AI-Powered Fraud Detection in Green Finance: A Case-Based Academic Study

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Abstract

As green finance becomes more popular around the world, concerns are growing about companies making false claims about their environmental practices—commonly known as greenwashing. This study explores how

"Artificial Intelligence" (AI) can help detect and prevent such dishonest behavior in green banking and finance. As sustainable finance gains momentum globally, concerns over greenwashing and fraudulent "Environmental, Social, and Governance" (ESG) practices have intensified, posing significant risks to the credibility and transparency of green banking. This study investigates the pivotal role of "Artificial Intelligence" (AI) in detecting such fraudulent activities in the context of green finance. By employing a qualitative, case-based research methodology, the paper examines how AI technologies are being leveraged to scrutinize ESG claims, analyze sustainability reports, and identify inconsistencies indicative of greenwashing. The study also explores the synergistic integration of AI with blockchain and predictive analytics to create robust, tamper-resistant systems that ensure the authenticity of green financial transactions. Moreover, it emphasizes the growing relevance of "Explainable AI" (XAI) in fostering stakeholder trust and regulatory compliance. Findings reveal that AI not only enhances fraud detection capabilities in green finance but also promotes accountability, reduces reputational risk, and supports long-term sustainable development goals. The research concludes that AI is a transformative enabler of integrity in sustainable finance, essential for navigating the complexities of ESG verification in an era of heightened environmental scrutiny.

Keywords: Green Finance, Artificial Intelligence, ESG, Financial Frauds

Introduction

Every aspect of life is affected by fraud, and identifying and stopping it is a crucial study topic that affects many societal stakeholders (Bao, Y et al., 2022). The financial sector is one such industry that has seen notable influence. Financial fraud is becoming more obvious, and hackers are using new methods and resources to breach networks. Crimes such as identity theft, credit card fraud, money laundering, and insider trading have become more advanced and prevalent, threatening the security of global financial systems. In recent decades, financial fraud has disrupted capital market operations and contributed to major economic losses across the globe (Amiram et al., 2018; Li et al., 2021).
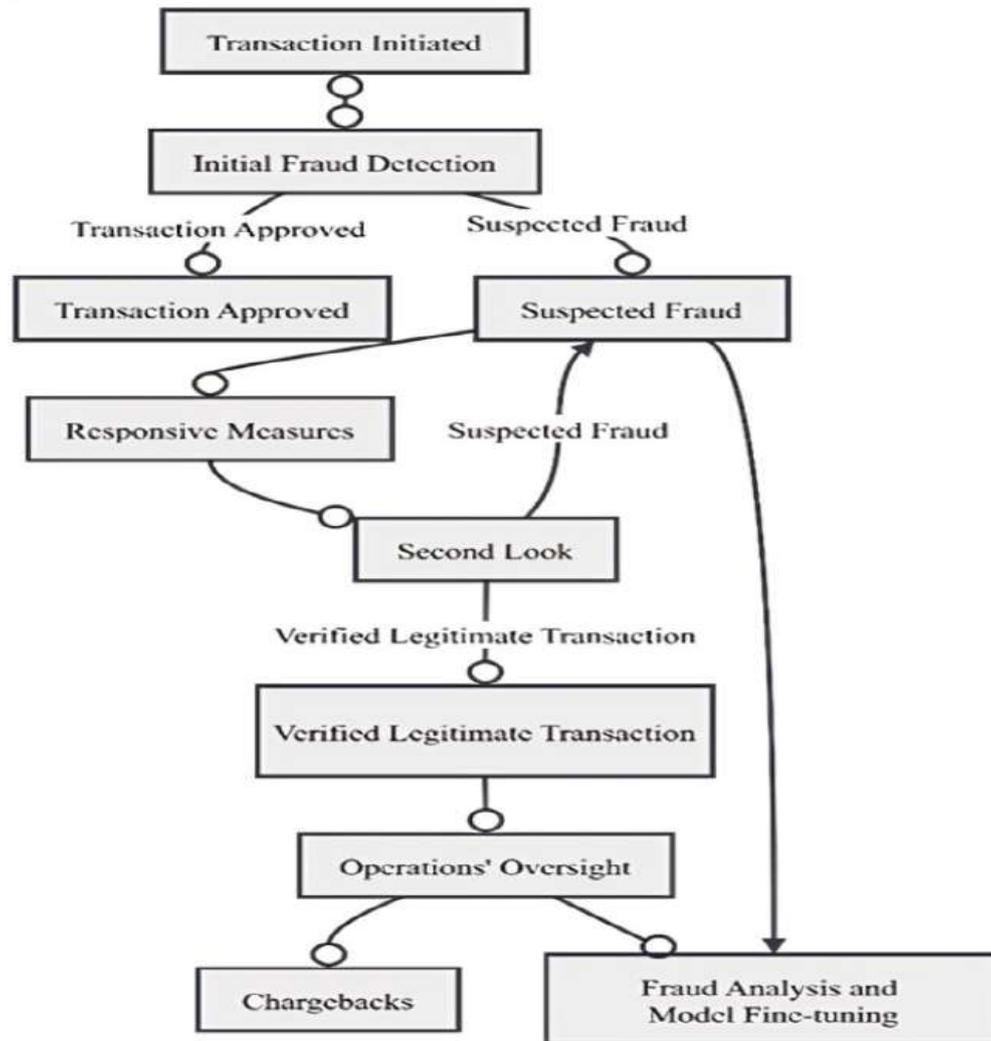
Figure 1: Fraud Detection Workflow Source: Emran, et. al. (2024).

