




Does ISO 14001 certification influence PROPER ratings? Perspectives from a mining case study

Fajrul Falakh^{1,2*} , Sudarmadji¹ , Sri Rahayu Budiani³ 

¹ Doctoral Program of Environmental Science, Universitas Gadjah Mada, Yogyakarta, INDONESIA

² Department of Environmental Engineering, Faculty of Science and Technology, Universitas Islam Negeri Walisongo, Semarang, INDONESIA

³ Faculty of Geography, Universitas Gadjah Mada, Yogyakarta, INDONESIA

*Corresponding Author: fajrulfalakh@walisongo.ac.id

Citation: Falakh, F., Sudarmadji, & Budiani, S. R. (2026). Does ISO 14001 certification influence PROPER ratings? Perspectives from a mining case study. *European Journal of Sustainable Development Research*, 10(3), em0404. <https://doi.org/10.29333/ejosdr/18525>

ARTICLE INFO

Received: 04 Aug. 2025

Accepted: 10 Apr. 2026

ABSTRACT

Environmental governance in Indonesia's high-impact industries combines internal management standards with external reputational regulation. This study examines how an ISO 14001-based environmental management systems (EMS) relates to environmental indicators and PROPER ratings in a longitudinal single-company case in coal mining. We use mixed evidence: sustainability-report indicators and reported PROPER outcomes for 2022-2024; documentary traces of EMS integrity (certification continuity, audit cycles, and non-conformity records [NCRs]); and semi-structured interviews with nine internal actors (managers, practitioners, and field workers). PROPER is stable across 2022-2024 and shifts to a higher category, while absolute operational indicators (emissions, energy, and water use) fluctuate. Audits recur and NCRs remain controlled, and interviews describe routinized EMS practices across organizational levels. Framed as information-based regulation, PROPER is treated as a disclosure-driven reputational signal rather than a monotonic performance proxy. The evidence rejects a purely symbolic certification interpretation, without supporting causal claims of impact reduction in this context.

Keywords: ISO 14001, environmental performance rankings, coal mining, Indonesia, sustainability, environmental management system

INTRODUCTION

Environmental degradation is widely recognized as a defining challenge of the 21st century, intensifying debates on how industries can reconcile economic activity with ecological limits. Coal mining is frequently scrutinized because its operations can generate substantial environmental pressure, including land disturbance, deforestation, air and water pollution, and greenhouse gas (GHG) emissions (Blondeel & Van de Graaf, 2018; Pudasainee et al., 2020). These impacts may threaten biodiversity and ecosystem functioning through habitat loss, acid mine drainage, and degradation of ecosystem services (Johnson, 2005; Mercado-Garcia, 2018; von Döhren & Haase, 2023). They are also frequently associated with concerns about community health and social welfare in areas surrounding mining sites, including exposure to potentially toxic elements in soil, water, and air, and broader well-being impacts on host communities (Chen & Li, 2024; Mensah et al., 2025; Meutia, 2023; Pattanayak et al., 2010).

In response, many firms, including those in mining, have adopted environmental management systems (EMS), such as ISO 14001:2018, to formalize environmental management

practices. ISO 14001 provides a structured framework for identifying environmental aspects, setting objectives, ensuring legal compliance, and pursuing continual improvement (da Fonseca, 2015). A substantial body of research suggests that ISO 14001 certification is associated with improvements in resource efficiency and compliance-related practices, although the reported effects vary across contexts and sectors (Benzidia et al., 2025).

Drawing on institutional theory, ISO 14001 certification may function as a legitimacy-seeking "myth" that signals conformity to external expectations, which can create a decoupling between formal EMS structures and day-to-day operational practices when adoption is primarily symbolic (Ferrón-Vílchez, 2016a; Meyer & Rowan, 1977). Empirical studies further suggest that substantive environmental improvements are more likely when certification is accompanied by broader implementation scope, stronger internal governance/control, and credible monitoring and auditing rather than being treated as a stand-alone signal, especially in externally scrutinized sectors such as mining and in multinational settings (Arocena et al., 2023; Johnstone, 2022; Riillo et al., 2025).

Similarly, national environmental performance rating systems, such as Indonesia's PROPER, are designed as informational regulations, translating compliance and beyond-compliance performance into publicly disclosed ratings (García et al., 2007; KLHK, 2021). These disclosure schemes can amplify reputational and market discipline (Deswanto & Siregar, 2018; Konar & Cohen, 1997; Wang et al., 2004), complementing conventional enforcement incentives and encouraging firms to pursue beyond-compliance improvements.

PROPER evaluates companies' environmental management performance annually through a tiered rating system symbolized by colors ranging from black, red, blue, green, and gold, with gold representing outstanding performance (Rahmatullah & Wahyuningrum, 2025). This public rating system incentivizes firms to exceed mere compliance and actively engage in sustainable environmental practices (Nurkhaeriyah et al., 2019). For firms, such disclosure mechanisms are intended to create reputational incentives to strengthen environmental management beyond regulatory minima (Nurkhaeriyah et al., 2019).

Empirically, early evidence from Indonesia indicates a positive association between ISO 14001 implementation and PROPER outcomes, suggesting that EMS elements may map onto multiple PROPER evaluation aspects and support firms in pursuing stronger ratings (Nurkhaeriyah et al., 2019). However, broader EMS research consistently shows heterogeneous and sometimes symbolic effects of ISO 14001 certification, such that adoption may not reliably deliver measurable environmental improvements across different settings. Therefore, whether (and under what conditions) ISO 14001 certification causally contributes to higher PROPER ratings remains an open empirical issue (de Vries et al., 2012; Falqi et al., 2020; Johnstone et al., 2020; Nawrocka & Parker, 2009; Ngo, 2023; Zobel, 2013).

Despite the recognized role of ISO 14001 and PROPER in environmental governance, empirical evidence directly linking ISO 14001-based EMS adoption to PROPER ratings in Indonesia, particularly within the coal-mining subsector, remains limited. Existing sector-focused scholarship has predominantly concentrated on technical and biophysical environmental issues, such as post-mining landscape rehabilitation and acid mine drainage management, rather than on the interaction between voluntary environmental standards and national performance rating regimes (Abfertiawan et al., 2020; Nurkhaeriyah et al., 2019; Pratiwi et al., 2025).

More broadly, however, the literature tends to address public disclosure and reputational regulation, including PROPER-related outcomes, separately from analyses of the effects of ISO 14001 certification. While studies on disclosure-based regulation emphasize reputational incentives and performance signaling (Konar & Cohen, 1997; Nishitani et al., 2017; Novitasari & Tarigan, 2022; Prabawani & Hadi, 2022), research on ISO 14001 largely focuses on organizational or environmental performance outcomes in isolation (Heras-Saizarbitoria et al., 2011; Johnstone, 2022). Consequently, there is limited evidence on whether and how EMS implementation translates into sustained improvements in

PROPER ratings and associated environmental indicators over time.

