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A LEGAL REVIEW OF CRIMINAL PROCEDURAL LAW REGARDING THE COMPLEXITY OF PROVING THE ELEMENT OF ECOLOGICAL LOSS IN COURT PROCEEDINGS

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ARTICLE INFORMATION	ABSTRACT
Keywords: *Criminal Procedure Law; Criminal Evidence; Environmental Crime; Ecological Loss; Scientific Evidence.* **How to quote:** Rakhman, Habibul. (2026). A Legal Review of Criminal Procedural Law Regarding the Complexity of Proving the Element of Ecological Loss in Court Proceedings, *Critical Legal System,* 1 (2), 124-140. **DOI:** https://doi.org/10.68113/ngfbk826	*Environmental protection and management constitute an essential pillar for ensuring the human right to a good and healthy environment. In practice, environmental criminal law enforcement frequently encounters evidentiary obstacles at trial because ecological loss is technical, cumulative, and scientifically complex. This article examines the position and challenges of Indonesian criminal procedure, particularly Law Number 20 of 2025 on the Criminal Procedure Code, in accommodating proof of ecological loss. Using normative legal research with statutory and conceptual approaches, the study assesses the relationship between the expanded evidentiary regime under Article 235 of the new Criminal Procedure Code and the evidentiary needs of environmental crimes. The analysis finds a persistent gap between the complexity of environmental offences and conventional judicial assessment. Scientific evidence, including laboratory testing, sampling protocols, pollutant-dispersion modelling, remote-sensing data, and environmental-economic valuation, often becomes decisive, yet judges and prosecutors may lack sufficient methodological literacy to evaluate its reliability. The problem becomes more acute in a battle of experts and in cases involving multiple sources of pollution, where causal attribution cannot always be established through linear and exclusive proof. The article argues for an objective validation standard, stronger judicial gatekeeping, court-appointed independent experts, and proportionate disclosure duties for corporations controlling technical data. Its novelty lies in linking the open evidentiary model of the 2025 Criminal Procedure Code with a specific procedural framework for scientific evidence in environmental criminal adjudication. Such reform is necessary to strengthen legal certainty, material truth, and ecological justice.*

A. Introduction

The Unitary State of the Republic of Indonesia guarantees everyone the right to a good and healthy environment, as affirmed in Article 28H paragraph (1) of the 1945 Constitution of the Republic of Indonesia. This constitutional guarantee places environmental protection among the obligations of the state, carried out through prevention, supervision, restoration, and law enforcement. Its

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principal regulatory framework is Law Number 32 of 2009 concerning Environmental Protection and Management, which combines administrative, civil, and criminal instruments.[1] Developments in environmental policy show that emission-reduction targets, natural-resource management, and economic development do not always proceed in harmony.[2] This condition requires environmental law to provide enforcement mechanisms capable of protecting the public interest and the sustainability of ecological functions.[3]

Environmental crimes have characteristics that differ from conventional offences. The effects of pollution and environmental destruction may emerge gradually, extend across large areas, affect many victims, and persist across generations.[4] Activities in forest areas, mining, textile manufacturing, energy production, and development projects may create ecological consequences that become apparent only after a considerable period.[5] Law enforcement concerning pollution of the Cikijing River demonstrates that the relationship between industrial activity, changes in environmental quality, and losses suffered by communities requires examination beyond ordinary observation.[6] The offender may also be a corporation operating through divided authority, internal policies, and layered operational decisions.[7] These characteristics raise questions about the responsible party, the form of fault, and the relationship between corporate decisions and the resulting damage.[8]

The problem becomes more pronounced when a case enters the evidentiary stage of a criminal trial. Article 235 paragraph (1) of Law Number 20 of 2025 concerning the Criminal Procedure Code provides that lawful evidence includes witness testimony, expert testimony, documents, the defendant's statement, physical evidence, electronic evidence, judicial observation, and anything

[1] Andri Gunawan Wibisana, "Tentang Ekor Yang Tak Lagi Beracun: Kritik Konseptual Atas Sanksi Administratif Dalam Hukum Lingkungan Di Indonesia," *Jurnal Hukum Lingkungan Indonesia* 6, no. 1 (2019): 41–71, https://doi.org/https://doi.org/10.38011/jhli.v6i1.123.

[2] Syaharani and Muhammad Alfitras Tavares, "Nasib Target Emisi Indonesia : Pelemahan Instrumen Lingkungan Hidup Di Era Pemulihan Ekonomi Nasional," *Jurnal Hukum Lingkungan Indonesia* 7, no. 1 (2020): 1–27, https://doi.org/https://doi.org/10.38011/jhli.v7i1.212.

[3] Ardianto Budi Rahmawan and Kenny Cetera, "Kajian Teori Public Trust Doctrine Dalam Kasus Lingkungan : Studi Kasus UU Minerba Baru," *Jurnal Hukum Lingkungan Indonesia* 7, no. 1 (2020): 28–47, https://doi.org/https://doi.org/10.38011/jhli.v7i1.178.

[4] Suparjo Sujadi, "Kajian Tentang Pembangunan Proyek Strategis Nasional (PSN) Dan Keadilan Sosial (Perspektif Hukum Pancasila)," *Jurnal Hukum Lingkungan Indonesia* 4, no. 2 (2018): 1–24, https://doi.org/https://doi.org/10.38011/jhli.v4i2.68.