To make matters worse, the early 2020 coronavirus pandemic (COVID-19) epidemic caused unprecedented disruptions to the global financial markets, increasing the likelihood of falling victim to financial fraud (Karpoff, J.M., 2020). For example, in the UK, fraud incidents involving financial products were increased by 33% in April 2020 comparing with April 2019 (Experian; National Hunter Fraud Prevention Service, 2020). Meanwhile, the United States experienced a 35% surge in fraudulent transaction losses in 2019 compared to the previous period, as reported by Fidelity National Information Services, which is a payment services provider supporting fraud monitoring for around 3,200 U.S. banks (Andriotis & McCaffrey, 2020).

The Reserve Bank of India recorded bank frauds a total of ₹30,000 crores in the fiscal year 2023, which is a substantial drop from the ₹1.3 trillion recorded in 2021. Even though the number has dropped by 77%, it is still significant. As a result, it is imperative that our citizens use caution while making financial transactions, particularly those who are not financially literate (Board of Governors of the Federal Reserve System, 2020). In the aftermath of the pandemic, financial fraud has emerged as a growing and increasingly critical concern (Zhu et al., 2021). Global institutions, customers, and economies are under strain due to the massive losses caused by financial fraud (Islam, M. S., & Rahman, N., 2025). Any deliberate attempt to purposefully exploit financial transactions (Rashid et al., 2018) or achieve illicit benefits (Krambia-Kapardis, 2002) is referred to as financial fraud, and it typically begins at the level of financial statements.

2.Review of Literature

"Green financing refers to financial instruments and investments that support sustainable development projects, particularly those aimed at environmental conservation and carbon reduction" (Qing, et al., 2024). Green finance has a crucial role in aligning economic growth with environmental stewardship. By integrating "Environmental, Social, and Governance" (ESG) factors into financial decision-making, green finance promotes investments in sustainability-focused initiatives like renewable energy, carbon neutrality, and environment-friendly development (Chenguel & Mansour, 2024). Green finance provides substantial financial support for preserving the environment and reducing carbon emissions. However, ESG frameworks, which are meant to ensure accountability and transparency in environmental and social governance, can sometimes be manipulated. Companies may engage in 'Greenwashing behaviors"(GWBs)—such as raising capital through "Green Finance Products" (GFPs) while not genuinely investing in sustainable projects or by making misleading environmental disclosures—thus undermining the goals of ESG and green finance (Delmas & Burbano, 2011).

2.1 The Rise of greenwashing in Finance

The concept of "greenwashing" was first introduced in the 1980s and refers to the deceptive strategy companies use to look more eco-friendly than they actually are (Delmas & Burbano, 2011). This often involves promoting misleading claims or selectively highlighting eco-friendly initiatives to distract from the company's real environmental footprint. In the sphere of sustainable finance, greenwashing specifically relates to the false portrayal of financial products as environmentally sustainable, misleading stakeholders about a firm's true environmental commitment (Schneider-Maunoury, 2023). As sustainability becomes a market expectation, an increasing number of organizations are falsely presenting themselves as environmentally or socially responsible, without making meaningful changes to their practices (Andreoli et al., 2022). While such misrepresentation may offer temporary brand enhancement, the long-term consequences are often damaging. Once exposed, these practices can lead to reputational harm, loss of consumer trust, investor withdrawal, financial losses, and legal consequences. Notable examples include Volkswagen and BP, both of which faced penalties and litigation due to greenwashing claims. Greenwashing also significantly influences stakeholder perceptions. Consumers and investors with strong environmental values may feel deceived by companies that overstate their sustainability credentials. This loss of trust can deter them from engaging with or supporting such firms, as seen in the controversies surrounding H&M and Deutsche Bank's asset management division, DWS, both of which were accused of misrepresenting their environmental practices (Reuters, 2022). Beyond individual companies, greenwashing threatens the overall credibility of ESG ("Environmental, Social, and Governance") disclosures. As Poiriazi et al. (2025) note, the integrity of ESG reporting is compromised when false claims go unchecked. Analysts and regulatory bodies have observed a sharp rise in greenwashing incidents in recent years. For instance, a PwC report revealed that cases of greenwashing in the banking sector have tripled over the past five years, signaling a widespread problem in financial services. Likewise, data from Sustainalytics shows a significant global increase in legal actions and investigations involving banks for alleged greenwashing and climate-related misrepresentation.

Events involving environmental products increased by approximately twelve times between 2020 and 2023. The increased scrutiny of sustainability claims by the public and regulators is reflected in this pattern. One notable example is the 2021 lawsuit filed by a group of investors against several foreign banks for allegedly greenwashing sustainability-related bonds. A study by an ESG analytics firm claims that there has been a sharp rise in "greenwashing" in the media and online in recent years. By the end of 2023, it had increased from less than 200 in early 2020 to over 23,000.

