Artificial Intelligence in Sustainable Finance: Mapping ESG Integration and Risk Detection Frameworks

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Abstract

This systematic review explores how Artificial Intelligence (AI) is being incorporated into sustainable investment practices, with a particular focus on its influence on decision-making processes, risk assessment, and the enhancement of environmental, social, and governance (ESG) outcomes. Drawing on 40 peer-reviewed studies published between 2018 and 2025, the review synthesizes the evolution of AI applications in responsible finance and identifies five major research clusters: (1) AI-driven ESG performance and sustainable finance integration, (2) AI, FinTech, and blockchain innovation for green finance, (3) AI-enhanced risk detection and financial resilience, (4) systematic and theoretical foundations of AI in sustainable finance, and (5) ethical, governance, and responsible AI frameworks.

Findings reveal that machine learning, natural language processing, and big data analytics are increasingly used to evaluate ESG indicators, optimize investment strategies, and improve transparency in sustainability reporting. However, several challenges persist, including algorithmic bias, data heterogeneity, limited model interpretability, and the absence of standardized ESG metrics. These limitations highlight the need for greater model transparency, ethical accountability, and interdisciplinary collaboration between data scientists, financial practitioners, and policymakers.

The review is framed by theoretical perspectives, including the Resource-Based View and Responsible AI frameworks, to contextualize AI's role in sustainable investment. Also, this review demonstrates that AI is not merely a technological tool but a transformative driver of sustainable investment practices. By fostering responsible innovation, improving data reliability, and supporting evidence-based decision-making, AI has the potential to build a more transparent, resilient, and inclusive financial ecosystem, accelerating the global transition toward sustainable development.

Keywords: *Artificial Intelligence; Sustainable Investment; Green Finance; ESG; Risk Management.*

1. Introduction

In recent years, the global investment landscape has undergone a notable transition toward more sustainable practices, largely fueled by rising awareness of environmental, social, and governance (ESG) considerations.(Dmuchowski et al., 2023) . As issues related to climate change, social disparities, and corporate governance grow more pressing, investors are increasingly prioritizing financial strategies that reflect responsible practices and support sustainable, long-term objectives.

Sustainable investments, which seek to generate both financial returns and positive societal impact, have gained considerable traction, with an increasing demand for investment strategies that integrate ESG criteria.(Kotsantonis et al., 2016). This movement reflects the broader trend of incorporating sustainability into all sectors of society, with finance being no exception.

However, despite the growing interest in sustainable investing, one of the key challenges lies in optimizing investment decisions within the complex and often opaque landscape of ESG factors. Traditional investment approaches, based on historical data and conventional risk assessments, struggle to fully account for the multifaceted nature of ESG performance.(Gopal & Pitts, 2024). To overcome these limitations, the integration of advanced technologies, particularly Artificial Intelligence (AI), offers a promising solution. AI's capacity to analyze vast amounts of data, recognize patterns, and optimize decision-making processes holds significant potential to transform how sustainable investments are made. From automating portfolio management to evaluating ESG factors with greater precision, AI stands as a key enabler in the evolution of sustainable finance.(Elhady & Shohieb, 2025).

Recent developments in AI, specifically in domains like machine learning (ML), big data analytics, and natural language processing (NLP), have created new opportunities have emerged for enhancing sustainable investing strategies.(Baran et al., 2022) These technologies not only enhance the ability to evaluate ESG metrics but also empower investors to uncover hidden patterns and opportunities that were previously difficult to identify. By leveraging these innovations, AI can support more informed, data-driven decisions that improve both the performance and impact of sustainable portfolios. Moreover, AI tools can aid in optimizing risk management strategies, allowing for the better anticipation of environmental and social risks that could affect the financial health of investments.(Shkalenko & Nazarenko, 2024).

To interpret the heterogeneous findings reported across the literature, this review is framed through a multi-theoretical lens. The Resource-Based View (RBV) conceptualizes AI as a firm-specific capability that can confer competitive advantage by enhancing ESG-related competencies. The Dynamic Capabilities theory explains how firms reconfigure routines and processes to integrate AI-driven innovations for resilience and sustainability. Institutional and Stakeholder theories illuminate the external pressures of regulatory bodies, investors, and social movements that shape firms' ESG disclosure and AI adoption. Finally, socio-technical and Responsible AI frameworks foreground governance, transparency, and fairness, addressing concerns about algorithmic bias and model explainability that mediate AI's real-world impact on sustainable investing. Framing the review in this way enables a more nuanced synthesis of empirical patterns and helps bridge the gap between technological capabilities and organizational, regulatory, and ethical contexts.