Taken together, these gaps point to a lack of longitudinal and regime-linked empirical research capable of disentangling selection effects from treatment effects and clarifying the conditions under which ISO 14001 certification and environmental management controls generate substantive—rather than symbolic—performance changes, particularly in resource-intensive sectors within emerging-economy contexts (Heras-Saizarbitoria et al., 2011; Johnstone, 2022; Nishitani et al., 2017).

This study addresses this gap by analyzing the interaction between ISO 14001:2018 implementation and PROPER performance in the Indonesian coal mining sector over three years. The findings are expected to inform practitioners and policymakers about the conditions under which ISO 14001-based EMS is associated with improved performance within a national rating regime, while also addressing broader sustainability objectives relevant to water, climate, and terrestrial ecosystems.

LITERATURE REVIEW

Environmental management in Indonesia's industrial sectors is governed by a combination of voluntary standards and disclosure-based regulatory instruments, most prominently ISO 14001 and the national PROPER program. While both are often positioned as mechanisms to strengthen corporate environmental accountability, they operate through different governance logics and may have heterogeneous effects across sectors and institutional settings. ISO 14001 provides organizations with a systematic approach to managing environmental impacts through continual improvement, legal compliance, and stakeholder engagement, and has become one of the most widely adopted voluntary environmental standards globally (Alsadan, 2025; Benzidia et al., 2025; Boiral & Guillaumie, 2018).

A substantial body of research associates ISO 14001 certification with improvements in environmental practices and, in some cases, environmental performance, although the magnitude and robustness of these effects vary across sectors and institutional contexts (Heras-Saizarbitoria et al., 2011; Testa et al., 2018). Recent studies have further emphasized the dual role of ISO 14001: as a substantive governance tool that strengthens environmental management control systems and internal accountability, and as a symbolic or strategic mechanism to secure external legitimacy, manage risk, or influence capital markets (Alsadan, 2025; Johnstone, 2022; Liu et al., 2023). This ambivalence underpins institutional perspectives that distinguish between ceremonial adoption and genuinely embedded environmental management. Conceptually, ISO-based EMS routines can shape environmental outcomes through several mechanisms: strengthening compliance assurance (identifying obligations and controlling operational risks), improving measurement and documentation quality (monitoring, traceability, and auditability), and enabling organizational learning via corrective actions and management review cycles; however,

these pathways depend on implementation depth and organizational commitment.

In Indonesia, PROPER, administered by the Ministry of Environment and Forestry under the applicable regulatory framework during the study period, publicly evaluates corporate environmental performance through a color-coded rating scheme ranging from black to gold. The program builds on disclosure-based initiatives evaluated by García et al. (2007), who found that public disclosure under PROPER was associated with reductions in biochemical oxygen demand and chemical oxygen demand among participating firms. Thus, functions, PROPER serves as a reputational regulation instrument, consistent with classic arguments on information-based regulation and community right-to-know systems (Konar & Cohen, 1997).

More recent empirical work situates PROPER within the broader ESG and corporate sustainability debates. Using PROPER-listed firms, Novitasari and Tarigan (2022) show that corporate social responsibility can enhance green innovation and firm performance, highlighting PROPER's role as an environmental performance and disclosure benchmark in Indonesian capital markets. Other studies have linked PROPER ratings with corporate social innovation and stakeholder engagement, underscoring how reputational incentives may shape environmental initiatives beyond mere legal compliance (Ali & Widianingsih, 2025; Prabawani & Hadi, 2022). Collectively, this stream reinforces PROPER's function as an external incentive mechanism, although it offers limited clarity on whether the adoption of an internal management system translates into sustained improvements in rating trajectories over time.

Empirical research explicitly examining the relationship between ISO 14001 and PROPER remains limited and is largely descriptive or cross-sectional in nature. Nurkhaeriyah et al. (2019) found that ISO 14001 clauses align with several PROPER assessment aspects, suggesting that standardized EMS routines may facilitate compliance assurance and documentation relevant to rating outcomes. Complementary Indonesian studies further indicate that environmental performance proxied by PROPER is associated with financial outcomes and that ISO 14001-based EMS may support regulatory compliance, although evidence on direct financial benefits remains mixed (e.g., Ali & Widianingsih, 2025). Overall, these studies suggest potential complementarities between internal management systems and external rating regimes, but they rarely examine performance dynamics over time or explicitly address alternative explanations such as selection effects (firms with stronger prior commitment are more likely to certify) versus implementation-depth effects.

At the sectoral level, research on Indonesian coal and mineral extraction has largely prioritized technical and biophysical environmental issues—such as post-mining landscape rehabilitation, land degradation, and acid mine drainage—over governance instruments and rating mechanisms. For instance, Pratiwi et al. (2025) reviewed strategies for managing and reforesting degraded post-mining landscapes, while Abfertawan et al. (2020) assessed technical approaches to prevent acid mine drainage in open-pit coal mines. Although these studies document substantial environmental risks and remediation challenges, they do not

systematically investigate how firm-level EMS adoption interacts with PROPER ratings and other disclosure-based regulatory tools. Practitioner-oriented and grey literature sources on ISO 14001 implementation in mining exist; however, the empirical evidence remains fragmented and predominantly non-longitudinal.

Institutional and decoupling-oriented scholarship cautions that certification to standards such as ISO 14001 does not automatically lead to substantive environmental performance improvements. Heras-Saizarbitoria et al. (2011) demonstrate that the observed performance differences between certified and non-certified firms may partly reflect pre-existing environmental commitments rather than certification-driven effects. Emerald-published work by Johnstone (2022) similarly shows that environmental management control systems associated with ISO 14001 can support substantive change or remain largely symbolic, depending on their integration into broader sustainability governance and accountability. Notably, this body of work is largely based on European SMEs and rarely incorporates national public rating schemes such as the PROPER.

Taken together, the literature suggests that despite the recognized role of ISO 14001 and PROPER in Indonesia's environmental governance architecture, empirical evidence directly linking ISO 14001-based EMS adoption to PROPER ratings, particularly within the coal-mining subsector, remains scarce. Much of the existing research examines disclosure-based regulation and PROPER outcomes on the one hand (Konar & Cohen, 1997; García et al., 2007; Novitasari & Tarigan, 2022; Prabawani & Hadi, 2022) and the effects of ISO 14001 certification (Benzidia et al., 2025; Boiral & Guillaumie, 2018; Heras-Saizarbitoria et al., 2011; Johnstone, 2022), providing limited insight into whether EMS implementation is associated with sustained improvements in PROPER ratings and environmental indicators over time. Accordingly, regime-linked and time-sensitive evidence is needed to clarify when EMS routines and environmental management controls generate substantive—rather than symbolic—performance changes in resource-intensive sectors within emerging-economy contexts (Heras-Saizarbitoria et al., 2011; Johnstone, 2022; Nishitani et al., 2017). By explicitly linking ISO 14001 adoption, PROPER trajectories, and environmental performance metrics in Indonesian coal mining, this study addresses this gap.