This data demonstrates the severe worldwide problem of ESG misrepresentation and the serious financial and reputational risks it poses to banks, asset managers, and other organizations, from developed markets in Europe and North America to developing nations in Asia and beyond. Corporate greenwashing immediately affects four key stakeholders: consumers, investors, business management, and the government.

Third-party certifications, non-governmental organizations, and regulatory bodies are crucial in preventing greenwashing. However, greenwashing is still a common problem, and their effectiveness varies, suggesting that more may be required than what is currently being done (Dempere et al., 2024).

2.2 AI's role in Ensuring Transparency in Green Banking

Artificial Intelligence (AI) plays a significant role in enhancing transparency within green banking by addressing inefficiencies in risk evaluation, capital distribution, and the validation of environmental impact claims (Joseph, Joseph et al., 2025). As the sector moves towards more data-centric operations, AI technologies are being actively utilized to verify the accuracy of Environmental, Social, and Governance (ESG) disclosures and financial records. These advanced tools empower organizations to identify inconsistencies in real time by leveraging data analytics at a scale and complexity beyond human capability (Nassar & Kamal, 2021). For instance, deep learning algorithms can uncover intricate patterns in transactional data that may indicate instances of greenwashing or manipulated sustainability reporting (Nassif et al., 2021). Moreover, natural language processing algorithms enable banks to analyze unstructured data such as sustainability reports, news articles, and corporate communications to verify the consistency of environmental claims (Chatterjee et al., 2024). This is crucial in promoting accountability and reducing reputational risk associated with false sustainability practices. The integration of AI enhances the transparency of green bonds and climate finance instruments by automating the auditing process and ensuring that green funds are directed toward genuinely sustainable projects (Zhou et al., 2021). According to Parimalarani and Meena (2024), AI's analytical capabilities—particularly in identifying environmental patterns and optimizing green investment portfolios—are essential for aligning banking operations with climate goals and ethical standards.

AI's ability to learn from historical data and adjust to emerging threats further reinforces its importance in fraud detection and compliance monitoring. As Nyre-Yu et al. (2022) argue, AI-driven systems not only reduce false positives but also adapt to new fraud typologies, thereby improving the reliability of sustainability assessments over time. Radanliev and Santos (2023) emphasize that AI's role in financial transparency is particularly crucial in a rapidly evolving regulatory landscape, where continuous monitoring and real-time reporting are required to meet ESG standards. Overall, the deployment of AI in green banking creates a robust framework for transparency, accountability, and trust in sustainable financial practices.

3. Objectives of the Study

Although Artificial Intelligence (AI) has shown great promise in financial fraud detection, much of the current research has focused on areas such as credit card fraud, anti-money laundering, and insider trading. There remains a significant gap in understanding how AI can specifically address fraud in the context of green finance and ESG disclosures. In particular, the application of advanced AI tools—such as natural language processing, machine learning, and sentiment analysis—in detecting greenwashing and enhancing transparency in green banking is still underexplored. Moreover, very few studies provide a detailed examination of real-world case applications or discuss future innovations that could shape AI-based fraud prevention in sustainable finance. This research aims to fill these gaps by

(i)   exploring how AI can detect greenwashing and false ESG claims,
(ii) analyzing AI-driven fraud prevention systems in green banking,
(iii) examining practical case studies, and

(iv) identifying emerging AI trends that could strengthen sustainable finance frameworks.

4. Research Methodology

This study is based on case study method to examine how AI has been utilized to detect greenwashing and ESG fraud. Case studies were selected from recent initiatives involving AI tools in sustainability reporting, banking, and fintech sectors. Secondary data were collected from corporate disclosures, AI project reports, and scholarly publications. The research uses a comparative case analysis to extract common AI strategies and evaluate their effectiveness in fraud detection. The study adopts a qualitative case study methodology to learn the application of artificial intelligence (AI) in detecting greenwashing and ESG-related fraud. The approach is particularly suited for examining complex, real-world issues where experimental or large-scale quantitative data is limited. We selected illustrative case studies from high-profile incidents—such as the Volkswagen Dieselgate scandal, Deutsche Bank's DWS greenwashing case (2023–2025), and emerging AI-driven environmental monitoring projects like Methane SAT/WWF—to understand how AI tools could function in practical fraud detection scenarios. Secondary data were collected through a systematic review of academic literature, industry reports, regulatory filings, company disclosures, news articles, and technology vendors' white papers. For each case, we documented the contextual background, the nature of the ESG allegation, and the actual or potential AI applications. We also examined reported outcomes and lessons learned.

5. Result and discussion

5.1 AI in Financial Fraud Detections

The rapid digitalization of financial services has led to a significant rise in fraudulent activities, posing critical threats to individuals, organizations, and the broader economy (Danielsson et al., 2022). In response, artificial intelligence (AI) has emerged as a powerful tool in combating financial fraud, particularly in identifying deceptive practices like greenwashing. For example, Vinella et al. (2023) developed a method that leverages a language model trained on synthetic labels for detecting greenwashing risk, achieving a notable accuracy rate of 86.34% when analyzing sustainability reports. Similarly, Xu et al. (2025) introduced Deep Green, a large language model (LLM)-based framework that evaluates financial statements and constructs a "Green Implement" metric to detect greenwashing behaviors.

