



COMPARATIVE ANALYSIS OF COMPLIANCE AND COST–BENEFIT PERFORMANCE OF AIR POLLUTION MITIGATION IN MINING

Tochukwu A. NGWU^{1*}, Jeremiah ONAOLAPO², Chinwe P. ORAMAH³, Kenechukwu R. NGWU⁴,
ThankGod UGWUADA⁵

¹Chiang Mai University, Chiang Mai, Thailand, tochukwuambrose@gmail.com

²The Education University of Hong Kong, Hong Kong, onaolapojeremiah01@gmail.com

³The Arctic University of Norway (UiT), Harstad, Norway, chinwe.p.oramah@uit.no

⁴Alex Ekwueme Federal University, Ndufu-Alike, Abakaliki, Nigeria, raphealluiz1@gmail.com

⁵Chulalongkorn University, Bangkok, Thailand, Ugwuadathankgod@gmail.com

DOI: 10.2478/minrv-2026-0030

received – 06.03.2026 / revised – 11.03.2026

accepted – 05.05.2026 / published – 22.09.2026

Abstract: Mining operations are vital for socio-economic development, yet they generate harmful particulate emissions during extraction processes. As a result, Environmental Management Plans (EMPs) and regulatory thresholds have been established to regulate these environmental impacts. Although these frameworks are aimed at ensuring operational compliance with stipulated pollution thresholds, they do not capture the degree of compliance or the cost-effectiveness of mitigation efforts. This limitation creates an efficiency paradox that limits meaningful comparison of environmental performance across mines. To address this gap, this study utilizes compliance performance evaluation system that translates particulate emission reduction outcomes into financial metrics and cost–benefit ratios. Using two limestone quarry case studies (L1 and L2), annual average PM_{10} concentrations were gauged against regulatory threshold, and the resulting emission reductions were economically valued using social cost proxies. The results show that L1 achieved PM_{10} reduction of 280.13 tons (85.3% reduction below pollution threshold), corresponding to a cost–benefit ratio of 11.4, while L2 reduced 245.01 tons (74.6%), with a cost–benefit ratio of 3.5. These findings demonstrate that compliance performance can be extended into economic evaluation systems which can facilitate transparent comparison of compliance and cost-effectiveness across mining operations. This approach therefore provides a practical decision-support tool for enhancing regulatory compliance, investment decision and ESG in the mining sector.
Keywords: Environmental compliance, Cost–benefit analysis, Mining, Emission management, Environmental management plans (EMPs), Environmental, Social, and Governance (ESG)

1. Introduction

Over the years, environmental regulation in mining has been structured around compliance with stipulated national and global operating standards [1]. These standards comprises of defined thresholds for various environmental impact domains such as air pollution, water contamination and other aspects with significant environmental footprints. These thresholds therefore serve as the primary benchmark for determining whether mining operations are environmentally acceptable. Part of the core practices that aid in complying to these stipulated standards are Environmental Management Plans (EMPs), which are designed to ensure that mining activities and their associated mitigation measures meet these stipulated regulatory requirements [2].

In recent years, compliance evaluation has been established as a systematic process of comparing observed environmental data and operational practices of the EMPs, against predefined standards and procedural expectations [1, 3, 4]. Although this has proven to be enforceable, it remains fundamentally binary, as it reduces environmental performance to a simple pass–fail outcome. This approach, therefore, introduces

* Corresponding author: Tochukwu A. Ngwu, Graduate Researcher, Chiang Mai University, Chiang Mai, Thailand, contact details (tochukwuambrose@gmail.com)

a significant limitation, because although it confirms whether a mine operates within acceptable limits, it does not indicate how well it performs beyond those thresholds. For instance, two mining operations may both meet stipulated particulate matter thresholds, yet one may achieve significantly greater emission reductions or do so more cost-effectively. Under this current approach, such differences are not captured [5]. As a result, compliance alone does not reflect the degree of environmental improvement achieved or the economic efficiency of mitigation efforts. Thus, restricting meaningful and fair comparison across mining operations.

