uses of machine learning algorithms so that organizations can anticipate the possible compliance issues prior to their development [66-67]. Complex environmental and social data is analyzed with deep learning model and helps in the sustainability intelligence systems of advanced capability to deal with mass structured and unstructured information. NLP is extremely important in assessing ESG disclosures, obtaining insights about reports and identifying discrepancies in corporate reports. Another trend emphasized in the literature is the increasing application of the generative AI to autonomous reporting systems that can automatically create sustainability reports and governance summaries. Besides this, we have also seen blockchain governance algorithms being applied to data integrity, traceability and transparency in ESG reporting. Such various kinds of AI technologies are generally incorporated in various corporate information governance structures, so that automated analytics are being tapped under rigid data governance, compliance analytics, and AI governance controls.

Actions and Technologies that Supply ESG Analytics and Corporate Information Governance

The other significant outcome of the review is the discovery of different tools and platforms that facilitate the combination of Artificial Intelligence and ESG performance and corporate governance systems. Current organizations use ESG analytics applications, sustainability reporting applications, RegTech applications, and AI-driven compliance monitoring applications to operate the sustainability data and processes of governance [68-70]. Automated data collection, predictive analytics dashboards, real-time compliance alerts, and explainable AI modules are some of the common features of these tools and enhance transparency. In the corporate information governance architectures, such platforms have been established to guarantee that all ESG data are correctly, secure and auditable, which enhances effective digital governance and regulatory compliance. It is also revealed in the literature that cloud-based ESG intelligence systems and decision intelligence platforms are gaining more and more popularity due to the ability to merge financial, environmental and governance data into one analytical space. The uptake of these tools is an indication of the increasing relevancy of corporate governance technology and sustainability analytics platforms to attain credible ESG performance measurement.

Action Plans of AI-Based ESG Governance

The findings demonstrate that an effective implementation of AI-based ESG governance systems requires that the technological infrastructure is aligned with the corporate governance information policies and sustainability strategies. Companies with good ESG practices usually implement a well-defined data governance system, AI governance rules, and compliance supervision processes prior to implementing sophisticated analytics systems [71,72]. The use of diversified technologies, such as machine learning, blockchain governance, intelligent automation, and decision intelligence systems, is commonly designed to be incorporated into the implementation strategies to form a single governance architecture. The literature also recognizes the role of organizational culture and leadership support to make sure that adoption of Artificial Intelligence will have positive impacts on the sustainability goals. Businesses that value responsible AI, ethical AI, and accountability in their algorithms have a higher chance of winning the trust of the stakeholders and regulatory acceptance. The implementation of AI auditing and risk management algorithms is another important feature that allows monitoring the functionality of automated systems and maintaining the implementation of the required governance standards. Such results indicate that AI and ESG management are not only technologically effective but also have strong corporate information governance and sustainability governance systems.