METHODS

Research Design and Case Selection

This study adopts a single-case, convergent mixed-methods design to examine how ISO 14001 EMS implementation is associated with environmental performance trends and PROPER outcomes in Indonesia. The case is a major Indonesian coal mining company certified to ISO 14001 and selected because it

- (1) operates in an environmentally high-impact sector,
- (2) is subject to PROPER evaluation, and

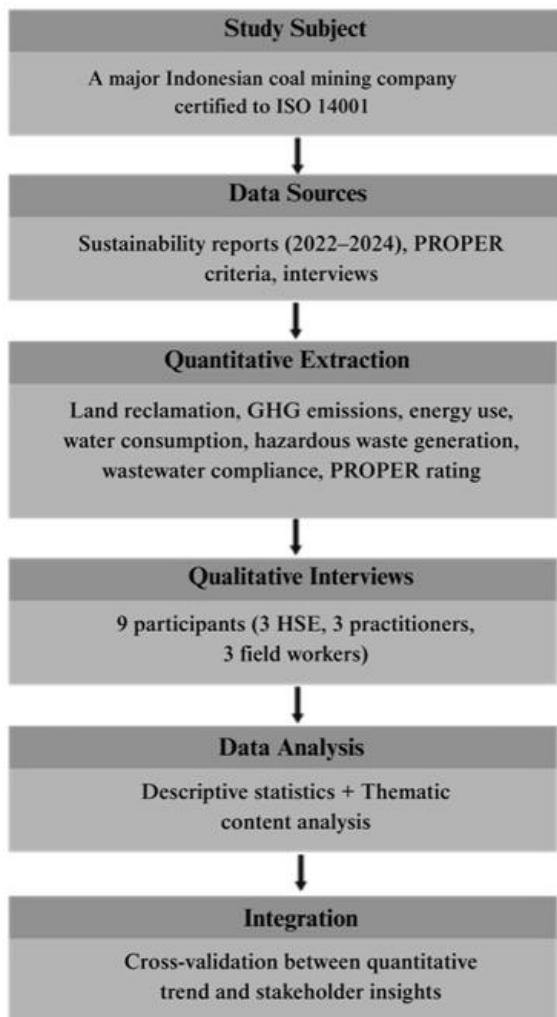


Figure 1. Research design and data integration process (Source: Authors' own elaboration)

- (3) publicly discloses environmental performance information through sustainability reports for three consecutive years (2022–2024).

Given the three-year observation window, the quantitative component focuses on descriptive trends and pattern comparison rather than statistical inference (Figure 1).

A convergent mixed-methods single-case design was applied, combining document-derived indicators from sustainability reports (2022–2024) and publicly available PROPER outcomes with semi-structured interviews ($n = 9$). Quantitative results were summarized through descriptive trend analysis and integrated with qualitative themes through triangulation and joint displays to identify convergence and divergence across data sources.

Data Sources

This study employs a mixed-evidence longitudinal single-case approach that integrates quantitative indicators and qualitative interview data to examine how ISO 14001:2018 implementation aligns with and provides governance context for environmental performance indicators and PROPER outcomes over time. This study focuses on a single Indonesian coal mining company that holds ISO 14001 certification and publicly discloses environmental information in its

sustainability reports for three consecutive years (2022–2024). Because the analysis is based on one firm observed over three annual points, this study prioritizes within-case temporal interpretation and triangulation rather than cross-firm statistical inference.

Quantitative data were extracted from the sustainability reports and consisted of annual indicators, including land reclamation area, GHG emissions, energy use, water use, hazardous waste generation, wastewater compliance, and the company's reported PROPER rating for each year. In addition, the study uses the relevant ministerial regulations and official PROPER guidelines issued by the Ministry of Environment and Forestry as a reference for the evaluation framework and assessment criteria.

In addition to sustainability reports, document-based qualitative data were obtained from ISO 14001 certification records, audit reports, and non-conformity record (NCR) summaries to capture the process-level evidence of EMS implementation.

Data Collection

Quantitative data were systematically extracted from publicly available sustainability reports. The selected indicators correspond to commonly monitored environmental aspects under ISO 14001 and performance domains assessed within the PROPER framework. A structured data matrix was compiled to organize the year-to-year patterns across the 2022–2024 period.

For qualitative insights, semi-structured interviews were conducted with a purposive sample of three internal informants representing key roles in environmental management and site operations: an HSE manager, an environmental practitioner, and a field worker. Informant selection prioritized individuals directly involved in environmental management oversight, compliance routines, documentation, and operational implementation at mining sites. Given the limited number of informants, the qualitative component was designed to support triangulation and contextual explanation rather than thematic saturation or statistical representation of the findings.

Interview data were organized through iterative coding, focusing on identifying recurring references to EMS routines, compliance-related practices, documentation processes, and implementation constraints. Coding was used to structure and summarize the interview evidence rather than to develop formal thematic typologies. All participants provided informed consent, and their identities were anonymized to protect their confidentiality (Table 1).

The interviews followed a thematic guide covering ISO 14001 implementation routines, perceived alignment with PROPER requirements, and indicators of substantive versus symbolic adoption in the daily operations. The interview recordings were transcribed verbatim and translated into English, where necessary, for analysis.

Data Analysis

Quantitative data were analyzed descriptively to summarize year-to-year patterns in environmental indicators alongside the company's reported PROPER status from 2022 to

Table 1. Participants

| Code | Role | Experience (years) |
|--------|--|--------------------|
| HSE-01 | HSE manager (Safety & environment department) | 12 |
| ENV-01 | Environmental practitioner (Environmental compliance department) | 8 |
| FW-01 | Field worker (Operations department–Mining site) | 5 |

Table 2. Core environmental performance indicators reported under the PROPER framework (2022-2024)

| Year | Land reclamation (ha) | GHG emissions (t CO ₂ -eq) | Energy use (GJ) | Water use (m ³) |
|------|-----------------------|---------------------------------------|-----------------|-----------------------------|
| 2022 | 5,050.06 | 109,437 | 315,242.19 | 3,893,551 |
| 2023 | 5,130.03 | 106,287 | 330,329.30 | 3,937,537 |
| 2024 | 5,222.84 | 109,015 | 343,295.28 | 3,056,593 |

Table 3. Compliance and regulatory performance under the PROPER regime (2022-2024)

| Year | Hazardous waste (tons) | Wastewater compliance (%) | PROPER rating |
|------|------------------------|---------------------------|------------------------|
| 2022 | 175.74 | 100 | Green |
| 2023 | 159.15 | 100 | Green (gold candidate) |
| 2024 | 193.15 | 100 | Green (gold candidate) |

2024. The analysis focused on identifying temporal patterns and changes in reported performance rather than testing statistical associations or causal relationships.

