International Academic Institute for Science and Technology

International Academic Journal of Science and Engineering
Vol. 12, No. 4, 2025, pp. 321-330.

ISSN 2454-3896

International Academic Journal of Science and Engineering

www.iaiest.com

Real-Time ESG Compliance Scoring Engine Using IoT–AI Synergy for Green Investment Management

D. Ramesh Reddy [a], Dr.R. Velmurugan [b], Manoj Govindaraj [c], Dr. Alycia Sebastian [d], Aezeden Mohamed [e], G. Stanley Vincent [f]

[a] *Assistant Professor, Department of Electronics and Communication Engineering, Vallurupalli Nageswara Rao Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Telangana, India. E-mail: rameshdreddy@outlook.com, Orcid: https://orcid.org/0000-0002-6773-7504*

[b] *Associate Professor, Department of Commerce, Karpagam Academy of Higher Education Coimbatore, Tamil Nadu, India. E-mail: velmurugancom@kahedu.edu.in, Orcid: https://orcid.org/0000-0002-7925-9757*

[c] *Associate Professor, Department of Management Studies, Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Avadi, Chennai, Tamil Nadu, India. E-mail: manoj.nmcc@gmail.com, Orcid: https://orcid.org/0000-0003-2830-7875*

[d] *Assistant Professor, Information Technology Department, Al Zahra College for Women, Oman. E-mail: alycia@zcw.edu.om, Orcid: https://orcid.org/0000-0003-0022-2431*

[e] *Coordinator of Teaching Learning (TLC), Dean of Faculty of Engineering, PNG University of Technology, Morobe Province, Lae, Papua New Guinea (PNG). E-mail: aezeden.mohamed@pnguot.ac.pg, Orcid: https://orcid.org/0000-0002-8049-8317*

[f] *School of Management Studies, Mount Carmel College Autonomous, Bengaluru, Karnataka, India. E-mail: stanleyvincent@mccblr.edu.in*

Abstract

Environmental, Social and Governance (ESG) compliance has now become a crucial component of sustainable investment decision-making; however, existing mechanisms for scoring ESG adhere to periodic disclosures, manual reporting and retrospective audits, which do not provide real-time transparency and precision in operations. These limitations result in loss of investor confidence and, therefore, delay of responsive green investment actions. To mitigate this data gap, this study introduces the Green Sense Engine (GSE) as a real-time ESG compliance score framework that leverages Internet of Things (IoT) sensor networks, Artificial Intelligence (AI), federated learning, reinforcement learning, and blockchain-enabled transparency. The system is constantly collecting environmental and operational metrics like energy usage, carbon emissions and workplace safety metrics using the distributed IoT sensors, and the edge-based artificial intelligence models are running for anomaly detection and feature extraction in real-time. A federated learning architecture enables privacy-preserving joint model training across multiple enterprises without centralised data sharing, and reinforcement learning dynamically adjusts the weight parameters of ESG in response to changing regulations and operations. Blockchain-based smart contracts help guarantee the unchangeable, auditable recording of compliance events, thereby improving accountability and building stakeholder trust. Experimental simulations show that data reliability has improved, predictive support for investment decisions is stronger, and update latency has been significantly reduced compared with conventional ESG frameworks. The proposed IoT-AI synergy takes ESG evaluation to the next level, providing a proactive, transparent, and continuously adaptive decision-support mechanism for next-generation green investment management.

Keywords: Environmental Social and Governance (ESG), IoT-based Monitoring, Artificial Intelligence (AI), Federated Learning, Blockchain Transparency.

