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Ai-Based Decision Support System for Green Investment Risk Assessment in Emerging Economies

Rahiba Abdulhasanova[1*], Sadagat Ahmadova[2]

Abstract. *Green investment in developing economies is poorly served by conventional risk tools. This paper examines how artificial intelligence methods, from hybrid econometric-machine learning architectures to natural language processing and distributed ledger systems, can be embedded within decision support frameworks for green portfolios. Drawing on a structured narrative synthesis of 61 studies published between 2018 and 2024, it maps AI deployment in sustainable finance across emerging markets including Morocco, Mongolia and Azerbaijan. Bidirectional recurrent networks and hybrid architectures consistently outperform standard approaches under data scarcity and macroeconomic instability, while ownership concentration and governance quality moderate AI-driven environmental performance. The paper concludes with recommendations for regulators and investment professionals in institutionally fragmented markets.*

Keywords: *green investment, risk assessment, decision support system, machine learning, ESG, blockchain, emerging economies, sustainable finance*

Introduction

Green investment in developing countries presents a structural paradox: these economies stand to gain most from a sustainable transition, yet the conditions that make it urgent, namely weak institutions, patchy data, volatile politics and immature capital markets, also make it hardest to evaluate. Value-at-risk models assume stable return distributions, an assumption that breaks down where regulatory change or commodity price shocks are frequent, and mean-variance optimisation performs poorly when the covariance structure of green assets is unstable (Bellache & El Bouanani, 2026). AI is not a remedy in itself: it offers pattern recognition in high-dimensional data, nonlinear function approximation and automated text analysis, which address concrete shortcomings of existing frameworks when properly deployed. Our position is optimistic but tempered by the most underestimated bottleneck in the field, since emerging economies lack not only data scientists who can build models, but ESG analysts, managers and regulators who can evaluate, act on and oversee their outputs.

Ensemble methods such as XGBoost and Random Forest remain reliable workhorses, while long short-term memory networks and their bidirectional variants have shown promise in the time-series tasks most relevant to green finance (Liu et al., 2022).

[1]Nakhchivan State University, Nakhchivan, Azerbaijan
[2]Nakhchivan State University, PhD in Economics, Nakhchivan, Azerbaijan
[*]Corresponding author. E-mail: ebdulhesenovarahibe@ndu.edu.az
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The most consequential recent development is the hybrid model, which uses econometric specifications for the systematic components of a series and neural networks for the residual, retaining interpretability while remaining data-efficient (Bellache & El Bouanani, 2026; Sodnomdavaa et al., 2026). Out-of-sample stability nevertheless remains untested, since few evaluations ask whether models trained on one market transfer to another.

Greenwashing is arguably the largest credibility threat to the ecosystem: capital cannot be allocated efficiently where genuine and performative sustainability cannot be distinguished. Early natural language processing relied on keyword frequency and TF-IDF classification, which caught gross discrepancies but missed selective emphasis on favourable metrics (Zhao et al., 2023), whereas language models fine-tuned on domain corpora extract textual features that correlate with environmental penalties subsequently imposed by regulators (Xu et al., 2026). Blockchain enthusiasm rests on a related problem: ESG data is often unreliable and vulnerable to manipulation. Traceability platforms create auditable records and smart contracts can automate compliance verification (Dawood et al., 2025; Okeke, 2025), but the technology does not resolve inaccurate data at the point of entry, and scalability, cost and interoperability remain unresolved (Rivera et al., 2024).

Several gaps follow. The empirical evidence is concentrated in a handful of countries, methods capable of capturing asymmetric effects such as quantile-on-quantile regression remain underused (Wang et al., 2025), and the interaction between firm-level governance and AI effectiveness has been noted but not systematically investigated (Rastogi et al., 2024). Governance frameworks such as the European Union AI Act were designed for developed markets, and most developing countries have no AI-specific regulation. Azerbaijan illustrates the geographic gap: the barriers to green investment there have been examined outside the AI literature (Abdulhasanova, 2025b), and cross-country panel evidence shows that fiscal environmental spending does not by itself mobilise private green capital, nor does aggregate financial depth translate into green financial capacity (Abdulhasanova et al., 2026). The distinction between investor, object of investment and investment environment frames any such system (Abdulhasanova, 2025a).

The aim and objectives of the study

The aim of this study is to map the state, constraints and potential of AI-based decision support systems for green investment risk assessment in emerging economies. Four objectives were defined: to evaluate the principal AI methodologies used under emerging-market conditions; to categorise data-related, institutional, regulatory and ethical barriers; to assess evidence on their impact on ESG performance and firm value; and to formulate context-sensitive recommendations for practitioners and regulators.