Chen (2024) advanced the field by proposing a dual-layered architecture that integrates financial data analysis with sentiment analysis, employing BiLSTM and CNN models. This system reached a fraud detection accuracy of 91.35%, underlining the effectiveness of deep learning in uncovering complex fraudulent patterns. These AI-driven approaches underscore the high potential of machine learning in reliably identifying financial misconduct.

The integration of AI with big data analytics further enhances fraud detection capabilities. Big data technologies enable the analysis of massive volumes of both structured and unstructured data, facilitating the discovery of hidden irregularities and offering real-time detection capabilities (Dosilovic et al., 2018). Such anomalies are often embedded deep within large-scale transactional datasets, making them nearly impossible to detect manually (Bhattacherjee & Badhan, 2024; Neebe, 2020; Deshmukh & Talluru, 1998; Qin et al., 2024).

5.1.1 Key Challenges in Detecting Green Finance Fraud

Green finance fraud, particularly in the form of greenwashing, presents multifaceted challenges that hinder effective detection and prevention. These challenges span regulatory inconsistencies, data limitations, technological complexities, and ethical considerations.
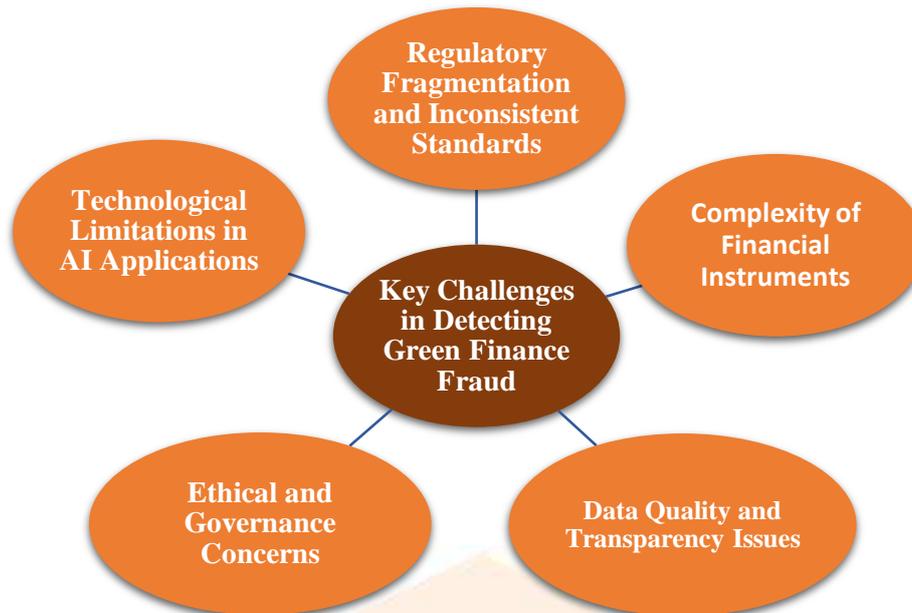
Figure 2 : Key Challenges in Detecting Green Finance Fraud

i. Regulatory Fragmentation and Inconsistent Standards

It is challenging to evaluate the veracity of green claims since there are inconsistent disclosures resulting from the lack of unified international standards for Environmental, Social, and Governance (ESG) reporting. Because of this legislative fragmentation, organizations might take advantage of gaps and pass themselves off as environmentally conscious without taking meaningful effort (Chan et al., 2023).

ii. Data Quality and Transparency Issues

Verifying ESG claims requires accurate and transparent data. Nevertheless, a lack of thorough data collecting and reporting procedures in many businesses results in disclosures that are unclear. The ability of stakeholders to verify the environmental impact of financial activities is hampered by this opacity (Delmas & Burbano, 2011).

iii. Complexity of Financial Instruments

Tracking money to their final destination is made more difficult by the complex nature of financial products like green bonds and ESG-linked derivatives. This intricacy can make it difficult to identify false statements and obfuscate the true environmental benefits—if any—of such devices (Schneider-Maunoury, 2023).

iv. Technological Limitations in AI Applications

Among the difficulties that can erode confidence in AI include the requirement for sizable, high-quality datasets for model training, the possibility of algorithmic bias, and the challenge of deciphering intricate AI judgments (Pavlidis, 2025).

v. Ethical and Governance Concerns

There are many ethical concerns while using AI to identify green finance fraud, especially with relation to openness and accountability. AI systems have the potential of reinforcing preexisting biases or making difficult-to-audit decisions in the absence of explicit governance frameworks (Gudimetla, 2025).