Despite the many advantages of AI, its integration into sustainable investing is not without its challenges. Data quality and the inherent biases within AI algorithms remain significant barriers to its effective application in this field. Moreover, the integration of ESG factors into AI models presents a complex task due to the diverse and often subjective nature of ESG data. The ongoing development of AI techniques that can more accurately assess and incorporate ESG criteria is crucial for unlocking the full potential of sustainable investments. Additionally, concerns regarding the transparency of AI models and the ethical considerations surrounding algorithmic decision-making must be addressed to ensure the responsible use of AI in this domain.(Cheong, 2024).

This systematic review seeks to offer a broad and detailed understanding of how Artificial Intelligence (AI) is currently being applied within the field of sustainable investing. By examining existing studies, we will explore the risks and opportunities associated with the use of AI technologies in this field. We will also discuss the challenges that researchers and practitioners face in integrating AI and ESG factors, and suggest future directions for advancing AI applications in sustainable finance. In doing so, this review seeks to offer valuable insights for researchers, investors, and policymakers who are working towards a more sustainable and efficient investment ecosystem

2. Methodology

2.1. Study selection and data extraction

In this study, we conducted a systematic literature review to gather and synthesize evidence on how artificial intelligence contributes to sustainable investment practices. Systematic reviews are understood as a structured scientific approach, guided by clear and strict rules, designed to ensure that the process is thorough, unbiased, transparent, and methodologically sound. The literature review was performed in prominent scientific databases, including Scopus.

The following keywords were used in our search strategy: "Artificial Intelligence", "Sustainable Investment", "ESG", "Machine Learning", "Green Finance", "Risk Assessment", "Investment Decision Making", and "Sustainability". These terms were combined using Boolean operators (AND, OR) to optimize search results.

The final search string we decided on was:

((TITLE-ABS-KEY (Sustainable Investment OR Green Finance OR ESG AND Artificial Intelligence) AND PUBYEAR > 2017 AND PUBYEAR < 2027) AND (review) AND PUBYEAR > 2017 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "COMP")))

A total of 245 potentially pertinent publications published between 2018 and October 2025 were found in the first search across Scopus. These articles underwent a rigorous selection process in several stages: examination of titles and abstracts to assess initial relevance, in-depth reading of pre-selected articles, evaluation of methodological quality, and application of inclusion and exclusion criteria.

Inclusion Criteria:
- Focused on the application or role of artificial intelligence (AI) in the context of sustainable or responsible investments.
- Examined how AI contributes to risk detection, ESG assessment, or decision-making processes in investment strategies.
- Included empirical or theoretical studies that provide evidence or conceptual insight into AI-driven approaches to sustainable finance.
- Released in the English language.
- Articles that are published in journals with peer review.

Exclusion Criteria:
- Non-empirical or Theoretical studies.
- Not published in peer-reviewed journals or not written in English.
- Did not explicitly address the integration of AI within sustainable investments or lacked a clear focus on risk detection, ESG, or responsible investment frameworks.

2.2. Study validation and limitations

Discrepancies that emerged during the selection and classification process were resolved through constructive discussion between the two primary reviewers. In cases where disagreement persisted, a third researcher was consulted to reach a final consensus and ensure the objectivity and consistency of the selection procedure.

Following the application of the established inclusion and exclusion criteria, 102 articles were removed due to duplication, insufficient thematic relevance, publication in languages other than English, or the absence of a recognized indexed impact factor. Consequently, 40 articles met all inclusion requirements and were retained for comprehensive analysis (see Table 1).

The final dataset thus represents the most methodologically robust and thematically aligned contributions within the field of artificial intelligence and sustainable investments.

Despite these efforts to maintain methodological rigor and transparency, several limitations of this review should be acknowledged.

Several limitations of this study need to be recognized.
- First, the review's limitation to English-language publications may have resulted in the exclusion of important studies carried out in other languages, which would have reduced the findings' global representativeness.
- Second, although Scopus was chosen for its extensive coverage and academic reliability, this database may not capture all relevant studies, particularly those published in less-indexed or emerging journals.
- Third, by limiting the review to peer-reviewed journal articles, we intentionally left out practitioner reports, policy papers, and scholarly books that might have contributed additional practical or contextual perspectives.

Consequently, the results of this review should be interpreted as representative of the current academic landscape, yet not exhaustive of all possible viewpoints within the broader field of artificial intelligence and sustainable investment research.