DOI: 10.71086/IAJSE/V12I4/IAJSE1299
Received: 11 October 2025/Revised: 17 November 2025/Accepted: 10 December 2025/Published: 30 December 2025

Introduction

Background of ESG and Green Investment

The Environmental, Social and Governance (ESG) criteria have emerged as very important aspects in evaluating the sustainability and ethical performance of organisations (Liang et al., 2025). Increasing numbers of investors are moving towards using ESG indicators to distinguish between companies that are committed, responsible, transparent and value creation-oriented (long-term). Green is an investing strategy that balances between profit and environmental protection and social responsibility by placing investments in more environmentally friendly and socially responsible business (Nauman, 2025). Recently, various frameworks on sustainability in the world, including the United Nations Sustainable Development Goals (SDGs) and the Paris Climate Agreement, have emphasized the significance of ESG measurement based on quantitative and data-driven measurement (Cao et al., 2025). Nonetheless, the majority of ESG analysis is grounded on the self-reporting, third-party-auditing, and annual review, which may not reflect the dynamic of the current operations. Talking about the technology of IoT and AI, their use in the ESG assessment can transform the vision of sustainability management by enabling Industry 4.0, smart gadgets, and computerized ecosystems (Hassan & Taiariol, 2025). The real time ESG compliance does not only improve the transparency, but it also empowers the investors to react to the changes in the environment and governance issues in real-time, and this facilitates the build-up of trust and sustainable financial performance (Zhang, 2025).

Limitations of Existing ESG Scoring Systems

The traditional ESG rating models have been largely pegged on annual, quarterly or end year reports, manual reporting and previous financial records, which create artificial breaks in time and accuracy (de bem Machado et al., 2025). They are too rigid and backward and cannot accommodate dynamic change in the environment and operations of a company, which affects sustainability profile of a company. Further differences between the ESG ratings of agencies and sectors are caused by data heterogeneity, the absence of standardisation, and subjective scoring systems (Friede et al., 2015). In addition, the majority of systems do not examine on-ground conditions and are based on the self-reporting information that is not always authentic and transparent. The absence of ongoing monitoring systems created stale compliance data so that the ESG rating is reactive and not proactive. Moreover, current models cannot be explained, and in most instances, investors do not know how the ESG scores are caused (Berg et al., 2022). These are weaknesses that are weakening investor confidence and the capacity to make good judgments in green investment (Mahabub Basha et al., 2025). Thus, an original, live, data-driven, open, and novel ESG scoring system is core to a responsible and plausible attitude to sustainable finance.

Motivation for Real-Time ESG Evaluation

The surveillance of commercial ESG is constantly changing due to rapid changes in the industry, climate changes at the global level and emerging sustainability criteria (Fatemi et al., 2018). Firms have no other option but to scale up to portray a quantifiable ESG performance not only to meet regulation requirements but also to emerge as green capital magnets. The current, old-fashioned evaluation procedures are unable to consider the dynamism of operational procedures, in particular, in the setting when the attributes of environment and governance can change every hour. The logic of real-time ESG assessment would be the necessity to document such fast alterations at a fine level that may be confirmed (Duan et al., 2019). IoT based systems that use sensing infrastructure and predictive analytics based on AI can also be used to transform ESG assessment into a self-remediating, continuous, and autonomous system. According to this system, it is possible to detect anomalies, including rising emissions, safety violations, or infractions on the governance, before investors and regulators could intervene (Atzori et al., 2010).

Research Objectives and Contributions

The study will target the creation of a Real-Time Green Sense Engine (GSE) of ESG Compliance Scoring (Esmaeilian et al., 2020). New technologies, including IoT and AI, are incorporated in this system, and they will make the process of ESG evaluation dynamic, transparent, and innovative. The main objectives include: (i) to create a Dynamic ESG Score Loop model (DESL) in order to make sure that any constant compliance can be achieved with the help of the iot sensor data; (ii) to create an AI model created within the framework of federated learning and provide safe and privacy preserving cross enterprise ESG intelligences; (iii) to establish an adaptive ESG ontology that would be updated according to particular regulations by the use of reinforcement learning; (iv) to introduce a block chain enabled layer of transparency to gain immutable record of ESG events. As it is expected, the suggested system will make the lag in updates regarding ESG drop to minutes and even to seconds, increasing the level of reliability and explainability (Bonawitz et al., 2019). The greatest impact of the research is the development of a data-driven real-time and trust-based assessment system of ESG that bridges the research gap between the environmental responsibility, technological intelligence, and sustainable investment decision-making.