5.1.2 Natural Language Processing (NLP) for analyzing ESG claims

NLP has emerged as a powerful tool for scrutinizing "Environmental, Social, and Governance" (ESG) claims, especially given the increasing volume of unstructured data produced by organizations (Bhattacherjee & Badhan, 2024). NLP algorithms are employed to identify inconsistencies and potential greenwashing in ESG narratives by parsing financial disclosures, regulatory filings, corporate sustainability reports, media stories, and social media content (Calamai et al., 2025; Bhattacherjee & Badhan, 2024). Tools like Climate BERT exemplify

how artificial intelligence can be trained on domain-specific corpora to analyze climate-related disclosures across various industries. Climate BERT uses transformer-based architectures to evaluate millions of textual data points, identifying discrepancies, vague language, or overstatements in corporate climate claims (Calamai et al., 2025).

The combination of NLP and financial fraud detection is a noteworthy development in this field (Bhattacherjee & Badhan, 2024). Large amounts of unstructured textual data, which frequently contain implicit signs of fraud, can be examined more easily thanks to natural language processing (NLP). This include information from legal contracts, audit reports, social media criticism, and internal communications (such emails) (Bhattacherjee & Badhan, 2024; Mwangi & Ndegwa, 2020). To find recurrent themes, emotive tones, and dubious terminology suggestive of fraudulent intent or ESG falsification, techniques like topic modeling, sentiment analysis, and keyword extraction are applied to various data sources (Amarasinghe et al., 2018).
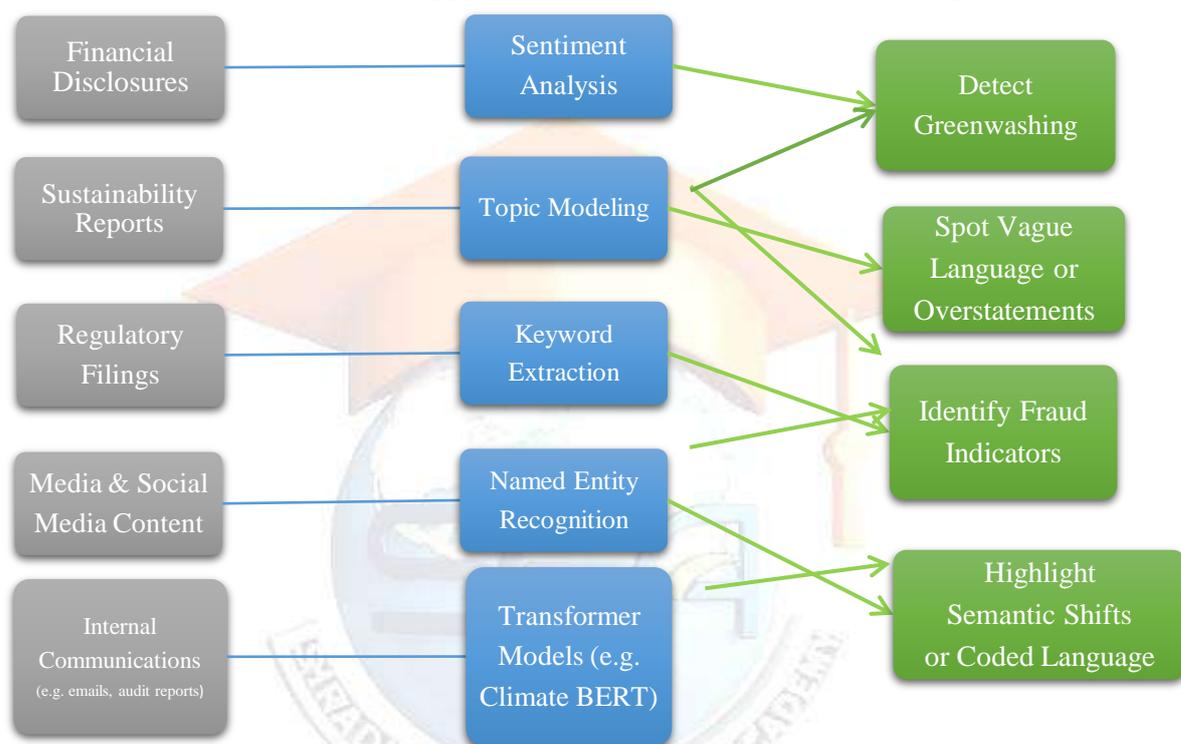

Figure 3 : NLP Applications in ESG Fraud Detection

Furthermore, the combination of NLP and machine learning improves fraud detection systems' ability to decipher coded language, sarcasm, and linguistic subtleties that conventional rule-based systems frequently overlook (Mwangi & Ndegwa, 2020). For example, euphemistic language patterns or semantic shifts that can indicate attempts to hide the truth can be detected by deep learning models trained on financial and ESG-specific datasets (Mwangi & Ndegwa, 2020). By enabling a more detailed comprehension of textual data, these hybrid techniques enhance the identification of intricate and dynamic fraud schemes (Amarasinghe et al., 2018; Mwangi & Ndegwa, 2020).

Even with these technological advancements, a number of problems still exist. According to Bhattacherjee and Badhan (2024), these include the requirement for high-quality labeled datasets, the possibility of algorithmic bias, the interpretability of black-box models, and the fluidity of fraud strategies. Moreover, developing generally applicable NLP models is made more difficult by linguistic diversity, domain-specific jargon, and changing ESG reporting standards (Calamai et al., 2025; Mwangi & Ndegwa, 2020). To improve these techniques and guarantee their ethical and successful application in ESG fraud detection, more research and interdisciplinary cooperation are necessary (Bhattacherjee & Badhan, 2024).