Table 1: Overview of the Reviewed Studies and Their Key Characteristics

Authors	Title	Publisher / Journal / References	Year	Research Purpose(s)	Theoretical Framework	Paper Type / Method
Iyer, R. et al	Integrating AI and ML technologies into indigenous financial systems: Applications of AI and ML in indigenous financial management	Book Chapter (Elsevier) (Iyer & Maralapalle, 2025)	2025	Investigate the use of AI and machine learning in local financial systems to enhance risk management and inclusivity.	-	Qualitative/Exploratory
Saeedi, M.; Ashraf, B.N.	The Role of Technology in Promoting Green Finance: A Systematic Literature Survey and the Development of a Framework	Journal of Risk and Financial Management (Saeedi & Ashraf, 2024)	2024	Review technology's role (AI, ML, blockchain) in green finance	-	Systematic literature review
Aziz, F. et al	Coastal urban flood risk management: Challenges and opportunities − A systematic review	Journal of Hydrology (Aziz et al., 2024)	2024	Evaluate opportunities and difficulties in managing the risk of coastal flooding.	-	Systematic review
Al Halbusi et al	The nexus of managerial and technical AI knowledge, disruptive innovation, and the circular economy: The role of organizational change capability and financial resilience	Technology in Society (Al Halbusi et al., 2025)	2025	Investigate how managerial and technical AI knowledge influences disruptive innovation and circular economy outcomes.	Dynamic Capabilities Theory	Partial Least Squares Structural Equation Modeling (PLS-SEM)
Khan, F. et al	Evaluating the capacity and limitations of generative AI in financial decision-making	Computer Standards and Interfaces (Khan et al., 2025)	2025	Analyze consumer vulnerability in financial decision-making involving generative AI.	Behavioral Finance Theory	Qualitative Interviews (n=50)
Huang, Y. et al	How does the construction of a new generation of national AI innovative development pilot zones drive enterprise ESG development?	Energy Economics (Huang et al., 2024)	2024	Explore the effects of the AI pilot policy on firms' ESG performance	-	Empirical; DID and PSM-DID
Liu, X. et al	How AI powers ESG performance in China's digital frontier?	Finance Research Letters (X. Liu et al., 2024)	2024	Examine AI's effect on ESG through innovation and digitalization	-	Empirical; panel data
Rahman, A.; Amjad, F.	The role of green finance, infrastructure, and technological capabilities in enhancing the competitiveness and resilience of Pakistani manufacturing firms	Clean Technologies and Environmental Policy (Rahman & Amjad, 2024)	2024	Analyze the role of green finance and technology in firm resilience	Resource-based view; integration–responsiveness framework	SEM–ANN (quantitative)
Zhang, D.	The pathway to curb greenwashing in sustainable growth: The role of artificial intelligence	Energy Economics (Zhang, 2024)	2024	To examine how AI mitigates greenwashing behaviors and enhances ESG disclosure quality in Chinese listed firms.	-	Article: Empirical study using panel data (2014–2021).
Lim, T.	Environmental, social, and governance (ESG) and artificial intelligence in finance: State-of-the-art and research takeaways	Artificial Intelligence Review (Lim, 2024a)	2024	To systematically map ESG and AI in finance research, identify knowledge gaps, and explore key research archetypes.	Ontological inquiry	Article: Systematic literature mapping.
Lăzăroiu, G., et al	Artificial intelligence algorithms and cloud computing technologies in blockchain-based fintech management	Oeconomia Copernicana (Lăzăroiu et al., 2023)	2023	To examine how fintech reconfigures financial services using AI, blockchain, and cloud technologies.	-	Review: Systematic review using PRISMA and bibliometric tools (Dimensions, VOSviewer).
Saxena, A. et al	Technologies Empowered Environmental, Social, and Governance (ESG): An Industry 4.0 Landscape	Sustainability (Switzerland) (Saxena et al., 2023)	2023	to examine how ESG reporting and sustainability are supported by Industry 4.0 technologies (AI, IoT, blockchain, big data).	-	Article, Literature review, and analytical study.
Lee, O. et al	Proposing an Integrated Approach to Analyzing ESG Data via Machine Learning and Deep Learning Algorithms	Sustainability (Switzerland) (O. Lee et al., 2022)	2022	To develop and test integrated AI models for ESG data analysis and prediction.	-	Article: Experimental study (five AI-based experiments).
Mhlanga, D.	Human-Centered Artificial Intelligence: The Superlative Approach to Achieve Sustainable Development Goals in the Fourth Industrial Revolution	Sustainability (Switzerland) (Mhlanga, 2022)	2022	To explore how human-centered AI can help achieve SDGs.	Human-in-the-loop; Human-centered AI	Article: Systematic literature review.
Al-Sartawi. Et al	The role of artificial intelligence in sustainable finance	Journal of Sustainable	20	To introduce and discuss AI's role in supporting	-	Editorial.