Recently, there has been a growing momentum for compliance outcomes to be quantified into tangible proxies using economic evaluation frameworks [2, 6, 7]. This growing motion has prevailed because environmental standards are founded on the basis of national and global health-based parameters [8, 9]. Thus, the degree to which emissions and other pollutants are reduced below regulatory thresholds can be translated into avoided health damages and quantified in economic terms. This approach creates a pathway for linking environmental performance with economic value, particularly within cost and benefit frameworks, where benefits must be expressed in measurable and comparable terms [6, 10, 11, 12]. By doing so, compliance outcomes can be extended from basic regulatory obligation to a systematic approach that allows for evaluating the degree of compliance and cost-effectiveness, which can help inform investment decisions.

Having established this core, this study advances the concept of “compliance performance” as a measurable and comparable indicator that bridges environmental outcomes and economic evaluation. Thus, instead of enquiring whether a mine complies with regulatory thresholds, the study examines how well it performs below those thresholds (degree of compliance) and whether the resources used to achieve that performance are justified (cost-effectiveness). This is demonstrated by using two limestone mines in Thailand (L1 and L2), where annual average particulate matter (PM₁₀) concentrations were assessed against regulatory thresholds, using compliance evaluation. The resulting particulate emission reductions were quantified and translated to economic terms using social cost proxies. The cost-effectiveness is determined using cost-benefit ratio that comprises of economic value of reduced emission against the EMPs investment costs.

This study thus illustrates a practical approach to advance compliance assessment from binary to performance-based evaluation. Thus, providing a more nuanced and equitable approach to understanding environmental compliance and cost-effectiveness in mining. It further offers a transparent basis for comparing compliance outcomes across mining operations and supports informed decision-making regarding environmental investments and ESG.

2. Methodology

This study applies a performance compliance evaluation approach to evaluate the environmental and economic effectiveness of particulate emission (PM₁₀) reduction in two limestone mines (L1 and L2). This approach integrates ambient air quality monitoring, compliance-based emission reduction estimation, and economic valuation to derive cost-benefit performance indicators, as shown in fig. 1. The mines operate under the same regulatory settings but differ in operational scale and Environmental Management Plans (EMPs) mitigation intensity. Both mines invest in the implementation of EMPs such as dust suppression measures such as water spraying, haul road management, continuous emission monitoring systems (CEMS), controlled blasting and so on. The datasets were obtained from annual EIA reports, accessed from the Office of Natural Resources and Environmental Policy and Planning, Thailand (Link to the source (eia.onep.go.th) (data to be provided on request)). Investment in EMPs were also obtained from the annual EIA reports, which comprises of operating expenditures that were utilized for reducing emissions and complying with regulatory requirements.

2.1. Data Collection

Ambient air quality conditions were obtained using 24-hour average PM₁₀ concentrations measured at monitoring stations located within the spatial boundaries of each mine’s concession area, using gravimetric method. Measurements were conducted using standard gravimetric methods. The regulatory threshold for ambient PM₁₀ is ≤ 0.12 mg/m³, which serves as the baseline for compliance evaluation, according to Thailand’s National Environment Board Announcement No. 24 (2004) [13].