5.1.3 AI-driven sentiment analysis for fraud detection

Sentiment Analysis (SA) involves identifying and interpreting the emotional tone expressed within a particular context. It serves as a valuable tool for understanding an individual's emotions, opinions, or even personality traits, which are often conveyed through verbal or written communication. Traditionally, people shared their thoughts and feelings through direct interactions with family, friends, and neighbors. However, with technological advancements, these exchanges have largely moved to digital platforms, making SA increasingly relevant. Modern technology now allows users to evaluate and interpret vast amounts of sentiment-based information in a matter of minutes (Khan et al., 2010).
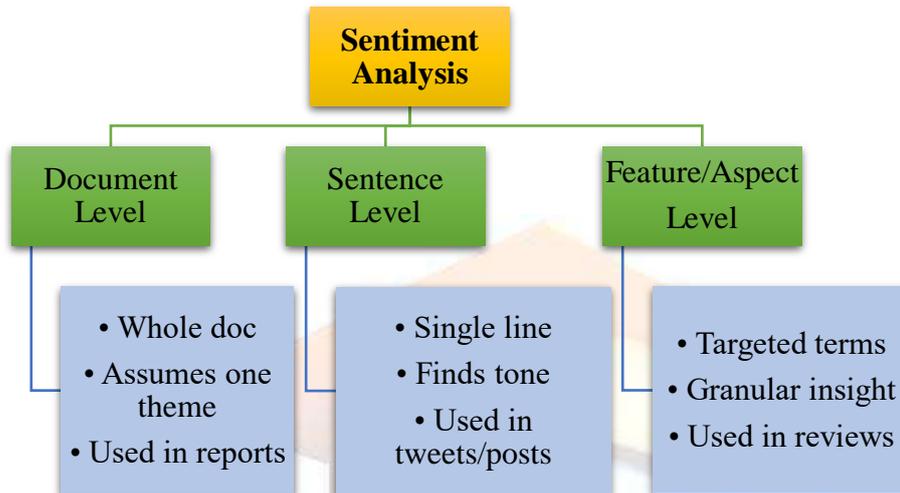
The three levels of sentiment analysis are feature level (also known as angle level), document level (DL), and sentence level (SL). Every emotion-related term in the entire document is examined at the DL (Liu, 2012).

The analysis of the sentences' good or bad effects does not focus on all points of view. This analysis offers a broad evaluation of the report. The analysis at the DL assumes that the entire manuscript has a single theme (Li et al., 2017).

The overall tone of the report is then evaluated to be either favorable or negative. Applications for this type of SA include client satisfaction surveys, patient assessments in therapeutic contexts, and social and mental assessments conducted via casual associations (Liu et al., 2005).

Similar to this, the goal at the SL is to determine the sentence's limit, and the outcome is displayed at the general sentence level. It establishes if the actual sentence is objective or exceptional. Additionally, in energetic sentences that are considered to be brief records, it analyzes whether the sentence's overall inclination is positive or negative. Short messages, Facebook postings, and tweets all make extensive use of it (Li et al., 2015).

By evaluating the sentiment of ESG communications, AI detects exaggerated positive tone or downplaying of risks, signaling potential greenwashing (Moodaley & Telukdarie, 2023).

5.1.4 Case studies: AI exposing greenwashing in corporate sustainability reports

Case Study 1 – GaiaLens: AI for ESG Data Validation

GaiaLens is a London-based ESG analytics firm that employs artificial intelligence and natural language processing (NLP) to scrutinize publicly available news sources, corporate disclosures, and regulatory filings. Its platform cross-verifies ESG scores by comparing reported data with media sentiment and third-party datasets. In 2024, GaiaLens flagged several large-cap firms for discrepancies between self-reported ESG metrics and media coverage, leading institutional investors to reassess portfolio weightings based on these findings. This highlighted how AI can provide real-time alerts about potential greenwashing or inconsistent ESG disclosures (McGrath, 2024).

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Case Study 2 – Omdena & VOY Finance: Collaborative Greenwashing Detection

In 2024, Omdena partnered with VOY Finance to train an AI model that identifies greenwashing in ESG disclosures. The project involved over 50 AI engineers and ESG analysts across the globe. Their model leveraged supervised machine learning to detect inconsistencies between emissions data and sustainability claims. It achieved an **85% accuracy rate** in identifying firms that overstated their environmental efforts. This success underscores the capability of AI in pattern recognition and anomaly detection within ESG datasets, particularly when traditional audits fall short (Omdena, 2024).

Case Study 3 – Trustpilot Hackathon: NLP for ESG Disclosure Analysis

During a 2024 ESG-focused hackathon hosted by TIMETOACT GROUP, developers created a custom language model trained on thousands of sustainability reports and ESG disclosures. The model was specifically designed to detect vague or evasive language, obfuscated trade-offs, and selectively reported metrics. It used context-aware embeddings to flag terms such as "aspiration," "committed," or "net-zero by 2050" when unsupported by credible short-term actions. This approach offered investors deeper insights into the sincerity and transparency of sustainability communication (Weber, 2024).

