

An Integrated AI Blockchain Framework for Real-Time Greenwashing Risk Detection in ESG Asset

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Abstract: Environmental, Social, and Governance (ESG) investing has become one of the foundations of sustainable finance by considering environmental and social factors in making an investment decision. Nevertheless, the fast growth in the number of ESG-labeled financial products has also fueled the fears about greenwashing, in which companies oversell or falsify their sustainability efforts. Current methods of ESG assessment are mostly based on periodical reporting and ratings by third parties and are not capable of detecting greenwashing as it happens. The current paper suggests the hybrid Artificial Intelligence (AI) and Blockchain solution to real-time greenwashing risk detection in ESG assets. The suggested conceptual model is an amalgamation of machine learning, natural language processing, blockchain-provided transparency, IoT-based sustainability monitoring, and sentiment analytics to constantly re-assess ESG disclosures and produce dynamic Greenwashing Risk Scores (GRS). The framework increases the level of transparency, accountability and explainability in ESG investment decision-making and promotes regulatory compliance. The suggested architecture helps to make the finance sustainable as it will help to monitor risks automatically, ensure better investor confidence, and enhance the ESG governance.

Keywords- ESG Investing; Greenwashing; Artificial Intelligence; Blockchain; Sustainable Finance.

Introduction

Environmental, Social, and Governance (ESG) investing has greatly altered the financial markets in the world because it has motivated companies to incorporate sustainability in their strategic and operational plans. The rise in popularity of green bonds, sustainable investment funds, and tokenized ESG assets have opened up investment opportunities and have also increased markets to risks of greenwashing at the same time. Greenwashing is a situation where companies are deliberately more vocal on environmental success or hide sustainability facts to appeal to socially responsible investors [1].

The existing ESG rating systems are mainly based on the periodic sustainability reports, external audits and manual evaluations. These methods have weaknesses of delayed reporting, poor disclosure norms, and inability to verify them. Therefore, investors typically find it hard to differentiate between truly

sustainable companies and those that create false ESG statements. The analysis of big financial and sustainability data using AI has shown significant promise in the areas of anomaly detection, predictive analytics and natural language processing [2]. On the same note, blockchain technology gives rise to records of transactions that are immutable and transparent and can enhance ESG data verification. Combining AI and blockchain can build an intelligent decision support system that will be able to constantly identify any discrepancies between reported sustainability pledges and the real performance of the operation. The current paper presents a novel AI-Blockchain framework that will allow tracking ESG disclosures in real-time and measuring the greenwashing risk with explainable analytics. The conceptual framework is a combination of AI-based analytics, blockchain validation, IoT sensors data, and the sentiment analysis of the stakeholders that should enhance transparency and sustainability governance [3].

Related work

There are a number of papers discussing AI use in the context of ESG analytics and blockchain-based sustainability reporting, as well as financial fraud detection. ESG ratings and anomalies in sustainability disclosures have been predicted using machine learning algorithms. Natural Language Processing (NLP) techniques have also been used to analyze corporate sustainability reports and news articles for detecting misleading environmental claims. The blockchain technology has risen as a trustworthy system of providing transparency and traceability in sustainable finance through the creation of imbalanced records of carbon credits, green bonds, and other eco-friendly transactions [4]. Nevertheless, it seems that the current literature focuses mostly on AI and blockchain separately, with little analysis on how these two concepts can be combined into continuous greenwashing monitoring.

Table 1. Comparison with the Existing Literature

Study	AI Analytics	Blockchain Validation	Real-Time Monitoring
Existing AI-based ESG models	Yes	No	Partial
Blockchain ESG reporting systems	No	Yes	No
ESG Rating Models	Partial	No	No
Proposed Framework	Yes	Yes	Yes

The suggested framework can mitigate these shortcomings, incorporating AI and blockchain, IoT monitoring, and sentiment analytics into a single greenwashing detection framework.

Key Contribution

The research proposed contributes to the sphere of sustainable finance and ESG analytics several important contributions. It creates a comprehensive Artificial Intelligence (AI) and Blockchain conceptual model of the real-time identification of greenwashing risks in ESG assets through a combination of the most advanced machine learning tools and data validation provided by the blockchain. The framework also utilizes various sources of data such as IoT-based sustainability monitoring and analysis of

stakeholder's sentiment to give a microscopic analysis of ESG performance. Additionally, it presents a dynamic Greenwashing Risk Index (GRI) which quantifies the risk of greenwashing by continually monitoring and ranking risks. Explainable AI boosts the transparency and interpretability of risk predictions and, thus, the confidence of investors and the justification of the decision-making process [5]. Moreover, the suggested framework makes it much easier to monitor automated compliance with ESG, providing useful decision-support to regulators, financial institutions, and policymakers to enhance sustainable finance governance.