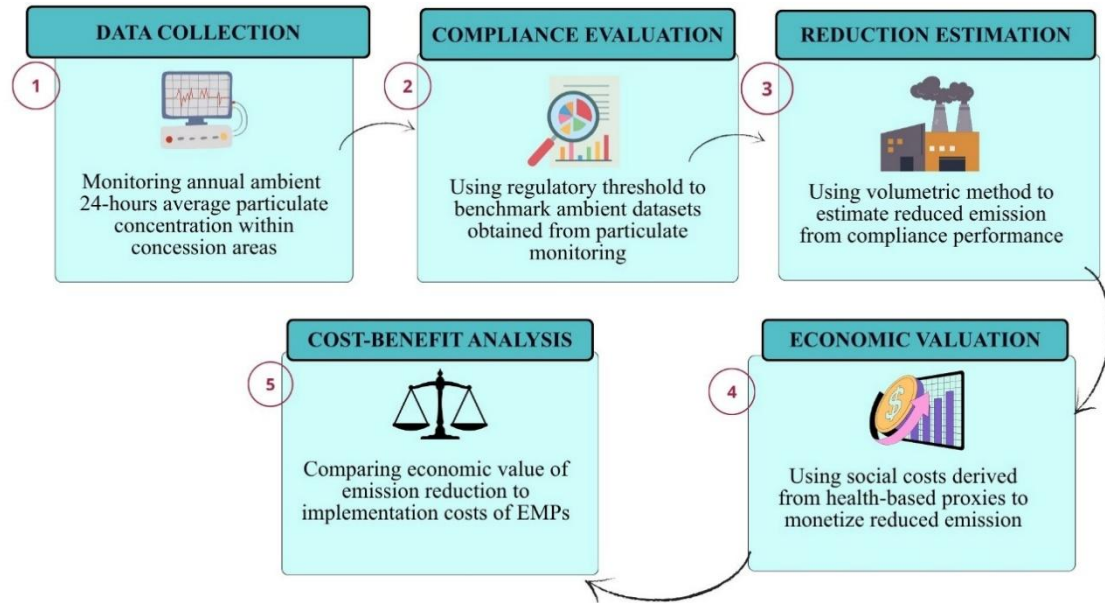


Fig.1. Methodological framework used in the study

2.2. Compliance Evaluation

To quantify compliance performance, each operational day was treated as an independent compliance event, consistent with daily regulatory standards [14]. For each day, the difference between the regulatory threshold and the measured concentration represents the achieved reduction in PM₁₀ concentration:

$$\Delta C = C_s - C_m \quad (1)$$

where ΔC is the achieved concentration reduction (mg/m³), C_s is the regulatory threshold, and C_m is the measured ambient concentration.

The annual mass of PM₁₀ avoided was then estimated by scaling this concentration difference over the physical and temporal boundaries of each mine. Concentrations were first converted from mg/m³ to µg/m³ (×1000) to ensure unit consistency. The atmospheric mixing height was assumed to be 1500 m based on empirical values [14]. The total avoided annual PM₁₀ mass was expressed as:

$$\text{Reduced PM}_{10} = \kappa \times A \times H \times \sum (\Delta C_i) \quad (2)$$

where κ is the unit conversion factor (10⁻¹²) to express mass in metric tons, A is the concession area (m²), H is the atmospheric mixing height (m), and $\sum (\Delta C_i)$ is the cumulative concentration reduction (µg/m³) across all operational days (299). The volumetric approach applied in Equation (2) assumes that the atmospheric mixing volume defined by the concession area (A) and mixing height (H) is effectively renewed during each operational day. Under this assumption, each day is treated as an independent compliance event, allowing the cumulative annual avoided particulate mass to be estimated as the sum of daily concentration reductions over the operational period. This simplification provides a practical basis for economic valuation of avoided emissions while acknowledging that actual atmospheric renewal rates may vary depending on meteorological conditions such as wind speed, wind direction, and atmospheric stability.

2.3. Economic Valuation

The economic value of emission reduction was estimated using a unit social cost of PM₁₀ as a proxy for health-related damages. This value was derived using the Greenhouse Gas Air Pollution Interactions and Synergies (GAINS) framework developed by International Institute for Applied Systems Analysis (IIASA) and United Nations Environment Programme (UNEP) [15]. The total national health burden was estimated by combining mortality costs, based on Years of Life Lost (YLLs = 413,000) and the Value of a Life Year (VOLY = USD 39,224), with additional morbidity costs, resulting in an annual burden of USD 18.0 billion. This value was normalized using Thailand's emission inventory to obtain a unit cost of USD 33,636 per ton of PM_{2.5}. A PM_{2.5}/PM₁₀ ratio of 0.56 was applied to convert this to a PM₁₀ basis, yielding USD 18,897 per ton. Using the September 2025 exchange rate (32.589 THB/USD), the final social cost was estimated at 615,834 THB per ton of PM₁₀ [16]. (THB stands for Thai Baht)

The economic value of air quality improvement is therefore given as:

$$E_V = \text{Reduced PM}_{10} \times C \quad (3)$$

where E_V represents the annual economic value (THB/year), Reduced PM_{10} is the total avoided emissions (tons/year), and C is the unit social cost (THB/ton).