Case Study 4 – Tesla: AI Reveals ESG Discrepancies

A 2024 independent AI analysis of Tesla's ESG data revealed a notable gap between its sustainability claims and actual operational metrics. While Tesla publicly emphasized its environmental leadership, AI tools analyzing emissions, labor controversies, and governance structures highlighted several red flags. These included underreported supply chain emissions and regulatory penalties related to labor practices. The study raised concerns among regulators and ESG funds, demonstrating the potential of AI in auditing high-profile green claims (Chakraborty & Miah, 2024).

5.2 Machine Learning & AI in Financial Crime Prevention:

ML algorithms are capable of analyzing vast volumes of transactional data in real time, allowing financial institutions to quickly detect anomalies that may indicate fraudulent behavior (Nguyen et al., 2022). As noted by Bhat and Gupta (2021), AI models—particularly those based on neural networks—are highly effective at uncovering complex patterns that traditional rule-based systems often miss. Furthermore, Zhang and Li (2020) emphasize that both supervised and unsupervised ML approaches contribute to stronger anti-money laundering (AML) frameworks by reducing false positives and improving the identification of illicit activities. Patel et al. (2023) also highlight that AI's ability to learn continuously from new data ensures that security measures remain adaptive and effective as financial crime tactics evolve.

5.2.1 AI-based fraud detection models in green banking transactions:

Artificial intelligence-based fraud detection algorithms play a vital role in ensuring the security and transparency of green banking transactions. By leveraging advanced technologies like machine learning, deep learning, and natural language processing, these systems can effectively identify abnormal activities, fraudulent Environmental, Social, and Governance (ESG) claims, and inconsistencies in green financial practices (Zhou, Zhang, & Wang, 2022). Fraud risks—especially greenwashing—are particularly prominent in green banking sectors involving ESG-related loans, carbon credits, and green bonds, primarily due to the complexity and lack of standardization in sustainability disclosures (Patil & Yadav, 2023). AI-driven models are capable of analyzing both structured and unstructured datasets in real time, making them significantly more effective at spotting irregularities that traditional rule-based approaches might miss (Li & Xie, 2021).

Additionally, by learning from previous fraud trends, these models continuously improve their forecast accuracy, reducing false positives and increasing the efficacy of detection (Zhou et al., 2022). AI algorithms help ensure the validity of sustainability indicators in high-risk areas such as carbon offset trading and ESG fund allocations by cross-checking data from many sources

(Sharma & Kumar, 2021). Integration with blockchain improves the system's resilience and adds another layer of protection against fraud by providing transparent, immutable transaction records (Patil & Yadav, 2023). As green finance expands globally, the use of AI in fraud detection not only safeguards financial institutions but also upholds investor confidence and regulatory compliance (Li & Xie, 2021).

5.2.2 Blockchain and AI integration for fraud-proof ESG investing

The incorporation of blockchain and artificial intelligence (AI) into ESG (Environmental, Social, and Governance) investing represents a paradigm shift in combating fraud, greenwashing, and a lack of transparency. Stakeholders can validate ESG claims using tamper-resistant data thanks to blockchain's decentralized and unchangeable ledger, which guarantees the traceability of sustainability measures across investment portfolios and supply chains (Tapscott & Tapscott, 2016). Blockchain, for example, may be used to track labor conditions, water use, and carbon emissions, and investors and regulators can view this data in real time. The system may automatically identify discrepancies in reported ESG data, such as mismatched disclosures or abrupt departures from sustainability benchmarks, when paired with AI, which is particularly good at pattern recognition and anomaly detection (Chen et al., 2021). To find possible differences between reported ESG performance and public perception, AI systems can also do sentiment analysis on news stories and company communications (Mao et al., 2019). Additionally, by eliminating human error and manual oversight, the convergence of these technologies facilitates the automation of ESG compliance using smart contracts (Zwitter & Boisse-Despiaux, 2020). The application of AI and blockchain becomes crucial for promoting accountability, decreasing greenwashing, and improving data dependability as ESG investing gains traction internationally, especially in light of heightened stakeholder and regulatory scrutiny (Nassiry, 2018; Rejeb et al., 2023). In addition to boosting investor confidence, the combined use of blockchain and artificial intelligence helps create a more moral and secure green finance environment that supports sustainable development objectives.

5.2.3 Predictive analytics for early fraud risk identification

Predictive analytics is a revolutionary tool for early fraud risk identification, particularly in industries like finance, insurance, and green investment. Predictive analytics can identify unusual trends and behaviors before fraudulent acts fully manifest by using statistical models, machine learning algorithms, and historical data (West & Bhattacharya, 2016). To determine the probability of fraud, these models frequently take into account factors like transaction frequency, location, and user behavior. Baesens et al. (2015) claim that using predictive analytics increases operational efficiency by lowering false positives and improving detection accuracy. Additionally, early fraud detection systems are crucial to maintaining investor confidence and advancing sustainable development goals in the context of green finance, where regulatory frameworks are still developing (Tang & Zhang, 2020). It has been found that combining real-time predictive models with AI-based technologies offers a proactive strategy for preventing fraud as opposed to only reactive steps taken after harm has been done (Ngai et al., 2011).