Qualitative interview data were organized through thematically informed coding to structure the informants' accounts of EMS routines, compliance-related practices, documentation processes, and implementation constraints. Coding was used to identify recurring references and organizational mechanisms relevant to ISO 14001 implementation and its interaction with PROPER-related routines, rather than to develop formal thematic typologies or theory-driven classifications.

Triangulation was applied by cross-referencing interview-based observations with sustainability report disclosures, document-based evidence (certification status, audit trajectories, and NCR records), and quantitative indicators reported in the PROPER framework. This process was used to assess the internal consistency across data sources and to support the contextual interpretation of observed patterns. Given the small number of informants, the qualitative findings are interpreted as targeted explanatory evidence rather than generalizable thematic results.

The analysis incorporates temporal sequencing and pattern matching to examine whether the observed PROPER trajectories and indicator changes are broadly consistent with documented EMS routines and governance processes without presuming causal attribution. This study follows an explanatory sequential design in which quantitative patterns are first summarized, followed by qualitative and document-based analyses to contextualize these patterns within the firm's environmental governance practices. Given the single-case design and limited time series, the analysis was descriptive and exploratory, rather than inferential.

RESULTS

Environmental Performance Outcomes Under the PROPER Regime (2022-2024)

This section presents environmental performance outcomes as assessed under Indonesia's PROPER program, a

disclosure-based reputational regulatory regime applied to selected high-impact firms. The indicators reported here represent performance outcomes evaluated by PROPER rather than the direct outputs of ISO 14001 implementation (**Table 2**).

The indicators in **Table 2** show the year-to-year variation in operational environmental loads and resource use across the observation period. Land reclamation increased steadily, and energy use rose alongside operational activity. GHG emissions fluctuated within a relatively narrow range, and water use declined substantially in 2024 compared to that in previous years.

Beyond operational environmental loads and resource use, PROPER assessments also emphasize compliance-based control outcomes and reputational ratings, which are presented in **Table 3**.

While operational environmental indicators exhibited year-to-year variations, wastewater compliance remained at 100% throughout the observation period. This compliance stability coincided with a consistent PROPER rating of green and a transition to green (gold candidate) status in 2023 and 2024.

Document-Based Evidence of ISO 14001 as an Internal Environmental Governance Mechanism

To contextualize the PROPER-assessed outcomes, this section presents document-based qualitative evidence on ISO 14001 implementation, focusing on certification continuity, audit trajectories, and NCRs as indicators of internal environmental governance processes.

- Certification status:** Document records indicate that the company maintained an active ISO 14001 certification throughout the observation period. The certification covered core coal mining operations as well as supporting and administrative functions, indicating the organization-wide applicability of the EMS. The continuity of certification across multiple years suggests that ISO 14001 was maintained as an ongoing management framework rather than as a one-off compliance exercise.

Table 4. Summary of document-based evidence on ISO 14001 implementation

| Evidence dimension | Period covered | Key observations | Analytical relevance |
|----------------------------|----------------|---|--------------------------------|
| Certification status | 2020-2026 | Certification maintained through surveillance and re-certification audits | Indicates continuity of EMS |
| Audit findings (NCR minor) | 2020-2021 | Minor NCRs related to documentation and routine monitoring | Early learning phase |
| Audit findings (NCR minor) | 2022-2025 | No minor NCRs reported | Stabilization of EMS routines |
| Audit findings (NCR major) | 2020-2025 | No major NCRs reported | Baseline systemic control |
| Scope of certification | Ongoing | Operations and administrative units covered | Organization-wide embeddedness |

Table 5. Summary of interview-based evidence on EMS practices

| Analytical focus | Interview evidence (summary) | Informant roles |
|---------------------------------|---|-----------------|
| EMS as operational framework | ISO 14001 referenced as a guiding structure for planning and operations | HSE, ENV, FW |
| Role differentiation | Distinct responsibilities across managerial, practitioner, and operational levels | HSE, ENV, FW |
| Documentation & audit readiness | Records prepared for audits and PROPER verification | HSE, ENV |
| Operational constraints | Resource limitations and regulatory changes noted | HSE, ENV, FW |

- b. **Audit trajectory:** Audit documentation shows that ISO 14001 implementation was subject to regular external evaluation through surveillance and recertification audits. Surveillance audits were conducted annually, followed by a formal recertification audit during the observation period. This audit trajectory reflects a repeated system review and external verification of EMS con-formity over time.
- c. **NCR pattern:** Analysis of audit records revealed the presence of minor NCRs during earlier surveillance audits, primarily related to documentation consistency and routine monitoring procedures. Importantly, no major NCRs were reported during the audit period. In subsequent audit cycles, minor NCRs were not recorded, indicating changes in the documented conformity status over time.

Table 4 shows the summary of document-based evidence on ISO 14001 implementation.

Interview-Based Insights into EMS Practices Under Reputational Regulatory Pressure

Interview findings provide insight into how ISO Interview findings provide insight into how ISO 14001-related routines are enacted in practice and how they support environmental management under PROPER's reputational regulatory framework.

Interviewees across different organizational roles described ISO 14001 as providing a structured reference framework that guides environmental management activities from planning to operational execution, as follows: HSE managers reported that implementation involved the systematic identification of environmental aspects, legal requirements, and stakeholder expectations, which informed internal planning and compliance routines, as follows:

Environmental practitioners have highlighted the role of ISO 14001's clause-based structure in clarifying responsibilities and organizing activities related to operational control, monitoring, training, and documentation. This structure reportedly supports consistency in environmental management practices across organizational units.

At the operational level, field workers described increased procedural clarity following repeated training and management communication related to environmental requirements, thereby supporting the application of standardized practices in daily operations.

Interviewees also emphasized the importance of documentation and record-keeping for audit and PROPER verification purposes, noting that the required records could be readily accessed during external assessments. In addition, the informants acknowledged ongoing challenges related to resource constraints and regulatory changes, which require continuous adjustments to environmental management routines.

Table 5 shows the summary of interview-based evidence on EMS practices.