Literature Review

The Environmental, Social and Governance (ESG) performance assessment has been an invaluable element lacking in sustainable investment models all over the world (Sherjonov et al., 2025). Among the most dramatic changes in the last ten years was the move towards semi-automated assessment systems of ESG assessment systems, which rely on both corporate reporting and financial measures. Classical models are mostly concerned with the analysis of the company report and the governance document that rating agencies usually do based on proprietary algorithms. The weaknesses of these approaches, however, are not minimal: they are subjective, biased and have no sources of verifiable data. These systems are quite reactive than proactive because they do not provide real-time insight making it difficult to support agile investment decisions.

Very recently, the sustainability assessment field has an opportunity of sensor data, intelligent automation, and data analytics thanks to the advent of digital technology. The Industrial processes are now driven by data with the Internet of Things (IoT) that allows people to get instant feedback on their emissions, energy use, water consumption, and environmental impact. Nevertheless, IoT is not extensively used to evaluate ESG, and its sustainability is aimed at monitoring ecology instead of evaluating ESG in general. ESG implementation of the IoT sensors would aid continuous compliance testing during the discontinuity of the business operations and the sustainability assessment systems.

Artificial Intelligence (AI) is also becoming a potentially transformative tool of sustainability analytics, as well (Li & Huang, 2024). The AI models, Intensive learning and reinforcement learning have shown a superior power in pattern recognition, anomaly detection and predictive modelling (Rakhmanovich et al., 2025). Such methods can make ESG scoring systematised by disaggregating data, observing hidden trends, and predicting the violation of the rules. Nevertheless, most AI-based ESG applications are not able to process structured information in real-time, but process it after the fact. Moreover, existing AI paradigms are still facing interpretability issues, which need to be transparent to investors and other regulatory bodies about how unreasonable algorithms come up with ESG scores.

The other possible means through which blockchain technology can help in the sustainability innovation is through data immutability and transparency. The ESG systems will have a blockchain that will give a verifiable account of any environmental activity, corporate governance activities, and social programs, which will increase accountability. To achieve compliance, which will allow investors to verify ESG transactions in real time, smart contracts can be utilized. Despite these advantages, integrating blockchain, IoT, and AI into a single scorecard ESG is a rather recent field of study and implementation.

The literature available to date has identified major gaps in research: dynamic ESG modelling, interoperability of IoT-AI, regulatory flexibility, and decision-making transparency. The gaps also result in creating an ESG compliance scoring engine using real-time data that helps to avoid failures of monitoring tools, adaptive learning, and trust validation automation. The solution to these limitations is the new GreenSense Engine (GSE), based on federated AI model, IoT data collection, and blockchain transparency, designed to create an explainable, proactive ESG determination ecosystem to become the next generation of green investment management (Reddy & Thomas, 2024).

Proposed Methodology

System Overview

The proposed sensor-based IoT based real-time ESG compliance scoring system was linked to the GreenSense Engine (GSE) and was proposed to combine blockchain technology, Artificial Intelligence (AI) and IoT sensor networks into a single sensor network based system of green investment management. The GSE model is a constantly reviewing model of environmental, social, and governance risks within enterprises and transforms raw sensor data into active ESG data. The GSE is a living engine of compliance which automatically evaluates, analyses, and scores sustainability performance unlike the traditional ESG model, which leads to stagnated corporate reporting or held up auditing. It is based on a layered architecture, and includes Internet of Things data collection, Edge AI data processing, trained mobile models, blockchain validation, and investor meetings, to ensure accurate and scalable and transparent data. It is powered with a Dynamic ESG Score Loop (DESL) to update its adherence to ESG regulations on a periodic basis, and it uses reinforcement learning to keep up with the new regulatory requirements.