2.4. Cost–Benefit Analysis

The cost–benefit performance of each quarry was assessed by comparing the economic value of emission reduction with the corresponding investment in EMPs:

$$\text{Cost–Benefit Ratio} = \frac{E_V}{\text{Investment Cost}} \quad (4)$$

This ratio provides a direct measure of cost-efficiency, indicating the economic return generated per unit of investment in air pollution control. By integrating compliance-based emission reductions with economic valuation, the methodology enables a transparent and comparable assessment of mitigation performance across mining operations. The conversions were according to Bank of Thailand (1 USD = 31.7 THB as of April, 2026).

3. Results

The results show distinct differences in both environmental and economic performance between the two mines (Table 1). L1 achieved a higher PM_{10} reduction of 280.13 tons, which corresponds to an 85.3% reduction below the regulatory threshold. Meanwhile, L2 achieved a reduction of 245.01 tons, corresponding to 74.6% reduction (Fig.2). Although both mines demonstrate significant compliance performance, L1 outperforms L2 in terms of emission reduction intensity.

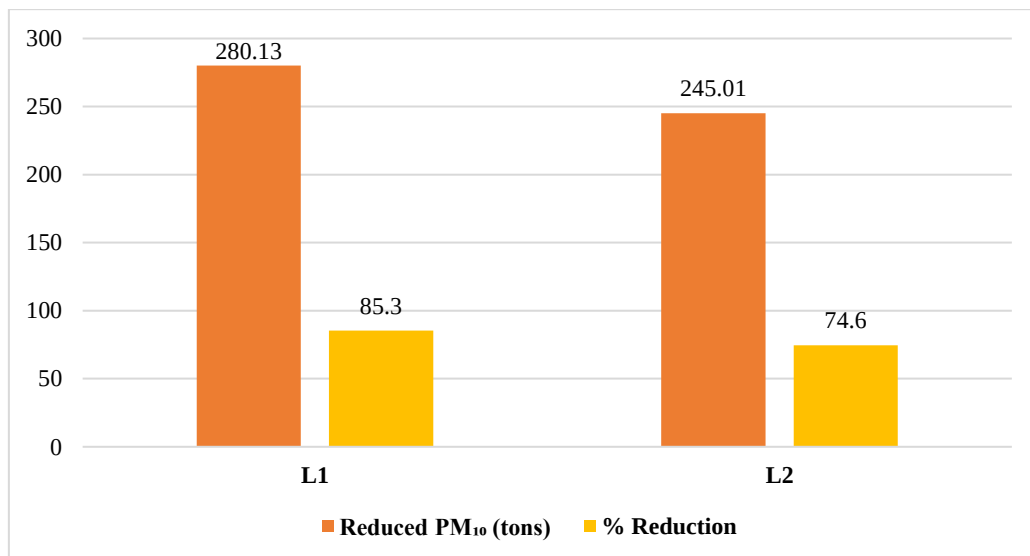


Fig. 2. Particulate matter reductions (PM_{10}) in tons and percentage across L1 and L2

When translated into economic terms, these reductions correspond to an estimated value of approximately USD 5.44 million for L1 and USD 4.76 million for L2. Despite the relatively close compliance performance in economic terms, the difference in EMPs investment costs significantly influences the end cost-benefit ratios (cost-effectiveness). L1 allocated an investment of about USD 0.48 million, whereas L2 put in a much higher allocation of approximately USD 1.35 million. This disparity is reflected in the cost–benefit ratios, where L1 achieved a ratio of 11.4, indicating that each dollar invested in mitigation generated over eleven dollars in environmental value. In contrast, L2 achieved a ratio of 3.5, showing a substantially lower return on investment despite achieving comparable emission reductions (Fig.3).

These results highlight that compliance performance alone does not fully explain environmental or cost-effectiveness, because, while both mines meet regulatory expectations and achieve significant reductions, their return on investment differ considerably. L1 demonstrates a more optimized balance between emission reduction and resource use, whereas L2 appears to rely on higher expenditure to achieve a relatively lower performance. Generally, the findings show that integrating compliance metrics with economic valuation provides a clearer basis for comparing mitigation competence across mining operations.