DISCUSSION

Reinterpreting PROPER Outcomes as Reputational Regulatory Signals

In this study, PROPER is positioned as Indonesia's principal governmental instrument for environmental oversight and performance evaluation of industrial activities, administered by the Ministry of Environment and Forestry through annual assessments and public disclosures (KLHK, 2021). PROPER is treated not merely as a technical monitoring instrument but as an information-based, disclosure-driven reputational regulatory regime that evaluates selected firms through screening (penapisan) and annual public ratings (KLHK, 2021). Under ministerial regulation no. 1/2021, PROPER is explicitly framed as an evaluation of corporate environmental management performance, implemented through staged planning, implementation, rating determination, and follow-up (including recognition, supervision, and enforcement) (KLHK, 2021). In other words, PROPER operationalizes regulation by reputation by translating heterogeneous environmental practices into a publicly legible signal (e.g., green, green-gold candidate), which can affect legitimacy, stakeholder trust, and the perceived credibility of environmental governance (García et al., 2007).

Read through this lens, the results are best interpreted as evidence of compliance stability under reputational pressure, rather than as direct proof of absolute environmental improvement. From 2022 to 2024, the company's PROPER status remained Green, with a transition to green (gold candidate) in 2023-2024, while wastewater compliance remained at 100%. Meanwhile, several operational indicators (e.g., GHG emissions, energy use, and water use) fluctuated over the same period.

This pattern is analytically important because, like many information-based and disclosure-driven reputational regulatory systems, PROPER primarily converts auditable compliance capacity into a public reputational signal—i.e., documented and reported governance routines (including required reporting and compliance evidence) that can be screened and assessed—rather than requiring monotonic decreases in absolute impact indicators. This is consistent with the general logic of information-based regulation that operates through public ratings/rankings and compliance-oriented disclosures (Bowen et al., 2020; Hu et al., 2021), as well as the evidence that disclosure-based metrics and ratings often emphasize regulatory compliance (Huang et al., 2025). Consequently, in resource-intensive settings where absolute indicators can vary with operational scale and output, stable reputational signals and compliance narratives may coexist with non-monotonic absolute trends, especially when output changes can mechanically raise absolute emissions even if efficiency improves (Liu et al., 2023)

Placing this finding in a broader comparative context, reputational and disclosure-based environmental regulations are widely used internationally, including in both the Global North and Global South, although institutional designs differ. Classic evidence from the United States shows how community right-to-know mechanisms can function as regulation-by-information: once toxic release information becomes public, firms may reduce emissions to avoid reputational and stakeholder penalties (Konar & Cohen, 1997). In Europe, disclosure-centered governance is institutionalized through pollutant registers, most notably the European pollutant release and transfer register (E-PRTR) established under regulation (EC) no. 166/2006, which mandates systematic reporting and public access to facility-level pollutant information (European Parliament & Council of the European Union, 2006). At the multilateral level, the Kyiv protocol on PRTRs codifies the objective of enhancing public access to environmental information via coherent, nationwide registers (UNECE, 2003). In emerging economies, rating and disclosure programs have also been used explicitly as incentive devices. For example, China's GreenWatch program disseminates color-coded environmental ratings through media exposure and is frequently discussed as a disclosure-based regulatory strategy (Wang et al., 2004). Across these contexts, the common mechanism is the same: public signaling creates reputational stakes, which can stabilize compliance behaviors and sometimes induce improvements, even when conventional enforcement capacity is uneven. However, the evidence base is not uniformly optimistic: disclosure systems can be weakened by measurement and verification problems, and self-reported reductions do not always track independent environmental conditions (de Marchi & Hamilton, 2006).

Therefore, the present study's core interpretive contribution is not a claim that ISO 14001 caused environmental improvement, but that under a reputational regime like PROPER, stable ratings combined with persistent compliance are best read as indicators of governance stability, while trends in absolute environmental pressures should be interpreted cautiously and in relation to the operational context.

ISO 14001 as an Internal Governance Mechanism, Not a Performance Proxy

The results in Section 4.2 suggest that ISO 14001 should be interpreted primarily as an internal environmental governance infrastructure rather than as a direct proxy for absolute environmental performance outcomes. ISO 14001 is a management system standard that specifies organizational requirements for structuring environmental responsibilities, controls, documentation, internal auditing, and corrective actions; it does not prescribe uniform performance thresholds or fixed numerical targets (Reichel, 2020). Accordingly, the most appropriate evidence for ISO 14001 functioning in this case is process-oriented: certification continuity, audit trajectories, and the pattern of NCRs, rather than the direction of outcome indicators.

Document-based evidence indicates certification continuity supported by recurring third-party audits, including the completion of a re-certification audit in 2023 and a continued certification status thereafter. This is analytically important because prior research conceptualizes ISO 14001 certification as enabling an environmental management control system, whose operation often extends beyond the firm's boundaries through external auditing and institutional requirements (Johnstone, 2022). In this sense, audit cycles function as governance routines that sustain process integrity and enforce evidence-based control, even when production conditions in resource-intensive sectors are variable.

The NCR trajectory between 2020 and 2025 further illustrates the dynamic, rather than linear, character of ISO-based continual improvement. While minor NCR counts decreased to zero in 2022, minor NCRs re-emerged in subsequent audits, including during and after the 2023 recertification cycle. This pattern is consistent with broader scholarship showing that the relationship between certified EMS and observable environmental performance is mixed and context-dependent; certification can coexist with stable or even deteriorating outcome performance if controls are decoupled from operational realities (Mosgaard et al., 2022). In this case, the content of NCRs is especially revealing: recurring issues concentrate on competence and training documentation, compliance-register updating, monitoring records, and document-control practices—precisely the administrative and control infrastructure through which ISO 14001 operationalizes governance (Mosgaard et al. 2022).

Simultaneously, the broader empirical literature cautions against treating ISO 14001 as purely symbolic. Recent international panel evidence associates higher ISO 14001 adoption with lower energy intensity and reduced GHG emission rates, suggesting that certification can generate cumulative operational benefits when effectively integrated into organizational processes (Cestau-Oyhantçabal et al., 2025). Conversely, other recent studies highlight the risk that

certification and reputational incentives may coexist with superficial sustainability commitments and ESG greenwashing, underscoring the need to interpret certification evidence alongside the quality of internal controls and their operational embedding (Cheng & Yan, 2025). Taken together, the results are best read as evidence of internal governance capacity—visible through audit-based verification and the managed resolution of minor NCRs—rather than as a stand-alone measure of absolute environmental impact.