Authors	Title	Source	Year	Objective		Method
		Finance and Investment (Al-Sartawi et al., 2022)	2 2	sustainable finance and ESG investing.		
Qi, S.; Pang, L.; Li, X.; Huang, L.	The dynamic connectedness in the "carbon-energy-green finance" system: The role of climate policy uncertainty and artificial intelligence	Energy Economics (Su & Qin, 2024)	2025	Examine interactions among carbon, energy, and green finance systems under climate policy uncertainty.	-	Time Frequency Spillover Analysis
Ma, C.-Q.; Liu. Et al	Decoding the nexus: How fintech and AI stocks drive the future of sustainable Finance	International Review of Economics and Finance (Ma et al., 2025)	2025	Analyze linkages between AI, FinTech, and sustainable finance markets.	-	Time-Varying Parameter VAR Model with Stochastic Volatility (TVP-SV-VAR)
Li, T.; Lau, W.T. et al	Blockchain Applications in Green Finance for Transparency and Accountability in Sustainable Investments	Sustainability (Switzerland) (Li et al., 2025)	2025	To increase transparency, look at integrating blockchain and artificial intelligence in green financing.	-	GMM and CNN (Attention-based Neural Networks)
Mahajan, R. et al	The role of business and management in driving the SDGs	Business Strategy and the Environment (Mahajan et al., 2024)	2024	Review the business and management role in SDGs	-	Systematic review
Puschmann, T. et al	Green fintech: Developing a research agenda	Corporate Social Responsibility and Environmental Management (Puschmann & Khmarskyi, 2024)	2024	Build a framework and an agenda for green fintech research	-	Systematic review analysis
Liu, L. et al	Trust in ESG reporting: The intelligent Veri-Green solution for incentivized verification	Blockchain: Research and Applications (L. Liu et al., 2024)	2024	Propose a blockchain–AI model for ESG verification	-	Conceptual/technical
Xu, S.; Zhong, M.; Wang, Y.	Can innovative industrial clusters enhance urban economic resilience?	Energy Economics (Xu et al., 2024)	2024	Study how industrial clusters affect resilience via green finance	-	Quasi-natural experiment; DID
Minkkinen, M.; Niukkanen, A.; Mäntymäki, M.	What about investors? ESG analyses as tools for ethics-based AI auditing	AI and Society (Minkkinen et al., 2024)	2024	Analyze ESG as tools for responsible AI auditing	-	Qualitative; thematic analysis
Katterbauer, K.; Castanho, R.A.; Syed, H.; Meyer, D.; Cleenewerck, L.; Yılmaz Genç, S.	Green Deep Seabed Mining: The Opportunities for Islamic Finance	WSEAS Transactions on Business and Economics (Katterbauer et al., 2024)	2024	Investigate the role of Islamic finance in green seabed mining	-	
Zhou, X.; et al	Integration of digitalization and green finance for sustainable and resilient manufacturing and service operations in China: an empirical analysis	Frontiers in Environmental Science (Zhou et al., 2025)	2025	Assess how digitalization and green finance jointly impact carbon neutrality and resilience.	Environmental Kuznets Curve (EKC)	Simultaneous Equations Model
Yu, J.; Lai, X.; Sun, T.; Lin, C.-T.	Could AI and Sustainable Finance Drive Energy Sustainability? A Wavelet Quantile Correlation Analysis	Emerging Markets Finance and Trade (Yu et al., 2025)	2025	Analyze interconnections between AI, sustainable finance, and energy uncertainty.	-	Wavelet Quantile Correlation
Tian, B. et al	AI-Boosted ESG: transforming enterprise ESG performance through artificial intelligence	Applied Economics (Tian et al., 2025)	2025	Analyze how AI affects business ESG performance and the mechanisms at play.	-	Two-way Fixed Effects Model
Mamun, A.Y.; László, V.	Advancing sustainability through financial inclusion and sustainable finance: a systematic literature review	Digital Finance (Mamun & László, 2025)	2025	Review how financial inclusion and digital innovations like AI contribute to sustainable finance.	-	PRISMA-based Systematic Literature Review
van der Heever, W. et al	Understanding Public Opinion towards ESG and Green Finance with the Use of Explainable Artificial Intelligence	Mathematics (van der Heever et al., 2024)	2024	Analyze ESG sentiment via explainable AI (XAI)	-	Empirical; aspect-based sentiment & XAI