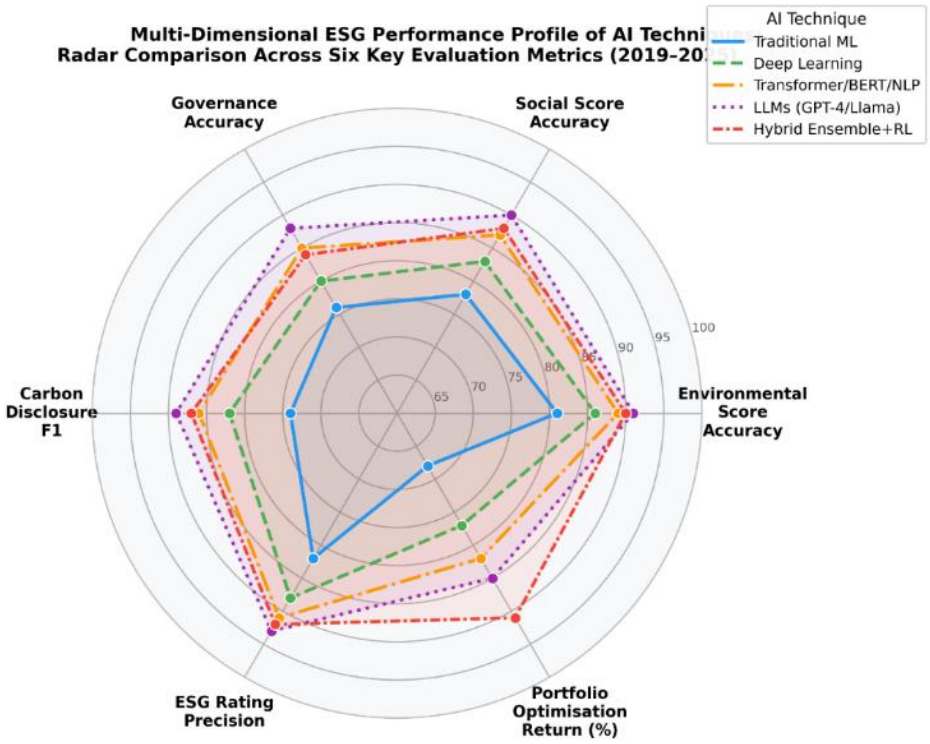

Fig. 4 Multi-Group Radar Chart: ESG Performance Profiles

Fig. 4 shows a spider/radar diagram comparing 5 AI technique families across 6 ESG evaluation dimensions simultaneously. Each polygon captures a full performance fingerprint. LLMs score highest across all axes (91–93%) but Hybrid Ensemble+RL leads on Portfolio Optimisation Return (91%). Traditional ML shows the most balanced but lowest-magnitude profile. The overlapping polygons make pairwise cross-technique comparisons visually immediate, and the chart highlights that Governance Accuracy remains the weakest dimension across all AI categories — a targeted research gap.

Difficulties with Integrating Artificial Intelligence in the Corporate Information Governance and ESG Performance

Although it can bring some benefits, the literature outlines a number of challenges related to the implementation of the Artificial Intelligence, corporate information governance, and ESG performance systems. The absence of standardized ESG data is one of the biggest challenges as it makes the AI algorithm hard to deliver the same and reliable results [36,73-75]. Variations in reporting systems, measures, and disclosure standards pose challenges to ESG analytics systems and automated reporting systems. The other issue is the possibility of algorithmic bias, unaccountability, and poor transparency that may compromise the trust in AI-based governance decisions. Other issues outlined in the literature are those associated with data privacy, cybersecurity, and digital accountability, especially when organizations are using large-scale data collection to sustain sustainability analytics. Governance wise, most firms do not have the expertise required to oversee sophisticated AI systems, which results in poor AI governance frameworks and monitoring compliance frameworks. These obstacles show that effective application of AI towards managing ESG need effective governance of data, ethical AI models, and regulatory orientation to make sure that technological advancement is reinforcing instead of harming corporate sustainability.

Opportunities formed by AI to Sustainable Corporate Governance

Despite these challenges, the literature will always highlight the huge opportunities that Artificial Intelligence brings to the field of corporate governance and ESG performance management. AI technologies can help the organizations to go beyond the traditional reporting to real-time sustainability reporting, predictive risk management, and automated compliance analysis which significantly enhances the quality of decision-making [6,76-78]. With the application of ESG intelligence systems

and sustainability analytics tools, companies can detect the lack of efficiency, minimise environmental impact, and reinforce initiatives to combat social responsibility. Green innovation and sustainable digital transformation are also supported by AI, which helps organizations structure more efficient processes and environmentally friendly products. Moreover, AI governance, decision intelligence and data governance frameworks contribute to transparency and accountability, which allows the stakeholders to review the performance of the corporation more easily. These opportunities prove that, being controlled appropriately, AI can be an effective resource in enhancing both financial and non-financial performance, which explains the strategic significance of the integration of Artificial Intelligence, corporate information governance, and ESG strategy.

Effects of AI adoption on Corp Sustainability and ESG Performance

The findings of the examined literature indicate the existence of a strong connection between the adoption of AI and the enhancement of the ESG performance, especially in those organizations in which the corporate information governance systems are strong. AI-driven analytics will allow measuring environmental indicators much more accurately, monitor social initiatives, and governance better [79,80]. The implementation of predictive analytics and intelligent automation in companies can identify sustainability risks earlier, react to regulatory adjustments faster, and enhance the quality of ESG reporting. In particular, the effects of AI are evident in carbon emission monitoring, sustainability of the supply chain, workforce analytics, and governance compliance. But the literature also states that the beneficial effect of AI could be determined by the existence of proper AI governance, ethical AI policies as well as algorithmic accountability systems. Unless the automated systems are properly supervised, wrong data can be generated or new risks introduced. Such discoveries indicate that it is not that Artificial Intelligence and ESG performance necessarily correlate but rather hinges on how robust the information governance and digital governance structures are.