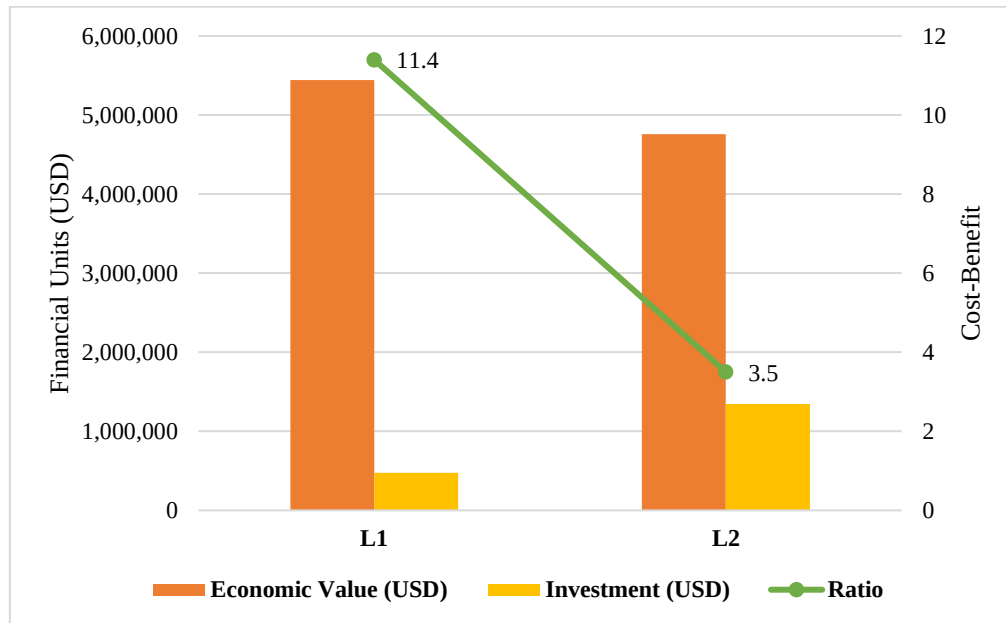


Fig. 3. Economic Value of Particulate matter reductions (PM₁₀), EMPs investments and cost-benefit ratios across L1 and L2

Table 1. Comparison of PM₁₀ Reduction, Economic Value, and Cost–Benefit Performance for L1 and L2

Mine	Reduced PM ₁₀ (tons)	Reduction (%)	Economic Value (USD)	Investment (USD)	Cost–Benefit
L1	280.13	85.3	5,442,000	476,000	11.4
L2	245.01	74.6	4,760,000	1,346,000	3.5

4. Discussions

4.1. Reframing Environmental Compliance as a Spectrum

The results of the study highlight the significance for a critical shift in how environmental performance in mining ought to be interpreted. Both sampled mines (L1 and L2) operate within the stipulated regulatory threshold for PM₁₀ (≤ 0.12 mg/m³), confirming that they both comply to the regulatory mandates. However, their degree of compliance differs substantially, because L1 achieved a reduction of 280.13 tons (85.3%), while L2 achieved 245.01 tons (74.6%). This demonstrates that compliance is not a uniform clause, but a system with distinct performance degrees. This supports the argument that compliance should be treated as a spectrum instead of a binary outcome [6, 9]. By quantifying how well operations perform below regulatory thresholds, the findings align with outcome-based and performance-oriented regulatory frameworks and empirical studies that emphasize actual environmental improvement over mere adherence to regulatory mandates [2, 6, 7]. Similar critiques of minimum-standard approaches have been widely noted in environmental regulation literature [1, 9, 17].

Beyond environmental outcomes, there are significant differences in terms of cost-effectiveness. This is because, although both mines achieve comparable reductions, L1 generates USD 5.44 million with an investment of USD 0.48 million, compared to L2's USD 4.76 million from USD 1.35 million. Thus, resulting in cost–benefit ratios of 11.4 and 3.5, respectively. This disparity shows that achieving compliance alone is insufficient; the efficacy of achieving it is equally significant. In essence, two mining operations may deliver similar compliance outcomes but require vastly different resource inputs. This reinforces the need to integrate economic evaluation into environmental performance assessment, which is consistent with prior studies that emphasize its significance in environmental decision-making [11, 12, 18, 19].