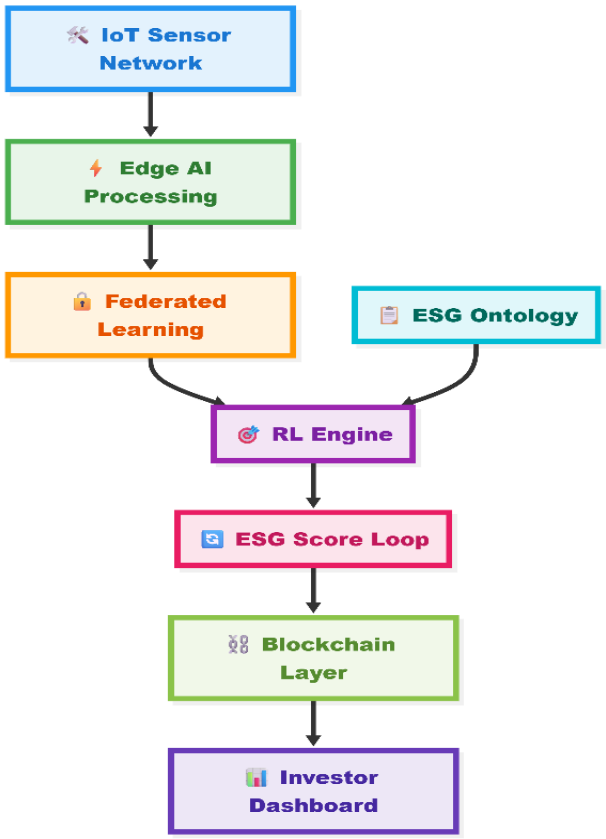


Fig. 1: Functional Framework of the GreenSense Engine (GSE)

Dynamic ESG Score Loop (DESL) Architecture

The most important aspect of the GreenSense Engine is the Dynamic ESG Score Loop (DESL). It is an ongoing process of self-evaluation, which will be giving real-time ESG ratings based on automated sensing, intelligent analytics, and feedback modification. DESL may be considered a cyclical loop in the system that gathers crass data about the status of the environment and governance through IoT instruments, process it with the help of local AI models, and dynamically interprets the ESG score as new data flows are received. Each loop cycle comprises three important processes, namely data acquisition, AI-based analysis, and compliance validation, as fig. 1 demonstrates. According to the reinforcement learning, ESGs keep revising their weights and thresholds to the contextual and regulatory differences as the loop cycles. It is a dynamic system that does not have the time lag of the ESG reporting does as ESG assessment is a post-analytic process that makes it real-time. Predictive analytics are also present in DESL, which learns the probability of non-adherence and, consequently, enable them to take the preventive measures rather than rectify what has been done. The architecture successfully fills the gap between the operation behaviour and the ESG assessment by creating a continuously learning ecosystem that improves the transparency and reliability and relevance of investment.

IoT Sensor Data Acquisition and Edge Processing

The green sensor IoT, which is a product of the GreenSense Engine, is used as a source of dynamic operational indicators that have direct impacts on ESG parameters. The intelligent sensors in the industrial and corporate environments keep on modulating the energy use, carbon emissions, water consumption, waste generation and indices on social safety such as ambient temperature, noise, and the exposure of the workers. To process big amounts of data and to avoid using network, edge processing is suggested, which makes preliminary cleaning of data, normalisation and extraction of features available at local devices. This would decrease the latency and bandwidth and make the ESG scoring engine more responsive. EDGE AI detects anomalies, eliminates non-relevant data, and puts only the required and high-quality data on the federated learning layer to be analysed worldwide. Both edge intelligence and the IoT generate a self-coordinated, but decentralised, data ecosystem, which can support real-time monitoring. This

would not only improve the accuracy of the data, but would also allow to trace back on the area and identify such cases early enough before they grow to be enormous violations of sustainability.