5.3 Future of AI-Powered Fraud Prevention in Sustainable Finance

The incorporation of Artificial Intelligence (AI) in sustainable finance has the potential to transform fraud prevention methods by providing real-time monitoring, anomaly detection, and predictive analytics. Artificial intelligence (AI) systems may efficiently examine large datasets for indications of greenwashing, misreporting, or non-compliance as ESG (Environmental, Social, and Governance) investments increase. Zhang and Lee (2023) claim that in order to maintain financial integrity and foster investor trust, AI-powered algorithms are being utilized more and more to evaluate the veracity of ESG disclosures. Furthermore, explainable AI (XAI) frameworks are anticipated to be incorporated into future AI systems as sustainable finance develops, improving decision-making transparency (Kumar et al., 2022). In green finance

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ecosystems, the combination of artificial intelligence (AI) and regulatory technology (RegTech) will further simplify compliance and due diligence.

5.3.1 AI-enhanced regulatory compliance in green banking:

Artificial intelligence (AI) strengthens regulatory compliance in green banking by automating monitoring operations, increasing transparency, and discovering noncompliance with environmental norms. The volume and complexity of data related to ESG (Environmental, Social, and Governance) standards can provide a challenge for traditional compliance systems. Large unstructured databases may be analyzed by AI, especially machine learning and natural language processing, which can identify possible irregularities or violations instantly (Dixon, 2021). To guarantee compliance with changing sustainability requirements, AI technologies, for example, can analyze regulation texts and compare them with institutional data (Zhou et al., 2022).Furthermore, by comparing corporate disclosures with real performance data, AI models help identify greenwashing and promote higher integrity in green financing (Ghosh & Chatterjee, 2023). AI is being used by regulatory agencies to carry out supervisory technology (SupTech) tasks, such as evaluating systemic environmental risks through predictive analytics (Arner et al., 2020). Furthermore, green banks are increasingly using AI-powered RegTech solutions to automate AML (Anti-Money Laundering) and KYC (Know Your Customer) checks with sustainability-specific criteria (Huang & Wang, 2022). AI integration guarantees more flexible, precise, and proactive compliance procedures as green banking laws continue to change, thereby advancing the more general objective of sustainable development.

5.3.2 Deep learning for identifying fraudulent financial patterns:

These advanced models enhance the accuracy of fraud detection across various domains—including credit card transactions, insurance fraud, and green finance—by autonomously extracting relevant features from raw data without requiring manual input (Fiore et al., 2019). Furthermore, hybrid models that include LSTM architectures and autoencoders have demonstrated success in identifying uncommon, invisible fraudulent activities with few false positives (Liu et al., 2020). Institutions can identify not only transactional fraud but also more complex schemes like greenwashing and false environmental claims thanks to deep learning's ability to analyze both structured transaction logs and unstructured text (like financial reports or ESG disclosures) (Jurgovsky et al., 2018;Patil et al., 2021). These systems, which use GPU acceleration for low-latency inference, are being used by financial institutions more frequently in real-time monitoring settings (Zhang & Zhou, 2022). The use of deep learning in financial fraud detection is a significant step toward more intelligent and adaptable risk management systems, notwithstanding issues with explainability and data protection (West et al., 2020).

5.3.3 Ethical considerations and AI's role in building trust in sustainable finance:

Artificial intelligence (AI) is essential for increasing openness and trust in sustainable finance,but it also raises difficult concerns regarding ethics. Concerns around data privacy, algorithmic bias, accountability, and explainability surface as financial institutions depend more and more on AI-driven models to evaluate environmental, social, and governance (ESG) risks and possibilities (Pizzi et al., 2021).To maintain stakeholder trust, ethical AI in sustainable finance needs to be open, equitable, and consistent with societal ideals (Binns, 2018). AI systems may unintentionally perpetuate discriminatory patterns or greenwashing practices in the absence of strong governance, undermining public confidence (Lepri et al., 2018). Explainable AI (XAI), which enables stakeholders to comprehend and contest financial decisions based on ESG indicators, is essential to establishing trust (Guidotti et al., 2018). Furthermore, in order to ensure adherence to international norms like the UN Principles for Responsible Investment, ethical frameworks must be in place to direct the use of AI in sustainability evaluations and investment decisions (Tolan et al., 2021). By enhancing accountability, identifying discrepancies in ESG disclosures, and encouraging data-driven environmental responsibility, AI can support sustainable finance when used properly (Jobin et

al., 2019). Thus, building and preserving confidence in sustainable financial systems depends heavily on the nexus of ethics and AI.

6. Conclusion: AI as the Guardian of Green Finance Integrity

An overview of fraud detection techniques powered by AI: The monitoring and validation of green finance is changing as a result of AI technologies like blockchain, machine learning, natural language processing and sentiment analysis. Future directions for financial security and ESG transparency facilitated by AI: Explainable AI (XAI), IoT integration for real-time environmental data, and AI-augmented ESG assessment are examples of future developments. AI will become more and more important in maintaining the integrity of green finance.

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