The comparison also clarifies differences in EMPs mitigation effectiveness. L1 demonstrates a more efficient balance between emission reduction and investment, while L2 relies on higher expenditure for lower relative gains. This confirms that increased investment does not necessarily yield proportional environmental benefits, consistent with findings on environmental efficiency and regulatory performance [20, 21].

From a regulatory perspective, these results expose a key limitation of compliance systems that are reliant on reaching regulatory thresholds. These binary compliance systems fail to distinguish between minimum and

high performance, offering little incentive to exceed standards. Therefore, treating compliance as a measurable spectrum enables benchmarking, identification of best-performing operations, and more efficient resource allocation, aligning with outcome-oriented environmental policy approaches [3, 9].

Generally, integrating compliance performance with economic valuation provides a more meaningful assessment of environmental effectiveness in mining. It reveals variations in both compliance outcomes and cost-effectiveness that remain obscured under traditional compliance frameworks, offering a stronger basis for decision-making and more effective environmental investment.

4.2. Applying Compliance Performance and Social Costs Across Stakeholder Levels

The compliance performance framework developed in this study extends beyond individual mine operations by providing quantifiable, economically expressed indicators of compliance performance. This creates a common language for engagement across stakeholders at local, national, and international levels. This is particularly important in addressing information asymmetry in environmental governance, where operators possess detailed performance data while regulators, communities, and investors rely on simplified compliance declarations that obscure actual environmental outcomes [4, 22].

At the local level, translating emission reductions into avoided health damages by using the social cost proxy approach offers communities a tangible understanding of environmental value. Instead of relying on binary compliance statements, stakeholders can engage with measurable outcomes, such as L1's avoidance of 280.13 tons of PM₁₀ annually, corresponding to an estimated USD 5.44 million in health-related benefits. This shift toward outcome-based or quantifiable communication systems, strengthens the social license to operate, which has been identified as a critical determinant of mining project viability [23].

At the national level, the cost-benefit ratio framework provides regulators with a practical basis for differentiated decision-making. The divergence between L1 (11.4) and L2 (3.5) indicates that treating regulatory compliance as a uniform or binary concept may be inefficient. As such, high-performing operations could be incentivized through mechanisms such as streamlined permitting or reduced bonding requirements, while lower-efficiency sites may warrant stricter oversight. This aligns with risk-based regulatory approaches applied in other environmental domains [11, 12]. Thus, in the case of Thailand, integrating such performance indicators into EMP approval and renewal processes under the Enhancement and Conservation of National Environmental Quality Act would enable more evidence-based and adaptive regulation [13].

At the international level, the use of standardized social cost metrics derived from the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) framework enables cross-country comparability of compliance performance. This is increasingly relevant for global sustainability reporting frameworks such as the Global Reporting Initiative (GRI) and other frameworks adopted by mining operations. Thus, by basing environmental performance in internationally recognized valuation methods, this approach allows mining operations especially those in developing economies to communicate environmental value in terms that are credible and comparable for global investors and regulators. This addresses a key limitation identified in environmental governance literature, where the lack of standardized economic metrics constrains cross-jurisdictional evaluation [24, 25].

5. Conclusions

This study demonstrates the limitations of conventional binary compliance frameworks in evaluating environmental performance in mining. By quantifying emission reductions below regulatory limits and translating them into economic value using social cost proxies, the study advances a compliance performance framework that captures both environmental outcomes and resource efficiency.

The findings show that L1 achieved higher emission reductions and significantly greater economic returns relative to its investment compared to L2, despite both sites being classified as compliant. This highlights that compliance alone is insufficient as a measure of environmental effectiveness and may obscure important differences in mitigation performance. Integrating cost-benefit analysis into compliance evaluation provides a more transparent and comparable basis for assessing environmental interventions across mining operations. Beyond comparative analysis, the study illustrates how economically expressed compliance metrics can support improved decision-making across stakeholder groups. At the regulatory level, such metrics enable more differentiated and performance-based policy approaches, while at the industry level, they provide a clearer framework for optimizing environmental investments and strengthening ESG reporting.