Substantive vs Symbolic Adoption: What Can (and Cannot) Be Inferred

A core debate in the ISO 14001 literature concerns whether certification reflects substantive integration of environmental management into routines and decision-making or symbolic adoption that is decoupled from operational change. Empirically, certification can coexist with heterogeneous implementation quality, and “having the certificate” does not automatically imply commensurate environmental outcomes, especially when performance is shaped by production intensity and sector-specific constraints. This distinction is central because the observable outputs of certification (audit artifacts and documented procedures) may signal governance efforts, while outcome indicators (e.g., emissions, energy, and water) may remain non-monotonic or even increase as the operational scale changes (Aravind & Christmann, 2011; Ferrón-Vílchez, 2017).

Read alongside this debate, the evidence supports a bounded substantiveness interpretation: the case shows credible internalization of EMS controls while stopping short of claiming direct outcome causality. The document-based record indicates certification continuity and an audit trail consistent with routinized governance, while the NCR profile remains low and manageable (i.e., minor NCRs recorded at low counts rather than escalating). Such patterns—particularly when linked to corrective actions and follow-up—are more consistent with an EMS that is operationally “kept alive” than with one that is maintained purely for ceremonial display. Simultaneously, prior research cautions that certification audits can overemphasize procedural and documentary compliance, meaning that the existence of audit evidence alone cannot be treated as proof of substantive environmental improvement (Heras-Saizarbitoria et al., 2013).

Interview evidence strengthens the inference that ISO 14001 is not merely symbolic in this case by showing that EMS practices are described as operating across organizational levels, from managerial planning and review cycles to practitioner documentation, training, and field-level operational controls. This aligns with broader institutional findings that external pressures can reinforce internal environmental management practices, while the extent of performance improvement remains contingent on the depth of practice embedding and resource allocation. Importantly, such accounts function as explanatory process evidence: they increase the plausibility that controls are enacted, but they do not, by themselves, establish that observed outcome indicators would have been lower in the absence of ISO 14001 (Cheng & Yan, 2025; Ngo, 2023).

Accordingly, what the present study can claim—conservatively and defensibly—is not that ISO 14001 “caused”

improved PROPER standing or reduced absolute impacts but that the combined evidence is sufficient to reject a symbolic-only interpretation. In disclosure- and reputation-sensitive environments, organizations may expand “talk” faster than “walk,” and the decoupling between qualitative governance claims and measurable environmental KPIs is well documented; this is precisely why strong causal claims require counterfactual designs, production-normalized metrics, or independent monitoring. In this case, the most rigorous position is that ISO 14001 appears to function as an internal governance infrastructure (controls, records, and corrective action routines) that plausibly supports compliance credibility, while absolute outcome trajectories remain analytically conditional on operational dynamics and should be interpreted cautiously (Ferrón-Vílchez, 2016b; Grueso-Gala & Camisón-Haba, 2025).

Contribution to Literature

This study contributes to the EMS and disclosure-based regulation literature in three ways: First, it offers a regime-linked interpretation that distinguishes ISO 14001 as an internal governance infrastructure from PROPER as a disclosure-driven reputational signal, clarifying why rating stability should not be considered as automatic evidence of monotonic impact reduction (Bowen et al., 2020; García et al., 2007; KLHK, 2021). Second, it moves beyond certified/non-certified comparisons by using process-trace evidence—certification continuity, audit trajectory, and NCR patterns—to assess EMS integrity over time, directly engaging in debates on audit variability and certification-performance decoupling (Aravind & Christmann, 2011; Heras-Saizarbitoria et al., 2013). Third, through triangulation with interview accounts, the study supports a bounded substantive inference: the evidence is insufficient for causal outcome claims yet strong enough to reject a symbolic-only interpretation of ISO 14001 adoption (Ferrón-Vílchez, 2016b; Prabawani & Hadi, 2022).

CONCLUSIONS

This study examined how ISO 14001-based environmental management practices relate to environmental performance indicators and PROPER outcomes in a longitudinal single-company case study of Indonesian coal mining. The results show that the firm maintained a stable PROPER standing across 2022-2024 with a shift to a higher standing category, while several absolute operational indicators have fluctuated over the same period. Rather than interpreting this pattern as direct proof of monotonic environmental improvement, this study treats PROPER as a disclosure-based reputational signal whose evaluative logic emphasizes verifiable compliance and governance credibility.

Document-based evidence—certification continuity, audit follow-up, and a controlled NCR profile—indicates that the EMS was actively maintained through routinized governance mechanisms, including corrective action and documented controls. Interview evidence further suggests that these routines are enacted across multiple organizational levels, supporting a conservative inference of bounded substantiveness: the evidence is insufficient to establish that

ISO 14001 causally reduced absolute impacts or directly produced higher PROPER standings, yet it is strong enough to reject a symbolic-only interpretation of adoption.

The main implication of this study is interpretive: in reputational regulatory contexts, stable external ratings may reflect sustained governance and compliance capacity, even when absolute indicators fluctuate with production dynamics. Practically, this underscores the importance of strengthening internal control loops (monitoring, documentation, corrective action) as a foundation for credible compliance under disclosure pressure, while recognizing that demonstrating absolute impact reductions may require complementary metrics (e.g., production-normalized intensities) and longer time horizons. Future research should test these mechanisms across multiple firms and longer periods, incorporate independent monitoring data where feasible, and address selection effects and counterfactuals that single-case designs cannot resolve.

Author contributions: **FF:** conceptualization, methodology, data curation, formal analysis, writing – original draft; **S:** validation, formal analysis; **SRB:** supervision, writing – review & editing. All authors reviewed and approved the final version of the manuscript.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that no ethical approval was required for this study. The study did not involve human subjects in a clinical or experimental context. The study was based on organizational data and professional interviews, and all participants provided informed consent.

AI statement: The authors stated that no generative AI or AI-based tools were used in the preparation of this manuscript.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from corresponding author.