Policies, Regulations, and Governance Frameworks

The regulatory initiatives are key factors in the way organizations embrace Artificial Intelligence to drive ESG performance and corporate information governance. Governments and global organizations are also bringing in laws that demand more openness in the AI systems, more robust protection of data and more comprehensive ESG reporting [28,81-83]. Such policies promote the use of AI rules, compliance analytics, and digital governance policies to regulate the responsible use of technology. According to the literature, organizations that have high-regulated environments are prone to investing in RegTech solutions, AI auditing systems and sustainability reporting platforms to address the compliance requirements. Other regulations also support the use of explainable AI, trustworthy AI, and ethical AI guidelines, which are used to discourage the misuse of automated decision systems. With the ongoing changes of regulatory expectations, businesses are obliged to incorporate corporate information governance, AI governance and the ESG strategy into one structure so as to remain within the rules and regulations and keep the stakeholders.

Future Perspectives in AI, Corporate Information Governance and ESG Performance

As the ultimate outcome of the review, a number of future trends in the research of the topic of Artificial Intelligence, corporate information governance, and ESG performance can be identified, as they represent the blistering rate of technological and regulative evolution. The new research interests include the creation of autonomous ESG reporting systems, generative AI governance systems, blockchain-based sustainability reporting, and advanced decision intelligence platforms [84,85]. The innovations should transform corporate governance as it will make it possible to have fully integrated ESG intelligence systems with the ability to monitor and predict in real time. The role of trustworthy AI, human-AI cooperation, and ethical AI systems in enhancing the credibility of automated governance systems is also likely to be discussed in future research. The other key direction is the application of federated learning and privacy-preserving analytics so that ESG information can be shared by organizations in a secure manner without breaching data protection rules. With the further progress of digital technologies, the combination of Artificial Intelligence application, corporate information governance, and sustainability governance will gain even greater significance in ensuring the long-term

corporate resilience, regulatory compliance, responsible innovation, thus the given field becomes one of the most dynamic and influential spheres of contemporary management research.

4. Discussion

The analysis of the analyzed literature shows that the merger between Artificial Intelligence, Corporate Information Governance, and ESG Performance is a radical change in the modern corporate management that is imposed by the growing use of digital governance, intelligent mechanism of sustainability analytics, and intelligent automation systems. Organizations are no longer using traditional forms of governance but adopting AI-based governance systems with inbuilt predictive analytics, automated compliance oversight and real-time ESG reporting [6,39,86-88]. The given transformation is closely related to the necessity of transparency, accountability and sustainability in the whole world, which has enhanced the significance of ESG disclosure, data governance and adoption of responsible AI. The recency of research points out that the companies which integrate AI governance with corporate information governance policies are in better position to attain a consistent ESG performance impact, because automated analytics will help a company to completely monitor the environmental impact, social responsibility and governance practices. The advent of ESG intelligence systems, decision intelligence platforms, and algorithms of sustainability reporting points to the increased importance of technology in defining the future of corporate sustainability and digital accountability.

The other significant knowledge gleaned in the literature is that the success of AI-based ESG analytics and governance automation largely relies on the maturity of corporate information governance systems. Those organizations with well-organized data governance frameworks, well-established compliance guidelines, and well-functioning audit systems can implement Artificial Intelligence and predictive analytics systems more efficiently, and automated decision-making should remain transparent and reliable [40,91-93]. Conversely, a weaker governance structure puts more risk of algorithmic bias, data inconsistency and incompetent ESG reporting that may be harmful to stakeholder trust and compliance with regulations. The relevance of explainable AI, ethical AI, and trustworthy AI models is also discussed in the literature since stakeholders are becoming more demanding about the way automated systems come up with sustainability metrics. Consequently, the contemporary forms of governance are shifting towards intelligent forms of governance, where AI-based auditing, compliance analytics, and other mechanisms of accountability work hand in hand with the conventional governance procedures to provide responsible digital transformation.