Singhania, M. et al	Sustainable finance research: Review and agenda	International Journal of Finance and Economics (Singhania et al., 2024)	2024	Map sustainable finance research trends and future directions	-	Literature review
Wang, J.; Wen, Y.; Long, H.	Evaluating the mechanism of AI contribution to decarbonization for sustainable manufacturing in China	Journal of Cleaner Production (Wang et al., 2024)	2024	Examine how AI promotes decarbonization	-	Empirical; OLS regression
Xie, H.; Qin, Z.; Li, J.	Entrepreneurship and Corporate ESG Performance—A Case Study of China's A-Share Listed Companies	Sustainability (Switzerland) (Xie et al., 2024)	2024	Study how entrepreneurship influences ESG performance	Institutional economics perspective	Empirical; panel data
Arévalo, P. et al	Smart Microgrid Management and Optimization: A Systematic Review Towards the Proposal of Smart Management Models	Algorithms (Arévalo et al., 2025)	2025	Review literature on AI-based energy management and storage systems in smart microgrids.	-	Systematic review METH (PRISMA 2020)
Manta, O.; Vasile, V.; Rusu, E.	Banking Transformation Through FinTech and the Integration of Artificial Intelligence in Payments	FinTech (Manta et al., 2025)	2025	Examine how FinTech and AI are changing payment and banking systems.	-	Conceptual/Qualitative Review
Georgescu, I. et al	Governing the Green Transition: The Role of Artificial Intelligence, Green Finance, and Institutional Governance in Achieving the SDGs Through Renewable Energy	Sustainability (Switzerland) (Georgescu et al., 2025)	2025	Analyze how renewable energy consumption is impacted by AI, green finance, and governance.	-	CS-ARDL, FMOLS, and DOLS panel models
Jarboui, A. et al	Unveiling the drivers behind carbon emissions disclosure: an ESG perspective	SBR JOURNAL (Jarboui et al., 2025)	2025	Identify determinants of carbon disclosure among French firms using AI techniques.	-	Machine Learning (H2O AutoML)
Iyer, R.; Maralapalle, V.C.	Integrating AI and ML technologies into indigenous financial systems: Applications of AI and ML in indigenous financial management	Book Chapter (Elsevier) (Iyer & Maralapalle, 2025)	2025	Explore AI and ML applications in indigenous financial systems to improve inclusion and risk management.	-	Qualitative/Exploratory
Si Mohammed, K. et al	The role of artificial intelligence and fintech in promoting eco-friendly investments and non-greenwashing practices in the US market	Journal of Environmental Management (Si Mohammed et al., 2024)	2024	Examine AI & fintech for eco-friendly investment	-	Empirical; VAR connectedness
Lim, T.	ESG and artificial intelligence in finance: State-of-the-art and research takeaways	Artificial Intelligence Review (Lim, 2024b)	2024	Map AI–ESG–finance research and gaps	-	Systematic mapping review
Lee, S.U. et al	A survey of energy concerns for software engineering	Journal of Systems and Software (S. U. Lee et al., 2024)	2024	Survey energy efficiency and sustainability in software engineering	-	Literature survey

Table 1 offers an overview of the selected studies, organized according to authors, titles, publishers, publication years, research aims, theoretical foundations, and methodological approaches. Complementing this synthesis, a descriptive statistical analysis was conducted to examine the annual distribution of publications within the Scopus database. As shown in Figure 1, research output on the topic has grown markedly over the past few years.
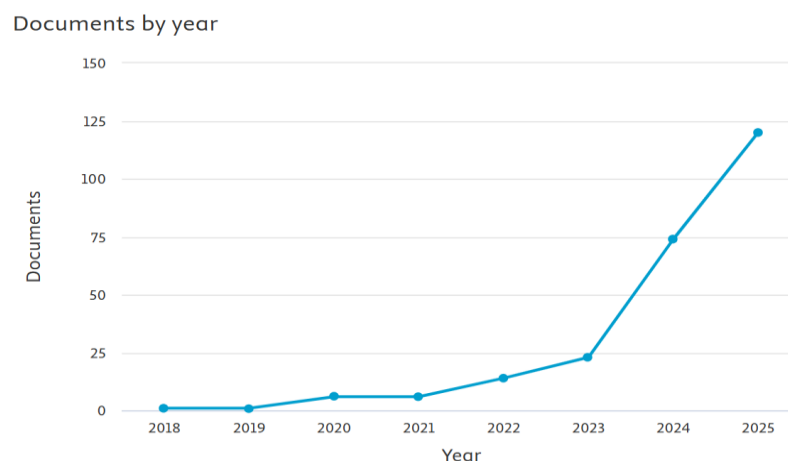

Fig. 1: Number of Publications on Sustainable Investment and Artificial Intelligence SCOPUS (2018–2025).