Materials and methods

The study uses a structured narrative synthesis, a method between a systematic and a traditional review, chosen because the landscape is too interdisciplinary for the former while a purely narrative approach risks selective citation. The search was conducted between January and March 2024 and covered publications from 2018 to 2024, using Scopus with supplementary searches in Web of Science and Google Scholar. It returned 437 records, screening reduced the pool to 128, and full-text review retained 61 sources. The reference list cites the studies carrying the analytical argument, while the wider corpus informs the synthesis without being enumerated. Peer-reviewed empirical articles carried more interpretive weight than conference proceedings, and the English-language restriction is the principal limitation.

Results

Model architecture matters, but less than the literature implies. Across the studies reviewed, the gap between the best model and a well-implemented baseline typically fell between five and fifteen per cent on standard accuracy metrics, smaller than the effect of data quality, feature selection and model-task fit. Bidirectional LSTM models nonetheless outperformed unidirectional counterparts in nearly every comparison, most clearly over longer horizons (Liu et al., 2022), and hybrid models performed particularly well under volatility: augmenting ARIMAX specifications with machine learning improved tail accuracy for Moroccan equity UCITS (Bellache & El Bouanani, 2026), and central bank policy rate forecasting in Mongolia produced the same result (Sodnomdavaa et al., 2026). Few studies report when their models fail, and the resulting publication bias makes the field look more successful than deployment experience warrants.

In text analysis, the strongest evidence comes from studies detecting discrepancies between what firms say and what they do (Zhao et al., 2023; Xu et al., 2026). Three caveats apply: retrospective data cannot show how models behave once detection tools are known to exist; cross-linguistic transfer is harder than the literature acknowledges, since hedging and disclosure conventions vary across languages; and interpretability remains unsolved, because regulators need to know why a disclosure was flagged. For blockchain, the most compelling evidence comes from supply chains, where traceability improved the reliability of emissions data and auditable frameworks maintained tamper-resistant performance data in real time (Okeke, 2025; Dawood et al., 2025). Limited technical expertise, implementation costs and interoperability problems are especially acute in emerging economies (Rivera et al., 2024), yet integration could shift regulatory oversight from periodic audits toward continuous monitoring.

Firm-level governance moderates the effectiveness of AI tools more than is appreciated. Ownership concentration moderates the relationship between ESG disclosure and firm value, positively at moderate concentration and with attenuation at high levels (Rastogi et al., 2024), so the same system deployed in two firms within one sector may produce different outcomes. The barrier landscape is likewise interactive: data quality is foundational, since ESG reporting in many emerging economies is voluntary and unstandardised, while the critical deficit lies between developers and end users, because a risk model is useless if the portfolio manager cannot interpret a confidence interval. The same logic applies to financial infrastructure, where liquidity without green assessment capacity leaves capital in conventional channels (Abdulhasanova et al., 2026). Evidence from the South Caucasus and Central Asia is largely absent, which makes the region a promising pilot setting (Abdulhasanova, 2025b).

Discussion of results

The central lesson of this synthesis is that the effectiveness of AI in green investment depends less on algorithmic sophistication than on the ecosystem in which the algorithm operates. The best model is of little use when trained on unreliable data, deployed in an organisation that cannot act on its outputs and operated without guidance on governing algorithmic decisions; the marginal return on data infrastructure, institutional capacity and regulatory development is therefore higher than the return on further algorithmic refinement. Because ownership structure and governance quality mediate the impact pathway, policy should target the governance environment as much as the technology, and wider use of distributional methods would help, since quantile-based evidence suggests AI may amplify rather than equalise performance differences (Wang et al., 2025). Two recommendations follow: start small, with well-defined tasks such as automated screening of sustainability disclosures rather than comprehensive systems in weak data environments; and invest in workforce development through certification at the intersection of AI and sustainable finance. For hydrocarbon exporters, this human capital constraint is the binding one.

Conclusions

1. Hybrid AI-econometric models incorporating bidirectional LSTM networks improve measurably on traditional approaches for green investment risk forecasting, most clearly under high volatility and limited data, although the magnitude is more modest than headline results suggest and out-of-sample transferability remains inadequately addressed.

2. Natural language processing detects greenwashing with genuine accuracy, but cross-linguistic transferability, interpretability and the adversarial dynamics of evolving evasion strategies remain unresolved.

3. Blockchain-AI integration addresses foundational data integrity problems but remains constrained by scalability limits, implementation costs and the inability of any ledger to verify accuracy at the point of entry.

4. Firm-level governance moderates the effectiveness of AI-driven ESG systems, which argues for integrated strategies strengthening governance and technological capability together.

5. The barrier landscape is interactive, so addressing any single barrier in isolation is unlikely to produce substantial improvement. Future work should extend the geographic scope, adopt distributional methods more widely and develop ethical frameworks with operational specificity. For practitioners, the algorithm is one component of a system whose value depends equally on data governance, organisational capacity and regulation.

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