REFERENCES

- Abfertiawan, M. S., Palinggi, Y., Handajani, M., & Pranoto, K. (2020). Evaluation of non-acid-forming material layering for the prevention of acid mine drainage of pyrite and jarosite. *Heliyon*, 6(11), Article e05590. <https://doi.org/10.1016/j.heliyon.2020.e05590>
- Ali, V. P., & Widianingsih, L. P. (2025). The effect of green investment on the disclosure of carbon emissions from SRI-Kehati companies. *Jurnal Ekuilnoma*, 7(1), 34-44. <https://doi.org/10.36985/6g5x9859>
- Alsadan, A. (2025). Strategic adoption of ISO 14001 certification and stock price crash risk. *International Review of Economics & Finance*, 102, Article 104250. <https://doi.org/10.1016/j.iref.2025.104250>
- Aravind, D., & Christmann, P. (2011). Decoupling of standard implementation from certification: Does quality of ISO 14001 implementation affect facilities' environmental performance? *Business Ethics Quarterly*, 21(1), 73-102. <https://doi.org/10.5840/beq20112114>
- Arocena, P., Orcos, R., & Zouaghi, F. (2023). The scope of implementation of ISO 14001 by multinational enterprises: The role of liabilities of origin. *Journal of Environmental Management*, 327, Article 116844. <https://doi.org/10.1016/j.jenvman.2022.116844>
- Benzidia, S., Rahoui, S., Ouiakoub, M., & Rostan, L. (2025). ISO 14001 and corporate financial performance: A systematic literature review. *Business Strategy and the Environment*, 34(1), 259-275. <https://doi.org/10.1002/bse.3969>
- Blondeel, M., & Van de Graaf, T. (2018). Toward a global coal mining moratorium? A comparative analysis of coal mining policies in the USA, China, India and Australia. *Climatic Change*, 150(1-2), 89-101. <https://doi.org/10.1007/s10584-017-2135-5>
- Boiral, O., & Guillaumie, L. (2018). Adoption and outcomes of ISO 14001: A systematic review. *Journal of Environmental Management*, 213, 629-636. <https://doi.org/10.1016/j.jenvman.2018.01.071>
- Bowen, F., Tang, S., & Panagiotopoulos, P. (2020). A classification of information-based environmental regulation: Voluntariness, compliance and beyond. *Science of the Total Environment*, 712, Article 135571. <https://doi.org/10.1016/j.scitotenv.2019.135571>
- Cestau-Oyhantçabal, R., & Arocena, P. (2025). Greener standards, cleaner production? Empirical evidence from ISO 14001 adoption. *Energy Efficiency*, 18, Article 111. <https://doi.org/10.1007/s12053-025-10400-7>
- Chen, D., & Li, X. (2024). Systematic assessment of source identification and ecological and probabilistic health risks of potentially toxic elements (PTEs) in soils of a typical coal mining area in Guanzhong Region. *Heliyon*, 10(17), Article e36301. <https://doi.org/10.1016/j.heliyon.2024.e36301>
- Cheng, Z., & Yan, X. (2025). Environmental management system certification and corporate ESG greenwashing. *Energy Economics*, 149, Article 108800. <https://doi.org/10.1016/j.eneco.2025.108800>
- da Fonseca, L. M. C. M. (2015). ISO 14001:2015: An improved tool for sustainability. *Journal of Industrial Engineering and Management*, 8(1), 35-50. <https://doi.org/10.3926/jiem.1298>
- de Marchi, S., & Hamilton, J. T. (2006). Assessing the accuracy of self-reported data: An evaluation of the toxics release inventory. *Journal of Risk and Uncertainty*, 32(1), 57-76. <https://doi.org/10.1007/s10797-006-6666-3>
- de Vries, H. J., Bayramoglu, D. K., & van der Wiele, T. (2012). Business and environmental impact of ISO 14001. *International Journal of Quality & Reliability Management*, 29(4), 425-435. <https://doi.org/10.1108/02656711211224866>
- Deswanto, R. B., & Siregar, S. V. (2018). The associations between environmental disclosures with financial performance, environmental performance, and firm value. *Social Responsibility Journal*, 14(1), 180-193. <https://doi.org/10.1108/SRJ-01-2017-0005>

- European Parliament & Council of the European Union. (2006). Regulation (EC) no. 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European pollutant release and transfer register (E-PRTR). *Official Journal of the European Union*. <https://eur-lex.europa.eu/eli/reg/2006/166/oj/eng>
- Falqi, I., Alsulamy, S., & Mansour, M. (2020). Environmental performance evaluation and analysis using ISO 14031 guidelines in construction sector industries. *Sustainability*, 12(5), Article 1774. <https://doi.org/10.3390/su12051774>
- Ferrón-Vílchez, V. (2016a). Does symbolism benefit environmental and business performance in the adoption of ISO 14001? *Journal of Environmental Management*, 183, 882-894. <https://doi.org/10.1016/j.jenvman.2016.09.047>
- Ferrón-Vílchez, V. (2016b). The dark side of ISO 14001: The symbolic environmental behavior. *European Research on Management and Business Economics*, 23(1), 33-39. <https://doi.org/10.1016/j.iedeen.2016.09.002>
- Ferrón-Vílchez, V. (2017). The dark side of ISO 14001: The symbolic environmental behavior. *European Research on Management and Business Economics*, 23(1), 33-39. <https://doi.org/10.1016/j.iedeen.2016.09.002>
- García, J. H., Sterner, T., & Afsah, S. (2007). Public disclosure of industrial pollution: The PROPER approach for Indonesia? *Environment and Development Economics*, 12(6), 739-756. <https://doi.org/10.1017/S1355770X07003920>
- Grueso-Gala, M., & Camisón-Haba, S. (2025). The role of reputation and regulation in shaping non-financial information reporting. *Administrative Sciences*, 15(5), Article 174. <https://doi.org/10.3390/admsci15050174>
- Heras-Saizarbitoria, I., Dogui, K., & Boiral, O. (2013). Shedding light on ISO 14001 certification audits. *Journal of Cleaner Production*, 51, 88-98. <https://doi.org/10.1016/j.jclepro.2013.01.040>
- Heras-Saizarbitoria, I., Molina-Azorín, J. F., & Dick, G. P. M. (2011). ISO 14001 certification and financial performance: Selection-effect versus treatment-effect. *Journal of Cleaner Production*, 19(1), 1-12. <https://doi.org/10.1016/j.jclepro.2010.09.002>
- Hu, Y., Sun, S., & Dai, Y. (2021). Environmental regulation, green innovation, and international competitiveness of manufacturing enterprises in China: From the perspective of heterogeneous regulatory tools. *PLoS ONE*, 16(3), Article e0249169. <https://doi.org/10.1371/journal.pone.0249169>
- Huang, H., & Huang, X. (2025). Unlocking ESG performance: How qualified foreign institutional investors enhance corporate sustainability in China's capital markets. *Sustainability*, 17(18), Article 8303. <https://doi.org/10.3390/su17188303>
- Johnson, D. B., & Hallberg, K. B. (2005). Acid mine drainage remediation options: A review. *Science of the Total Environment*, 338(1-2), 3-14. <https://doi.org/10.1016/j.scitotenv.2004.09.002>
- Johnstone, L. (2022). The means to substantive performance improvements: The role of ISO 14001 standardisation, control systems and the environmental management system. *Sustainability Accounting, Management and Policy Journal*, 13(5), 1082-1104. <https://doi.org/10.1108/SAMPJ-11-2021-0456>
- Johnstone, L., Hallberg, P., & Serra, A. (2020). The construction of environmental performance in ISO 14001-certified SMEs. *Journal of Cleaner Production*, 263, Article 121559. <https://doi.org/10.1016/j.jclepro.2020.121559>
- Kementerian Lingkungan Hidup dan Kehutanan Republik Indonesia (KLHK). (2021). *Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor 1 Tahun 2021 tentang Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup (PROPER)* [Regulation of the Minister of Environment and Forestry Number 1 of 2021 concerning the Corporate Performance Rating Assessment Program in Environmental Management (PROPER)].
- Konar, S., & Cohen, M. A. (1997). Information as regulation: The effect of community right-to-know laws on toxic emissions. *Journal of Environmental Economics and Management*, 32(1), 109-124. <https://doi.org/10.1006/jeem.1996.0955>
- Liu, Y., Zhang, X., & Pan, X. (2023). Carbon emissions and efficiency dynamics under production scale effects. *Sustainability*, 15(22), Article 15912. <https://doi.org/10.3390/su152215912>
- Mensah, S. K., Nyantakyi, E. K., Mensah, G. S., Siabi, E. K., Ackerson, N. O. B., Antwi-Agyei, P., Donkor, P., Siabi, S. E., Bandoh, T., Owusu, P. A., & Vuu, C. (2025). Assessing the environmental and socio-economic impacts of small-scale mining activities in the Atiwa East District of Ghana. *Scientific African*, 27, Article e02542. <https://doi.org/10.1016/j.sciaf.2025.e02542>
- Mercado-Garcia, D., & Wallace, G. W. (2018). Freshwater ecosystem services in mining regions: Modelling options for policy development support. *Water*, 10(4), Article 531. <https://doi.org/10.3390/w10040531>
- Meutia, D. B. A. A. (2023). Environment degradation, health threats, and legality at the artisanal small-scale gold mining sites in Indonesia. *International Journal of Environmental Research and Public Health*, 20(18), Article 6774. <https://doi.org/10.3390/ijerph20186774>
- Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology*, 83(2), 340-363. <https://doi.org/10.1086/226550>
- Mosgaard, M. A., Bundgaard, A. M., & Kristensen, H. S. (2022). ISO 14001 practices: A study of environmental objectives in Danish organizations. *Journal of Cleaner Production*, 331, Article 129799. <https://doi.org/10.1016/j.jclepro.2021.129799>
- Nawrocka, D., & Parker, T. (2009). Finding the connection: Environmental management systems and environmental performance. *Journal of Cleaner Production*, 17(6), 601-607. <https://doi.org/10.1016/j.jclepro.2008.10.003>