Between 2018 and 2021, the number of publications remained modest, averaging fewer than five documents per year. A moderate increase appeared in 2022 with 14 publications, followed by a more substantial rise to 23 in 2023. The trend intensified sharply in 2024, when the number of studies reached 74, reflecting an accelerated academic interest in the intersection between artificial intelligence, sustainable finance, and ESG-related research. The upward trajectory culminated in 2025, which recorded 120 publications representing the peak of scholarly output to date.

Overall, these findings highlight a clear temporal concentration of research efforts between 2023 and 2025, confirming the growing strategic relevance of AI-driven sustainability and ESG themes in academic discourse. This surge suggests that scholars increasingly recognize the transformative potential of artificial intelligence in shaping sustainable investment practices and corporate responsibility frameworks

3. Results

Our analysis identified five distinct thematic clusters that structure the existing body of research within the intersection of Artificial Intelligence (AI), sustainability, and finance.

These clusters were derived through a systematic examination of each article's research objective, keywords, and conceptual orientation, allowing for the grouping of studies with shared methodological and thematic patterns.

1) AI and ESG Performance encompasses studies investigating how AI technologies influence corporate environmental, social, and governance (ESG) outcomes, including efficiency gains, innovation, and sustainability-driven competitiveness.
2) AI, FinTech, and Green Finance brings together research exploring the convergence between financial technologies, green financing mechanisms, and artificial intelligence applications that promote sustainable investments and environmental responsibility.
3) AI and Risk Management includes works focusing on the role of AI-based tools in identifying, predicting, and mitigating financial, environmental, and operational risks associated with sustainability transitions.
4) Theoretical and Systematic Reviews, consists of conceptual and review papers that synthesize existing evidence, propose new frameworks, and highlight emerging research directions across the AI–ESG–finance nexus.
5) Ethics, Governance, and Responsible AI covers studies addressing the ethical implications, transparency challenges, and governance structures necessary for ensuring the responsible adoption of AI in sustainable finance and corporate ESG practices.

Together, these clusters provide a coherent mapping of the research landscape, illustrating the diversity of approaches and thematic depth within the growing literature on artificial intelligence and sustainable investment.

Table 2: Descriptive Mapping of the Reviewed Literature Across the Five Thematic Clusters

Cluster	Topic	Authors
1 — AI & ESG Performance	AI-Driven ESG Performance and Sustainable Finance Integration	Zhang, D. Liu, X et al Tian, B. et al Huang, Y et al Xie, H et al Lim, T. Si Mohammed, and al van der Heever, W et al Mhlanga, D.
2 — AI, FinTech & Green Finance	AI, FinTech, and Blockchain Innovation for Green Finance Transformation	Li, T Puschmann et al Lăzăroiu, G et al. Manta, Liu, L. et al Iyer, R. et al Khan, F. et al Rahman, A et al
3 — AI & Risk Management	AI-Enhanced Risk Detection and Resilience in Sustainable Financial Systems	Qi, S. et al Yu, J.; Lai, X. et al Zhou, X.; Gao, Z. et al Georgescu, I. et al. Arévalo, P.et al. Saeedi, M.; Ashraf, B.N. Mahajan, R. et al
4 — Theoretical & Systematic Reviews	Systematic and Theoretical Foundations of AI in Sustainable Finance Research	Mamun, A.Y.; László, V. Singhania, M.; Chadha, G. et al Al-Sartawi, A.M.A. et al Saxena, A. et al. Aziz, F. et al. Lee, S.U.; Fernando, N. et al Minkkinen, M. et al
5 — Ethics, Governance & Responsible AI	Ethical, Governance, and Responsible AI Frameworks in Sustainable Investment	Jarboui, A. et al Al Halbusi, H. et al Katterbauer, K. et al.