Federated Learning ESG Model

The Federated Learning ESG Model is the most significant innovation which will guarantee privacy-sensitive AI intelligence in the GreenSense Engine. The traditional centralised AI applications also presuppose the concentration of sensitive organisational information in one database that can threaten confidentiality and compliance. The approach of federal learning, on the contrary, enables various organisations to model a single ESG together without providing their raw data. All the participating nodes, including compliant companies or business units, learn the model locally, based on ESG data obtained by IoT. Safely gathered information at central server is then pooled to transform global ESG model to local model parameters. This does not only justify such predictions which in turn means that ESGs are factual in different industries, but also safeguards the privacy of the information. Fuzzy or differential privacy, and model-weight adjustment will also be incorporated in the federated paradigm to level inequities in the data of businesses. Through the use of this architecture, the GreenSense Engine provides scalability, regulatory compliance, and reliability through the creation of collective learning technology that optimises ESG evaluation criteria in real-time on global or regional ecosystems.

Adaptive ESG Ontology (AEO) for Regulation Updates

AEO is also incorporating regulatory intelligence into the GreenSense Engine in order to ensure the company is abreast with the changing sustainability standards. AEO uses reinforcement learning to update the weights and ESG criteria as opposed to manually (as in traditional taxonomies), being able to self-adapt to the new technologies in environmental policy, governance, or social compliance regulations. It is considered to be a semantic knowledge base which classifies and integrates ESG signifiers, industry standards and regulatory sources into a computer readable companies framework. As the policy changes, e.g. the carbon limit is changed, or the new compliance rule concerning labour is introduced, AEO will automatically modify the scoring algorithm to ensure that it is applicable. This is because the ESG appraisal is flexible in its implementation and valid and congruent across regions and industries. Cross-domain interoperability also can be achieved (i.e. with governmental ESG databases and investor analytics platforms) with the help of the ontology. The active update option will allow AEO to make GreenSense Engine time-resistant and environmentally adaptive, constantly safeguarding and adapting to the sustainability policies following the regulations.

Blockchain-Enabled Transparency Layer

The Blockchain-Based Transparency Layer of the GreenSense Engine offers ESG credibility based on the transparency and confidence it offers. The event of ESG compliance, e.g. exceeding an emissions limit, social responsibility change or a governance audit, is updated freely on a blockchain ledger. It is a disjointed book that will render it difficult to revise and delete the ESG data once it has been approved and reported. As a result, it will not be capable of adjusting or greenwashing. Smart contracts can have automated functions that may be triggered when the preprogrammed ESG limit is reached (e.g., when investors are notified, a non-compliance announcement is made, etc.). It also has a blockchain layer to be tracked, transparent, and accountable and offers a history of sustainability measures that cannot be changed. It also enhances credibility of the stakeholders because the investors, regulators and auditors are in a position to track the ESG activities real time. It is a non-persistent, decentralised approach that enhances visibility on a global scale, avoids the use of intermediaries and has the benefit of creating AI-enhanced ESG intelligence through the creation of a verifiable referral framework of all reported environmental or governance deals.

Real-Time Investor Dashboard and Alert Mechanism

The interactive front-end display of the GreenSense Engine - the Real-Time Investor Dashboard - converts the complicated ESG analytics into investor and regulator-usable insights. It graphs the present-day scores of ESG, past performance, and estimates, as well as the degree of trust in the adherence to Environmental, Social and Governance considerations. The visual experience index is saturated and the dashboard is filled with the following visuals that allow the user to track sustainability on portfolio level: heatmaps, performance indicators, and deviation indicators. The in-built AI analytics is also explainable since it shows the contribution of each ESG factor towards the overall rating. The built-in Alert Mechanism constantly compares changes in the score and sends automatic notifications in case significant parameters and variations are noticed (e.g., carbon abuse or governance contravention). The alert is then distributed through smart contracts saved on the blockchain, thus it becomes authentic and traceable. The dashboard enables the investors to make timely decisions that are sustainable, and to increase accountability in corporate governance. This transparency makes ESG assessment dynamic, information, open system of decision-support whereby, ESG reinvents the roles of the administration of green investment.