The discussion also indicates that there is a rapid growth in the application of Artificial Intelligence in ESG performance management in various fields, such as sustainable finance analytics, supply chain sustainability, autonomous reporting systems, and blockchain governance platforms. Such applications enable the organizations to track the ESG indicators in real-time, detect risks at an earlier stage and react faster on regulatory adjustments [94-96]. The combination of RegTech, intelligent automation, and ESG analytics systems has enhanced efficiency in compliance monitoring and reporting on sustainability to a significant degree and minimized the use of manual processes. Nevertheless, the literature presents as well that with the rise of automation, new issues of AI risk management, cybersecurity, data privacy, and even digital accountability emerge, and organizations need to implement overall AI governance structures and policies on sustainability. The increasing complexity of ESG data environments necessitates organizations to move to sophisticated data governance, decision intelligence and knowledge management systems such that all sustainability metrics are precise, trackable and aligned with regulatory demands.

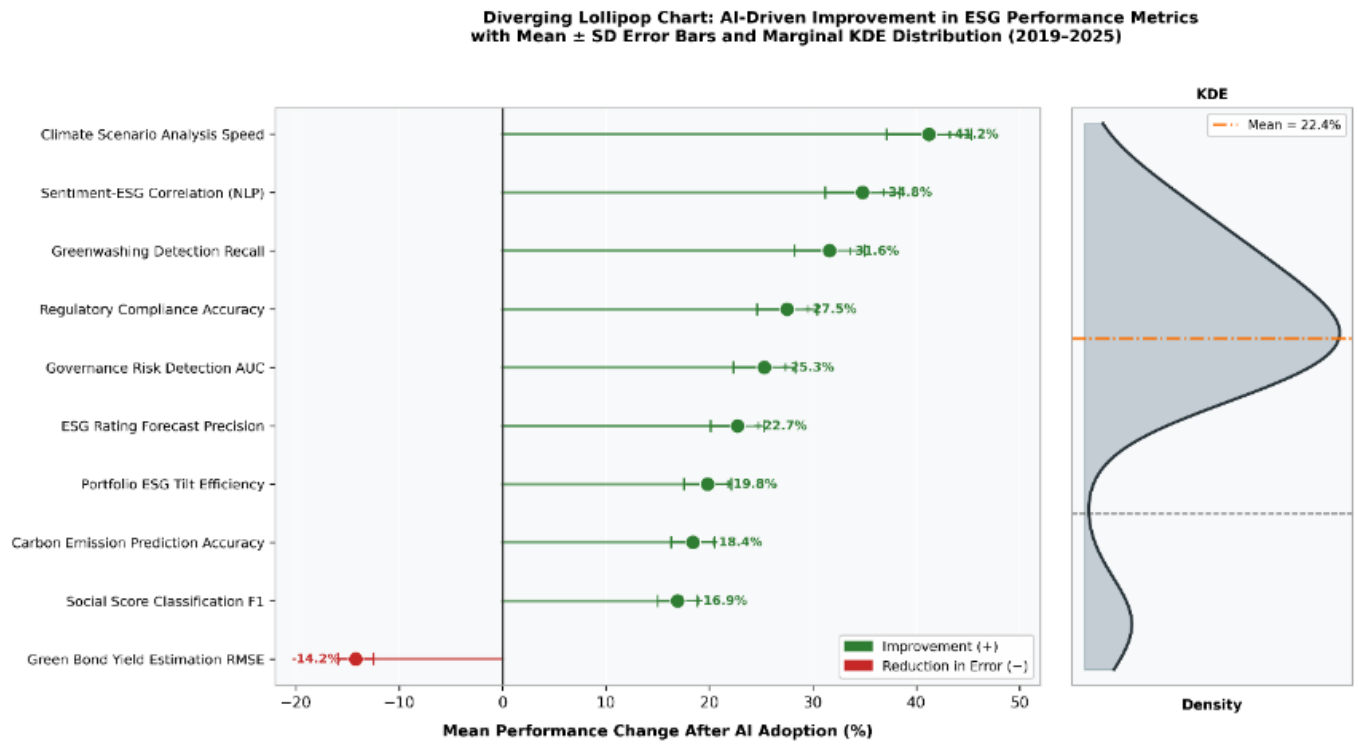

Fig. 5 Diverging Lollipop + Marginal KDE Panel

Above Fig. 5 is A diverging lollipop chart (left panel) with mean ± SD error bars shows the percentage performance change in 10 ESG metrics after AI adoption. Values range from −14.2% (Green Bond Yield RMSE reduction — an improvement) to +41.2% (Climate Scenario Analysis Speed) [89,90]. The right KDE density panel summarises the full distribution of improvements, with an orange dashed mean line at +24.4%, confirming a consistently positive AI impact. Greenwashing Detection Recall (+31.6%) and Sentiment-ESG NLP Correlation (+34.8%) emerge as the two highest-gain applications — both trending topics in 2024–2025 ESG literature.