4. Discussion

4.1. AI-driven ESG performance and sustainable finance integration

This cluster encompasses research examining how Artificial Intelligence (AI) improves the assessment, tracking, and optimization of Environmental, Social, and Governance (ESG) performance within sustainable finance contexts. Authors such as (Zhang, 2024) (X. Liu et al., 2024) , (X. Liu et al., 2024) , and (Huang et al., 2024) Demonstrate that AI-driven models can significantly improve ESG disclosure accuracy and reduce greenwashing behaviors. (Lim, 2024b) and (Mhlanga, 2022) They further highlight the critical role of explainable, human-centered AI systems in enhancing investor trust and ensuring accountability within sustainable investment practices. Similarly, (Si

Mohammed et al., 2024) and (van der Heever et al., 2024) They underscore the application of AI and interpretable machine learning models to assess public sentiment regarding ESG practices, enabling more ethical and transparent financial decisions. Collectively, these works reveal that AI plays a transformative role in integrating ESG analytics into sustainable investment strategies. By combining big data, automation, and explainability, AI enables investors to achieve higher efficiency, predictive accuracy, and alignment with long-term sustainability objectives.

- Analytical clarification and justification:

This cluster brings together studies that employ AI primarily as a tool for measuring, predicting, or interpreting ESG performance. The grouping is justified by a shared analytical objective rather than by a single methodological approach. While the reviewed studies rely on different AI techniques and data types, they converge in their attempt to reduce subjectivity and improve the reliability of ESG assessment processes.

- Comparative insight:

Although the studies included in this cluster differ in their data inputs and modeling strategies, they collectively demonstrate that AI enhances ESG evaluation through complementary mechanisms. This diversity strengthens the cluster's conceptual coherence while simultaneously revealing persistent challenges related to data consistency and standardization.

4.2. AI, fintech, and blockchain innovation for green finance transformation

This cluster includes research examining the intersection of Artificial Intelligence (AI), financial technology (FinTech), and blockchain as facilitators of sustainable and transparent finance. Research by Yahya and (L. Liu et al., 2024)Demonstrates that integrating AI and blockchain technologies enhances transparency, trust, and traceability in sustainable investment processes. (Puschmann & Khmarskyi, 2024) and (Lăzăroiu et al., 2023)Highlight the rise of Green FinTech, linking digital financial innovation to environmental responsibility and accountability. Likewise, (Manta et al., 2025)Explore how AI-integrated payment and banking systems improve operational efficiency and customer confidence, while (Iyer & Maralapalle, 2025)Examine AI and machine learning's contribution to inclusive and indigenous financial systems. Together, these studies underscore how the fusion of AI, blockchain, and FinTech fosters digital transformation in sustainable finance. This convergence promotes equitable access, regulatory transparency, and ethical governance, positioning technological innovation as a core driver of the global green financial ecosystem

- Analytical clarification and justification:

Studies in this cluster are grouped based on their common focus on improving transparency and trust in ESG information through technological integration. The defining characteristic of this cluster is the use of AI in combination with digital financial infrastructures to address information asymmetry in sustainable finance.

- Comparative insight:

While all studies emphasize transparency enhancement, they differ in the technological role assigned to digital infrastructures. This variation highlights an ongoing debate between technologically driven verification mechanisms and practical implementation constraints.

4.3. AI-enhanced risk detection and resilience in sustainable financial systems

Cluster 3 unites research focused on AI's contribution to risk detection, financial resilience, and uncertainty management within sustainable finance. (Maghsoudi et al., 2025)Analyze how generative AI influences consumer vulnerability in financial decision-making, whereas (Rahman & Amjad, 2024) Examine how green finance and technology jointly enhance manufacturing firms' resilience. Studies such as (Al Halbusi et al., 2025) and (Yu et al., 2025) Apply time-frequency and wavelet quantile methods to model interactions between AI, energy systems, and climate policy uncertainty. Similarly, (Zhou et al., 2025) and (Georgescu et al., 2025) Investigate how digitalization and AI-based governance mechanisms strengthen economic adaptability and energy sustainability. (Arévalo et al., 2025) Further extend this work by applying AI in smart microgrid management to optimize energy efficiency and reduce environmental risks. Collectively, this body of literature confirms that AI-driven analytical tools can substantially improve the capacity to anticipate, quantify, and mitigate sustainability-related risks, thereby enhancing long-term financial stability and resilience in global investment systems.

- Analytical clarification and justification:

This cluster encompasses studies that apply AI to the anticipation and management of sustainability-related risks. Articles are grouped due to their forward-looking orientation and shared emphasis on predictive risk intelligence.