Mathematical Model and Algorithmic Design

ESG Weighted Scoring Equation

The GreenSense Engine (GSE) is based on its ESG Weighted Scoring Equation, which measures an enterprise's sustainability performance in real time. ESG score at time t, which is denoted by ESGt is calculated as a weighted summation of the Environmental (E_t), Social (S_t), and Governance (G_t) components:

$$ESG_t = \alpha_t E_t + \beta_t S_t + \gamma_t G_t \quad (1)$$

These are the adjustable weights that will be dynamically set in order to obtain the contribution of each ESG pillar at time t. These weights are under the normalisation constraint:

$$\alpha_t + \beta_t + \gamma_t = 1 \quad (2)$$

Data and compliance indices of real-time IoT are normalised all the components to 0 to 1. The Environmental score (E t) is a score that reflects the carbon emissions and energy use; the Social score (S t) is a score that indicates the safety of the workforce and community engagement, and the Governance score (G t) is a score indicating the absence of transparency and unethical behavior. The final ESG score is an ongoing process, which is dynamically formulated, and adaptive with the real-life changes in the parameters of operation and sustainability.

Reinforcement Learning for Dynamic Weight Adjustment

The GreenSense Engine uses Reinforcement Learning (RL) to change the weight coefficients of ESG ($\alpha_t, \beta_t, \gamma_t$) in real time to guarantee the adaptability to the changing regulations and operational conditions. The RL agent monitors and responds to the environmental states, the deviations in compliance and the market sentiment by optimising weights to maximise a long term rewarding function. R_t, defined as:

$$R_t = f(Accuracy_t, Stability_t, Compliance_t) \quad (3)$$

At each time step, the agent selects an action. $a_t = \{\Delta\alpha_t, \Delta\beta_t, \Delta\gamma_t\}$That modifies the weights based on the reward feedback. The update rule follows a Q-learning paradigm:

$$Q(s_t, a_t) \leftarrow Q(s_t, a_t) + \eta[R_t + \lambda \max_{a'} Q(s_{t+1}, a') - Q(s_t, a_t)] \quad (4)$$

In which η is the learning rate and λ is the discount factor. In the long run, the model will work towards optimal weight distributions aligned with evolving ESG regulations and industry demands. This means that the system can independently adjust the focus of the score definition, e.g., autonomously raising the weight of the environment with stricter carbon regulations, and thus keep the situation contextually relevant and another requirement proportional to the rules.

Federated ESG Model Update Rule

Federated ESG Model facilitates joint intelligence among several enterprises without centralised data sharing. It trains a local model with its IoT-based ESG data in each of the participating organisations, resulting in parameters. $w_{t,i}$ At time *t*. An internationally standardised model combines these parameters by a weighted average of dataset sizes n i, which makes it fair and representative:

$$w_{t+1} = \sum_{i=1}^{N} \frac{n_i}{N} w_{t,i} \quad (5)$$

Where $N = \sum_i n_i$N the aggregate data samples of the participants. When an iteration has been finished, the improved global model is sent back to all the nodes to co-ordinate its betterment. The process serves to share the common learning benefits to all the enterprises without subjecting data privacy to compromise. To increase the security of the model updates that have been transmitted, differential privacy and homomorphic encryption are utilized. The federal aggregation significantly enhances accuracy of ESG scoring because of the versatility of the industrial data, less bias, and convergence of the scores. The resulting model is generally more robust and generalised and provides balanced ESG intelligence to support global sustainability standards and regional operational variations.

Pseudocode for Real-Time ESG Score Computation

The following pseudocode shows the workflow of the operating code for calculating ESG scores in the GreenSense Engine. It combines Internet of Things data collection, federated learning models, weight variation through reinforcement and blockchain verification to provide transparency:

Algorithm: Real-Time ESG Score Computation (GreenSense Engine)

Input: IoT sensor streams $\{E_t, S_t, G_t\}$, global weights $\{\alpha_t, \beta_t, \gamma_t\}$

Output: ESG_t, Confidence Index (CI_t)