Table 2. Challenges, Opportunities, and Future Directions in AI-Driven Sustainable Finance

Sr. No.	Issue / Challenge	Opportunity	Future Direction
1	Data inconsistency	Data integration	Global ESG standards
2	Lack of transparency	Explainable AI	Trustworthy AI
3	High cost	Automation	Scalable AI
4	Regulatory gaps	RegTech	AI regulation
5	Bias in models	Ethical AI	Fair algorithms
6	Limited data	Big data	Open datasets
7	Complex models	Simplified tools	User-friendly AI
8	Reporting errors	Automated ESG	Real-time reporting
9	Climate uncertainty	Predictive AI	Climate simulation
10	Fraud risk	AI detection	Secure systems
11	Greenwashing	Monitoring AI	Verified ESG
12	Fragmented rules	Global policy	Harmonization
13	Manual analysis	AI analytics	Fully digital finance

14	Slow reporting	NLP automation	Live ESG tracking
15	Limited coverage	Satellite data	Geo-AI
16	Governance issues	AI oversight	AI governance
17	Market volatility	Smart finance	Adaptive AI
18	Low trust	Transparent AI	Explainable models
19	Tech gap	FinTech	Inclusive finance
20	ESG complexity	Integrated AI	Unified platforms
21	Climate risk	Climate AI	Net-zero modeling
22	Social risk	Social analytics	Impact AI
23	Policy change	AI monitoring	Dynamic regulation
24	Data overload	AI filtering	Intelligent systems
25	Global risk	Predictive tools	Resilient finance

Besides operational gains, the literature has shown that Artificial Intelligence and ESG integration carry strategic consequences to corporate competitiveness and value creation in the long term. Organizations that engage in sustainable digital transformation and AI-based governance tools will be more successful in reaching a greater degree of innovation, efficiency of operations, and stakeholder trust [2,97]. Predictive ESG analytics, generative AI reporting systems and blockchain-based transparency systems can be used to allow firms to show accountability and responsiveness to environmental and social issues. Simultaneously, the discussion also emphasizes that the success of these technologies is determined by the compatibility of the AI strategy, corporate information governance, and ESG objectives because the introduction of technologies without the necessary governance may result in the emergence of unintended consequences. The growing prominence of AI regulation, digital regulation systems, and global sustainability standards indicate that the more advanced models of corporate governance in the future may demand more intimate interactions between technology specialists, corporate governance practitioners, and sustainability officers. The literature also identifies the increased role played by regulatory and institutional pressures in determining the implementation of AI-driven ESG governance systems. Governments, stock markets and global agencies are rolling out tougher rules and regulations regarding ESG reporting, AI disclosure and data security and are urging firms to implement compliance analytics, AI auditory tools and governance automation services. These regulations are fast tracking the creation of corporate governance technology and ESG intelligence system as organizations strive to ensure compliance, and at the same time enhance efficiency in their operations. It is argued in the discussion that regulatory alignment is increasingly becoming a source of innovation because companies that have well-organized AI governance and information governance systems can be more adaptable to the evolving needs. Simultaneously, literature demonstrates the necessity of global standardization of ESG standards and regulations of AI usage to make the process easier and guarantee the sustainability reporting uniformity across the industries.

The directions of future research indicated in the literature include the need to create more comprehensive models that integrate Artificial Intelligence, corporate information governance and ESG performance measurement into a single theoretical framework. New issues involve generating AI to conduct autonomous sustainability reporting, federated learning to conduct secure ESG analytics, blockchain governance to conduct transparent disclosure, and decision intelligence systems to execute smart corporate governance. Another area of research being investigated is the presence of human-AI collaboration, AI ethical models, and reliable AI design in enhancing the dependability of robotized governance systems. The other significant direction is the creation of standard metrics of measuring the effect of AI adoption on ESG performance since the existing methods of measurements are diverse in different organizations. With the ever-changing nature of digital technologies, the concept of the

combination of AI governance, sustainability analytics, and corporate information governance will become a prominent motif of the further studies in the area of corporate sustainability and responsible innovation.