- Comparative insight:

Despite a common focus on risk detection, the studies differ in their conceptualization of sustainability risks. This heterogeneity enriches the analysis but also underscores the absence of standardized AI-based risk assessment frameworks.

4.4. Systematic and theoretical foundations of AI in sustainable finance research

Cluster 4 brings together conceptual and systematic review studies that establish the theoretical and methodological basis for understanding AI's integration into sustainable finance. (Saeedi & Ashraf, 2024) and (Singhania et al., 2024) Conduct comprehensive literature surveys that map the evolution of research in AI-driven green finance, identifying critical knowledge gaps and future research agendas. (Mamun & László, 2025) and (Mahajan et al., 2024) Highlight the growing intersection between digital financial inclusion, sustainability, and artificial intelligence, while (Saxena et al., 2023) and (Al-Sartawi et al., 2022) Conceptualize the broader implications of Industry 4.0 technologies in ESG and sustainable finance. Moreover, (Aziz et al., 2024) and (S. U. Lee et al., 2024) Address how AI applications support environmental risk assessment and energy efficiency. Collectively, these systematic and theoretical works construct a holistic understanding of how AI reshapes sustainable finance, laying a strong groundwork for interdisciplinary research that combines technological innovation with sustainable development concepts.

- Analytical clarification and justification:

The studies in this cluster are united by their normative perspective on AI deployment in sustainable finance. They emphasize the importance of transparency, accountability, and ethical safeguards as foundational requirements for responsible AI adoption.

- Comparative insight:

While there is broad agreement on ethical principles, the reviewed studies propose different governance mechanisms. This divergence reflects the evolving and fragmented nature of AI governance in sustainable finance.

4.5. Ethical, governance, and responsible AI frameworks in sustainable investment

This final cluster focuses on the ethical and governance dimensions of Artificial Intelligence (AI) within sustainable finance. (Minkkinen et al., 2024) Examine how ESG-based auditing tools can ensure responsible and transparent AI deployment in investment decision-making. Similarly, (Jarboui et al., 2025) Apply machine learning to identify the determinants of carbon disclosure, demonstrating how AI enhances environmental accountability. (Al Halbusi et al., 2025) Investigate the nexus between managerial AI knowledge, organizational transformation, and the circular economy, highlighting the role of leadership in ethical AI adoption. Furthermore, (Katterbauer et al., 2024) Explore Islamic finance as an ethical alternative for sustainable resource management, expanding the cultural perspective of responsible investment. Together, these studies underscore the growing importance of human-centered and ethically governed AI in sustainable finance. They call for transparent, explainable, and socially aligned AI systems capable of reconciling technological efficiency with moral and environmental responsibility.

- Analytical clarification and justification:

This cluster groups studies that examine AI applications within specific economic sectors. The classification reflects the recognition that sustainability challenges and ESG priorities vary significantly across industries.

- Comparative insight:

Sectoral diversity enhances the explanatory power of this cluster but also reveals disparities in data availability and ESG maturity. These differences limit cross-sector comparability and highlight the need for harmonized sustainability reporting practices.

5. Conclusion

Through this systematic literature review on Artificial Intelligence (AI) in sustainable investing, we examined how advanced technologies are transforming the way investors assess, manage, and respond to environmental, social, and governance (ESG) challenges. The analysis of the selected studies revealed a rapidly evolving research landscape where AI is no longer a peripheral tool but a central driver of innovation in responsible finance. From enhancing ESG performance prediction to detecting greenwashing and strengthening transparency, AI applications are reshaping both the theoretical and practical dimensions of sustainable investment.

Findings across the clusters demonstrate that AI's impact extends beyond efficiency; it enables deeper ethical accountability, data-driven decision-making, and resilience against sustainability risks. Yet, persistent challenges remain. Issues of algorithmic bias, data heterogeneity, and limited model transparency continue to constrain the full potential of AI in this domain. Bridging these gaps requires not only technical refinement but also stronger governance frameworks and interdisciplinary collaboration among data scientists, financial analysts, and policymakers.

Ultimately, this review highlights that AI-driven sustainable investing is more than a technological evolution; it represents a paradigm shift toward a more transparent, ethical, and resilient financial system. By fostering responsible innovation and aligning digital intelligence with sustainability goals, AI can become a catalyst for a greener, fairer, and more inclusive global economy.

- Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the development of this manuscript, the author or authors of this manuscript used [ChatGPT model 5] to improve the text's flow and clarity. After using this tool, the author or authors thoroughly examined the text, made any required revisions, and took full responsibility for the release.

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