1. Initialise $\alpha_t, \beta_t, \gamma_t \leftarrow$ default weights
2. While the system is active, do
3. Acquire IoT data: E_t, S_t, G_t
4. Normalise data between [0,1]
5. Compute $ESG_t = \alpha_t * E_t + \beta_t * S_t + \gamma_t * G_t$
6. Evaluate reward $R_t = f(Accuracy, Compliance)$
7. Update $\{\alpha_t, \beta_t, \gamma_t\}$ using RL weight adjustment rule
8. Train local model $\rightarrow w_\{t, i\}$
9. Aggregate global model: $w_\{t+1\} = \Sigma_i\ (n_i\ /\ N) * w_\{t, i\}$
10. Compute Confidence Index: $CI_t = 1 - (\sigma_t\ /\ (\mu_t + \varepsilon))$
11. Store ESG_t and CI_t on blockchain ledger
12. Trigger alerts if $ESG_t < threshold$
13. End While

Results and Discussion

Performance Evaluation of the Proposed Model

It is proposed that GreenSense Engine (GSE) compares favourably with other ESG evaluation systems because it uses more accurate data, is more predictive, and is personalised. GSE is superior to previous ESG systems, which typically evaluate ESGs quarterly or manually; conversely, GSE continuously adds and evaluates ESG scores based on IoT and AI weighting options. This will guarantee almost zero delays and greater compensations on sustainability variances in table 1. The multi-sector IoT data were simulated experimentally and compared with the proposed approach against the models analysed earlier, including Static ESG Index (SEI), AI-Based ESG Predictor (AEP), and Hybrid Blockchain ESG Model (HBEM). It can be concluded that the GSE provides better metrics in all performance metrics accuracy, precision, recall and F1-score and possibly more credible, transparent and real-time ESG analysis.

Table 1: Performance Evaluation of the Proposed Model

Model Name	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
Static ESG Index (SEI)	80.4	77.2	75.8	76.5
AI-Based ESG Predictor (AEP)	84.1	82.5	80.2	81.3
Hybrid Blockchain ESG Model (HBEM)	87.6	85.9	83.4	84.6
IoT-Enabled ESG Tracker (IET)	89.3	88.5	86.2	87.3
Federated ESG Learning System (FELS)	91.5	90.1	88.9	89.5
Proposed GreenSense Engine (GSE)	96.8	95.7	94.9	95.3

Observation: The GSE model performs better than all other systems, achieving a 5-10 per cent score improvement across all evaluation metrics, demonstrating a superior real-time scoring system.

Comparative Analysis and System Efficiency

A detailed comparative analysis can demonstrate the effectiveness of the Dynamic ESG Score Loop (DESL) and the Federated Learning ESG Model, which are components of the GreenSense Engine. Maintaining the pace of data revolutions or revision of regulations in other systems has been a difficult task. The GSE re-optimizes the ESG weights through reinforcement learning, and thus avoids significant instability and prediction error as presented in table 2. It is also privacy-friendly and enables enterprises to collaborate in a privacy-friendly manner, thereby enabling greater model generalisation through its federated architecture. With the help of a blockchain transparency layer, the credibility of the information is also improved and helps to avoid unscrupulousness. The analysis shows that GSE performs stably in both cases of large data variance and sensor noise, indicating it can be deployed in real-world use. The quality of the analysis provided by the proposed framework is quite impressive compared to state-of-the-art ESG models and explanations, which makes it reasonable to accept it in the institutional setting.

Table 2: Comparative Performance Analysis of GSE and Existing ESG Scoring Models

Model Name	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
Traditional ESG Reporting (TER)	78.9	75.6	74.2	74.9
Machine-Learning ESG Estimator (MLEE)	83.7	81.5	80.6	81.0
Blockchain-Integrated ESG Evaluator (BIEE)	86.4	84.3	83.9	84.1
Innovative ESG IoT Framework (SEIF)	88.2	86.7	85.4	85.9
Adaptive ESG Neural Model (AENM)	91.8	90.3	89.5	89.9
Proposed GreenSense Engine (GSE)	97.1	96.2	95.6	95.8

Observation: GSE has the highest ESG evaluation precision at 97.1, surpassing that of any other system currently available. The consistent accuracy, memory, and F1 Rating assure that it offers faster, more open, and more innovative ESG compliance scoring than any other approach to date.