Method, Experiments and Results

The suggested research will follow a conceptual analytical model based on merging Artificial Intelligence (AI), Blockchain technology, IoT-based sustainability monitoring, and ESG analytics to identify the risk of greenwashing in the real-time. The six stages of the methodological workflow include Literature Review, Data Acquisition, AI Analytics, Blockchain validation, Greenwashing Risk Scoring and Explainable Decision Support. The suggested framework will combine corporate ESG reports, financial reports, records of blockchain transactions, IoT sensors, and news articles or social media posts. ESG-related reports, such as corporate ESG reports, contain sustainability reports and ESG scores, whereas financial statements include firm-level financial reports, such as revenue, assets, and liabilities. Blockchain logs guarantee open validation of green bonds and tokenized ESG assets, and IoT sensors provide real-time data of the environment like carbon emissions and energy use. Moreover, the sentiment of stakeholders and ESG scandals are mined in news and social media sources on the basis of natural language processing methods [6]. The theoretical research takes into account a population of over 500 ESG companies, 1,000 tokenized ESG assets, and blockchain transaction data of 2018-2026. Machine learning and natural language processing algorithms are used to detect irregularities in sustainability disclosures, and blockchain is a way to guarantee integrity and transparency of data by maintaining immutable records. The results of AI analytics, blockchain validation are combined to determine a Greenwashing Risk Index (GRI), which offers a quantitative evaluation of the risk of greenwashing and contributes to automated monitoring of ESG compliance and real-time decision-making [7].

The Greenwashing risk index suggested is calculated as:

$$GRI = w_1(DI) + w_2(AI) + w_3(BTI) + w_4(SI)$$

where:

- DI = Disclosure Inconsistency Score
- AI = AI-Detected Anomaly Score
- BTI = Index of Blockchain Transparency
- SI = Sentiment Indicator of Stakeholders
- w_1, w_2, w_3, w_4 = respective weights assigned to each indicator ($\sum w_i = 1$)

Table 2. Greenwashing Risk Classification

GRI Score	Risk Level	Interpretation
0–25	Low	ESG disclosures are largely consistent and transparent.
26–50	Moderate	Minor inconsistencies requiring periodic monitoring.
51–75	High	Significant greenwashing indicators requiring investigation.

76–100	Critical	Strong evidence of greenwashing requiring immediate regulatory attention.
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The last phase features Explainable Artificial Intelligence (XAI) as a means to enhance transparency and interpretability of AI-based decisions. These justifications help the investors, regulators, auditors and corporate managers to have the rationale behind the risk assessment and aid in informed decision-making [8]. The explainable decision-support system finally produces a live ESG Greenwashing Dashboard with automated risk warnings, compliance checks and key sustainability indicators visualization, thus increasing accountability and facilitating responsible ESG management.

Discussions

The suggested model shows how AI and blockchain technologies can be used to complement each other to enhance ESG governance. AI can help to constantly identify anomalies in financial reports, sustainability reports, and stakeholder communications, whereas blockchain ensures integrity and transparency of data. The combination of environmental data generated by IoT also helps to reduce the use of self-reported corporate data, and this reduces the chances of greenwashing [9]. The explainable AI aspect also boosts trust as it makes the risk classifications transparently explainable as opposed to viewing predictions as black-box results. The implications of such a framework are immense on the investors that need to find credible ESG reporting, regulators who ensure that firms are acting responsibly, and those who wish to become better responsible business actors [10]. The new tokenized sustainable finance systems, such as carbon credit markets and green bonds created on blockchains, are also supported by the proposed framework.

Conclusions

1. The paper deals with the increasing problem of greenwashing in investments related to environmental, social, and governance by suggesting a framework of real-time detection.
2. The system combines the Artificial Intelligence, Blockchain technology, IoT sustainability monitoring, and ESG analytics into a single architecture.
3. The offered Greenwashing Risk Index can be constantly monitored, automatically evaluated as to compliance, and support the decision-making process regarding investment.
4. The conceptual framework helps in the study of sustainable finance, but empirical validation through actual ESG data will be done in the future. Future studies can potentially consider the performance of machine learning, streamline explainable AI models, and test the framework in other foreign financial markets.

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