In summary, the proposed framework offers a practical pathway for shifting environmental governance in mining from a conventional binary system toward a performance- and metric-oriented approach. By linking

compliance outcomes with economic valuation, it supports more informed, accountable, and data oriented environmental management practices. Future research should expand the application of this framework across a broader range of mining contexts and environmental impact categories, including water quality, noise, and greenhouse gas emissions. Further studies could also integrate uncertainty analysis and dynamic modeling approaches to better capture temporal variations in compliance performance and investment efficiency.

Acknowledgements

During the preparation of this work the author(s) used QuillBot, Scribbr in order to paraphrase and adjust vocabulary. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article. The datasets for the research were obtained from annual EIA report archived in; Link to the source (eia.onep.go.th). The datasets will be made available on request.

References

- [1] **Wu Y., van Rooij B.**, 2021
Compliance Dynamism: Capturing the Polynormative and Situational Nature of Business Responses to Law, *Journal of Business Ethics*, vol. 168, pp. 579–591, <https://doi.org/10.1007/s10551-019-04234-4>
- [2] **Ngwu T.A., Oramah C.P., Somprasong K., Charoentanaworakun C.**, 2025
Evaluating the cost-effectiveness of Environmental Protection Plans in quarrying using the Social Return on Investment framework, *Pollutants*, vol. 5, 42, <https://doi.org/10.3390/pollutants5040042>
- [3] **Emerson K., Baldwin E., Scott T.A., Pidot J.R., Lien A.M., Currim F., Bethard S., Ram S., Miller M.L., López-Hoffman L.**, 2022
Toward NEPA performance: A framework for assessing EIAs, *Environmental Impact Assessment Review*, vol. 97, 106879, <https://doi.org/10.1016/j.eiar.2022.106879>
- [4] **Butler T.**, 2011
Compliance with institutional imperatives on environmental sustainability: Building theory on the role of Green IS, *The Journal of Strategic Information Systems*, vol. 20, no. 1, pp. 6–26, <https://doi.org/10.1016/j.jsis.2010.09.006>
- [5] **Mazur E.**, 2010
Outcome Performance Measures of Environmental Compliance Assurance: Current Practices, Constraints and Ways Forward, *OECD Environment Working Papers*, no. 18, OECD Publishing, Paris, <https://doi.org/10.1787/5kmd9j75cf44-en>
- [6] **Lee S.-T., Jung S.-M.**, 2025
Social return on investment as a tool for environmental impact and strategic assessments: evidence from South Korea, *Environmental Impact Assessment Review*, vol. 112, 107765, <https://doi.org/10.1016/j.eiar.2024.107765>
- [7] **Vazquez-Brust D.A., Plaza-Úbeda J.A.**, 2021
What Characteristics Do the Firms Have That Go Beyond Compliance with Regulation in Environmental Protection?, *Sustainability*, vol. 13, no. 4, 1873, <https://doi.org/10.3390/su13041873>
- [8] **Attavanich W.**, 2021
Willingness to Pay for Air Quality in Thailand: An Analysis of Multiple Pollutants, *Research Paper No. 15/2021*, Kasetsart University, Bangkok, Available online: https://kukr.lib.ku.ac.th/kukr_es/BKN/search_detail/result/424865
- [9] **Ngwu T.A., Somprasong K.**, 2026
Evaluating the equity–efficiency trade-off in mining environmental interventions using compliance, economic and social metrics, *Environmental Impact Assessment Review*, vol. 120, 108488, <https://doi.org/10.1016/j.eiar.2026.108488>
- [10] **Cordes J.**, 2017
Using cost-benefit analysis and social return on investment to evaluate the impact of social enterprise: Promises, implementation, and limitations, *Evaluation and Program Planning*, vol. 64, pp. 98–104, <https://doi.org/10.1016/j.evalprogplan.2016.11.008>
- [11] **Lopez M., Adams M., Walker T.**, 2024
Cost-benefits analysis of noise abatement measures in the port of Halifax, Nova Scotia, Canada, *Transportation Research Interdisciplinary Perspectives*, vol. 24, 101057, <https://doi.org/10.1016/j.trip.2024.101057>
- [12] **Sköld P., Bergion V., Lindhe A., Keucken A., Rosén L.**, 2022
Risk-Based Evaluation of Improvements in Drinking Water Treatment Using Cost-Benefit Analysis, *Water*, vol. 14, no. 5, 782, <https://doi.org/10.3390/w14050782>