- Ngo, Q.-H. (2023). Do environmental management practices mediate institutional pressures-environmental performance relationship? Evidence from Vietnamese SMEs. *Heliyon*, 9(7), Article e17635. <https://doi.org/10.1016/j.heliyon.2023.e17635>
- Nishitani, K., Jannah, N., & Kaneko, S. (2017). Does corporate environmental performance enhance financial performance? An empirical study of Indonesian firms. *Environmental Development*, 23, 10-21. <https://doi.org/10.1016/j.envdev.2017.06.003>
- Novitasari, M., & Tarigan, Z. J. H. (2022). The role of green innovation in the effect of corporate social responsibility on firm performance. *Economies*, 10(5), Article 117. <https://doi.org/10.3390/economies10050117>
- Nurkhaeriyah, F. R., Nurcahyo, R., & Dachyar, M. (2019). Descriptive relationship analysis between the Program for Pollution Control Evaluation and Rating (PROPER) and ISO 14001. *IOP Conference Series: Materials Science and Engineering*, 598(1), Article 012091. <https://doi.org/10.1088/1757-899X/598/1/012091>
- Pattanayak, S. K., Wunder, S., & Ferraro, P. J. (2010). Show me the money: Do payments supply environmental services in developing countries? *Review of Environmental Economics and Policy*, 4(2). <https://doi.org/10.1093/reep/req006>
- Pratiwi, S., Narendra, B. H., Siregar, C. A., Iskandar, Mulyanto, B., Suwardi, Suryaningtyas, D. T., Dharmawan, I. W. S., Suharti, S., & Marsandi, F. (2025). Tin mining and post-tin mining reclamation initiatives in Indonesia: With special reference to Bangka Belitung areas. *Land*, 14(10), Article 1947. <https://doi.org/10.3390/land14101947>
- Prabawani, B., & Hadi, S. P. (2022). Sustainability indicator: An initial parameter for convenience product. *Jurnal Presipitasi: Media Komunikasi dan Pengembangan Teknik Lingkungan*, 19(1), 179-189. <https://doi.org/10.14710/presipitasi.v19i1.179-189>
- Pudasainee, D., Kurian, V., & Gupta, R. (2020). Coal: Past, present, and future sustainable use. In *Future energy: Improved, sustainable and clean options for our planet* (3rd Edn., pp. 21-48). <https://doi.org/10.1016/B978-0-08-102886-5.00002-5>
- Rahmatullah, G. P., & Wahyuningrum, I. F. S. (2025). Environmental disclosure practices in manufacturing sector in developing countries: Evidence from Indonesia. *E3S Web of Conferences*, 650, Article 02049. <https://doi.org/10.1051/e3sconf/202565002049>
- Reichel, J. (2020). ISO 14001 standard. In *Encyclopedia of sustainable management*. Springer. https://doi.org/10.1007/978-3-030-02006-4_319-1
- Riillo, C. A. F. (2025). ISO 14001 and innovation: Environmental management system and signal. *Technological Forecasting and Social Change*, 215, Article 124000. <https://doi.org/10.1016/j.techfore.2025.124000>
- Testa, F., Miroshnychenko, I., Barontini, R., & Frey, M. (2018). Does it pay to be a greenwasher or a brownwasher? *Business Strategy and the Environment*, 27(7), 1104-1116. <https://doi.org/10.1002/bse.2058>
- United Nations Economic Commission for Europe (UNECE). (2003). *Protocol on Pollutant Release and Transfer Registers (PRTRs)*. Kyiv. https://unece.org/DAM/env/pp/prtr/docs/PRTR_Protocol_e.pdf
- von Döhren, P., & Haase, D. (2023). Ecosystem services for planning post-mining landscapes using the DPSIR framework. *Land*, 12(5), Article 1077. <https://doi.org/10.3390/land12051077>
- Wang, H., Bi, J., Wheeler, D., Wang, J., Cao, D., Lu, G., & Wang, Y. (2004). Environmental performance rating and disclosure: China's GreenWatch program. *Journal of Environmental Management*, 71(2), 123-133. <https://doi.org/10.1016/j.jenvman.2004.01.007>
- Zobel, T. (2013). ISO 14001 certification in manufacturing firms: A tool for those in need or an indication of greenness? *Journal of Cleaner Production*, 43, 37-44. <https://doi.org/10.1016/j.jclepro.2012.12.014>