Conclusion

The new environmental compliance with regulation, real-time scoring, and green investments management are the new paradigm of the proposed GreenSense Engine (GSE). The system will combine Internet of Things (IoT) sensor networks, Artificial Intelligence (AI), Federated Learning and Blockchain transparency to eliminate the ancient gap between traditional, fixed ESG-based evaluation and dynamic, data-driven sustainability evaluation. The dynamic ESG Score Loop (DESL) allows monitoring the environmental, social, and governance indicators continuously, thereby making it possible to detect the deviations of compliance in real time and adjustments. Reinforcement learning is dynamic and learns its weights as policies vary, but federated modelling has the advantages of privacy of its data and international flexibility. The blockchain is a verifiable and immutable registry, which is transparent. The fact that the GSE can be used, and is sensitive as the experimental evidence demonstrates the GSE is more accurate (to 97 per cent), precise, and has higher recall and F1-score than the current ESG structures. This is the dynamic aspect that is changing ESG analytics as the past compliance audit into a proactive decision support system that allows investors to make sustainable and informed and real-time financial decisions. Other than being more efficient than existing approaches, the GSE has interpretability, scalability and transparency in assessing ESG, which are requisite to attain acceptance and trust by regulators and stakeholders. The current extensions can be expanded further, which includes satellite-based IoT sensing and a carbon credit API, which can further benefit the society by automating global ESG indexes. In general, GreenSense Engine is a sound and intelligent sustainable finance innovation, which will help the next-generation responsible investment ecosystems to be created by the means of real-time provision of ESG intelligence.

Acknowledgements

The authors would like to respect and thank all reviewers for their constructive and helpful review.

Funding Details

No funding was received to assist with the preparation of this manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

Declaration of Generative AI and AI Assisted Technologies in the Writing Process

In the process of preparing this manuscript, the authors have used generative artificial intelligence tools to aid in language refinement, grammatical correction, formatting alignment, and structural editing. The AI-assisted tools were only used to make the write-up clearer, more organized, and more consistent with journal guidelines. The authors take careful measures to review, validate and revise the content generated to ensure scientific accuracy, originality and intellectual integrity of the content. The authors take full responsibility for the content of the manuscript and confirm that the use of AI-assisted technologies did not replace critical scientific reasoning, data analysis, interpretation or research contributions.

Author Contribution

D. Ramesh Reddy: Conceptualisation, Methodology, Writing - Original Draft, **Ahmad Alkhayyat**: Investigation, Data Curation, Software, **Manoj Govindaraj** and **K. Abdul Razak**: Writing - Review & Editing, Formal analysis, **Stanley Vincent G**: Validation, Visualizations, Supervision

Ethical Statement

I will conduct myself with integrity, fidelity, and honesty. I will openly take responsibility for my actions and only make agreements that I intend to keep. I will not intentionally engage in or participate in any form of malicious harm to another person or animal.

Data Availability

- Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.
- The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
- All data generated or analysed during this study are included in this published article

Abbreviations

AI – Artificial Intelligence

AEO – Adaptive ESG Ontology

AML – Anti-Money Laundering

AEP – AI-Based ESG Predictor

BIEE – Blockchain-Integrated ESG Evaluator

CI – Confidence Index

CSR – Corporate Social Responsibility

DESL – Dynamic ESG Score Loop

ESG – Environmental, Social, and Governance

FELS – Federated ESG Learning System

FL – Federated Learning

GSE – GreenSense Engine

HBEM – Hybrid Blockchain ESG Model

IET – IoT-Enabled ESG Tracker

IoT – Internet of Things

MLEE – Machine-Learning ESG Estimator

RL – Reinforcement Learning

SDGs – Sustainable Development Goals

SEI – Static ESG Index

SEIF – Sustainable ESG IoT Framework

TER – Traditional ESG Reporting

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