- [13] **National Environmental Board**, 2004
Collection of Environmental Quality Standards under the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992), Royal Thai Government, Bangkok, Available online: <https://www.pcd.go.th/laws/2819/>
- [14] **Phaihong S., Sriket C.**, 2018
The relationship between mixing height and particulate matter less than 10 μm (PM_{10}) from climate change in nine provinces in Northern Thailand, *Journal of Science and Technology*, vol. 10, pp. 20–32
- [15] **Kiesewetter G., Klimont Z., Ru M., Slater J.**, 2023
National assessment of the cost of inaction of tackling air pollution in Thailand, *International Institute for Applied Systems Analysis and United Nations Environment Programme*, Available online: <https://pure.iiasa.ac.at/id/eprint/18826/1/Cost-of-Inaction-Thailand.pdf>
- [16] **Emissions Database for Global Atmospheric Research (EDGAR)**, 2015
Country profile: Thailand, Available online: https://edgar.jrc.ec.europa.eu/country_profile/THA
- [17] **Wambwa D., Mundike J., Chirambo B.**, 2023
Environmental Protection Fund audits in Zambia: A strategy for ensuring regulatory compliance in Zambia's mining sector, *The Extractive Industries and Society*, vol. 16, 101353, <https://doi.org/10.1016/j.exis.2023.101353>
- [18] **Mo L., Liu J., Chen J.**, 2020
Quantifying ecosystem services of dominate forests in the Beijing Mountain area, *Environmental Science and Pollution Research*, vol. 27, pp. 27773–27785, <https://doi.org/10.1007/s11356-020-09013-7>
- [19] **Ngwu T.A.**, 2026
Economic valuation of PM_{10} emission reduction strategies in mining: A case study of a limestone quarry in Thailand, *International Journal of Engineering Research & Technology*, vol. 15, <https://doi.org/10.5281/zenodo.18924061>
- [20] **Jones N., Begley A., Malesios C., Svajda J., McGinlay J., Dimitrakopoulos P.G.**, 2023
Exploring the spatial distribution of social impacts in protected areas, *Frontiers in Environmental Science*, vol. 11, 1229437, <https://doi.org/10.3389/fenvs.2023.1229437>
- [21] **Wu R., Gesang D., Zhou G., Li Y.**, 2024
Spatial disparities and dynamic evolution of professional public health resource supply level in Beijing, China, *BMC Public Health*, vol. 24, 2524, <https://doi.org/10.1186/s12889-024-19905-9>
- [22] **Rodrigue M., Magnan M., Cho C.H.**, 2013
Is Environmental Governance Substantive or Symbolic? An Empirical Investigation, *Journal of Business Ethics*, vol. 114, pp. 107–129, <https://doi.org/10.1007/s10551-012-1331-5>
- [23] **Moffat K., Zhang A.**, 2014
The paths to social licence to operate: An integrative model explaining community acceptance of mining, *Resources Policy*, vol. 39, pp. 61–70, <https://doi.org/10.1016/j.resourpol.2013.11.003>
- [24] **Hermann B.G., Kroeze C., Jawjit W.**, 2007
Assessing environmental performance by combining life cycle assessment, multi-criteria analysis and environmental performance indicators, *Journal of Cleaner Production*, vol. 15, pp. 1787–1796, <https://doi.org/10.1016/j.jclepro.2006.04.004>
- [25] **Farouk A.M., Radzi A.R., Romali N.S., Farouk M., Elgamal M., Hassan R., Omer M.M., Rahman R.A.**, 2024
Performance indicators for assessing environmental management plan implementation in water projects, *Sustainability*, vol. 16, no. 8, 3146, <https://doi.org/10.3390/su16083146>



This article is an open access article distributed under the Creative Commons BY SA 4.0 license. Authors retain all copyrights and agree to the terms of the above-mentioned CC BY SA 4.0 license.