5. Conclusion

The current literature review, based on PRISMA, summarizes the rapidly growing field of research on Artificial Intelligence in sustainable finance and ESG performance, and proves that the intersection of machine learning, ESG analytics, financial technology (FinTech), and responsible investing is transforming the structure of the modern financial system. Overall, the production of recent research shows that AI has emerged as a prime facilitator of sustainability based on data, enabling financial companies, corporations, and regulators to assess environmental, social, and governance risks at a rate, precision, and volume completely unattainable before. The reviewed literature indicates that AI applications, including predictive analytics, natural language processing, deep learning, and big data modeling have been used to enhance the ESG rating, screening of green investments, climate risk assessment, and sustainability reporting to a significant level, and in this way, have bolstered the connection between financial performance and long-term value of the society.

In the review, AI is also changing the decision-making processes in sustainable finance by allowing the real-time observation of corporate actions, analyzing ESG disclosure reports automatically, and sophisticated portfolio optimization in accordance with the climate finance agenda, green bonds, and impact investments. Such changes suggest that the adoption of AI to ESGs is more than a technical innovation but a paradigm change towards digital sustainability and algorithmic governance when financial markets become highly dependant on intelligent systems in order to achieve transparency, accountability, and regulatory adherence. Meanwhile, the literature continues to stress the significance of explainable AI, ethical AI, and trustworthy AI, because the increased reliance on the automated decision systems is accompanied by the emergence of the new risks in the form of the algorithmic bias, inconsistencies in data, model obscurity, and cybersecurity risks.

The other valuable outcome of this review is that AI-based ESG assessment enhances the environmental performance, social responsibility, and the quality of governance of the company, especially in combination with green innovation, digital transformation, and enhanced analytics capacities. Companies that embrace the use of AI sustainability solutions are more likely to be aligned with the global sustainability models, such as climate transition strategies and responsible investment principles. Nonetheless, AI in sustainable finance is demanding in the availability of ESG data of high quality, standardized reporting procedures, and strong regulatory models, and therefore, the continuous harmonization of ESG data globally, integration of RegTech in finance, and the governance of AI in finance remain necessary. The review also suggests that the further studies must involve development of integrated AI-ESG models, in which sustainability metrics, financial indicators, and socio-environmental impacts are considered at the same time with the help of advanced computational methods. The new directions of sustainable finance research include generative AI in finance, AI-based climate risk models, sustainable digital financial platforms, blockchain-based sustainable ESG reporting, and autonomous investment systems, which could potentially be the future of sustainable finance studies. Also, multidisciplinary solutions with finance, computer science, sustainability science, and public policy are needed to tackle complex problems in responsible AI implementation and long-term environmental regulation.

To summarize, the literature reviewed by the PRISMA 2020 framework proves that Artificial Intelligence is becoming a key technology to support sustainable finance and ESG performance to create more accurate, transparent, and future-oriented financial systems. Although the advantages of AI-based ESG analytics and sustainable investing are enormous, the success of the transformation in the long term will be determined by the development of ethical principles, regulatory frameworks, factoring algorithms, and sustainability metrics used worldwide. Further development of AI-based sustainable finance, ESG analytics, climate finance, and responsible AI governance will thus be critical towards ensuring that technological innovation does not only provide efficiency to the financial economy but

also environmental sustainability, social equity, and robust global economic growth. The rapid evolution of the Artificial Intelligence (AI) has had a drastic impact on the global financial ecosystem, especially in the sphere of sustainable finance and Environmental, Social, and Governance (ESG) performance where information-based decision-making is becoming a core requirement to reach long-term economic, social, and environmental goals. Over the last several years, machine learning, big data analytics, natural language processing, and predictive modeling have become essential tools with financial institutions, regulators, and corporations relying on them to assess risks in terms of sustainability, enhance the quality of disclosure in ESG, and create more responsible investment strategies. The increasing complexity of the sustainability problem, such as climate change, social inequality, and corporate governance failures, has endorsed the implementation of AI-enabled ESG analytics, digital finance, climate risk modeling, and sustainable investing systems, and thus the intersection of AI and sustainable finance is one of the most dynamic and fast-changing research fields in the field of finance, management, and information systems. The recent research proves that artificial intelligence technologies may dramatically improve the accuracy of ESG assessment, automatize sustainability reporting, and assist and support financiers according to environmental and social objectives and, therefore, increase the influence of data-driven sustainability and algorithmic governance in the current financial markets.

Conflict of interest

The authors declare no conflicts of interest.

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