[5] Dalila Doman and Nadia Doman, "Penerapan Prinsip Pembangunan Berkelanjutan Dan Ekonomi Berwawasan Dalam Peraturan Perundang- Undangan Penggunaan Kawasan Hutan Dalam Rangka PSN Pasca Pengesahan Perpres 66 / 2020," *Jurnal Hukum Lingkungan Indonesia* 7, no. 1 (2020): 71–97, https://doi.org/https://doi.org/10.38011/jhli.v7i1.222.

[6] Agung Kurniawan Sihombing, "Penegakan Hukum Terhadap Pencemaran Lingkungan Di Sungai Cikijing, Jawa Barat Akibat Aktivitas Industri Tekstil PT. Kahatex," *Jurnal Hukum Lingkungan Indonesia* 7, no. 1 (2020): 98–117, https://doi.org/https://doi.org/10.38011/jhli.v7i1.209.

[7] Yeni Widowaty, "Pertanggungjawaban Pidana Korporasi Terhadap Korban Dalam Kasus Tindak Pidana Lingkungan Hidup," *Jurnal Yudisial* 5, no. 2 (2012): 154–69, https://doi.org/https://doi.org/10.29123/jy.v5i2.152.

[8] Nuzul Qur'aini Mardiya, "The Regulation of Corporate Liability in Environmental Criminal Act," *Jurnal Hukum Dan Peradilan* 7, no. 3 (2018): 483–502, https://doi.org/https://doi.org/10.25216/jhp.7.3.2018.483-502.

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else that may be used for evidentiary purposes, provided that it was obtained lawfully. This formulation broadens the means available to public prosecutors to explain the occurrence of an environmental crime. Laboratory results may be presented through documents and expert testimony; satellite imagery or monitoring recordings may be introduced as electronic evidence; and soil, water, air, or waste samples may be submitted as physical evidence. Judicial observation may also assist in assessing the correspondence among the evidence presented at trial. Article 235 paragraph (1) primarily regulates the types of evidence and the basis for their use; it does not yet provide specific standards for assessing the quality of scientific evidence. Expert testimony and test results must still be examined in terms of methodological accuracy, sampling procedures, chain of custody, possible error, reproducibility, and consistency with other facts established at trial.[9]

Ecological loss cannot always be detected through the senses. Groundwater contamination by hazardous and toxic waste, increased concentrations of particular substances in the air, changes in soil quality, the death of biota, and declining ecosystem functions require scientific expertise. Investigators must determine the place and time of sampling, preserve the chain of custody, use laboratories that meet applicable standards, and explain the relationship between test results and the alleged conduct. A study of environmental criminal judgments issued between 2009 and 2020 shows that scientific evidence has been used, although judicial approaches to assessing it and relating it to the precautionary principle have not always been consistent.[10] Experience in other jurisdictions likewise demonstrates the need for criteria by which the relevance and reliability of a method can be examined before scientific results are used as the basis of a judgment.[11]

A further difficulty arises when the parties present experts whose opinions conflict. The prosecution expert may state that an environmental quality standard has been exceeded, whereas the defence expert may challenge the sampling location, the testing equipment, or the causal conclusion. Such disagreement may shift the examination away from the damage that occurred and towards the experts' ability to present their views. This issue concerns the application of liability for pollution, which must remain grounded in evidence capable of being tested.[12] In

[9] Aryanto and Tanudjaja, "Tinjauan Yuridis Pertanggungjawaban Pidana Dan Proses Pembuktian Perempuan Sebagai Kurir Narkotika Dalam KUHAP Dan UU Narkotika," *Jurnal Ilmu Hukum, Humaniora Dan Politik* 6, no. 3 (2026): 2513–23, https://doi.org/https://doi.org/10.38035/jihhp.v6i3.8229.

[10] Fachrizal Afandi et al., "Penggunaan Bukti Ilmiah Dan Penerapan Prinsip Kehati-Hatian Dalam Putusan Perkara Pidana Materiil Lingkungan Hidup Di Indonesia Tahun 2009 – 2020," *Jurnal Hukum Lingkungan Indonesia* 9, no. 1 (2022): 77–120, https://doi.org/https://doi.org/10.38011/jhli.v9i1.500.

[11] Windu Kisworo, "Aplikasi Prinsip-Prinsip Terkait Bukti Ilmiah (Scientific Evidence) di Amerika Serikat Dalam Pembuktian Perkara Perdata Lingkungan di Indonesia," *Jurnal Hukum Lingkungan Indonesia* 5, no. 1 (2018): 24–59, https://doi.org/https://doi.org/10.38011/jhli.v5i1.74.

[12] Diah Ayu Rachma and Aditya Mochamad Triwibowo, "Implementation Of Strict Liability Principles In Environmental Law Enforcement In Indonesia," *Jurnal Yudisial* 16, no. 1 (2023): 103–20, https://doi.org/https://doi.org/10.29123/jy.v16i1.574.

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corporate cases, the difficulty increases because production-process records, operational data, and waste-treatment systems are generally controlled by the company.[13]

Proving causation is the most difficult aspect of material environmental offences. A single river may receive pollutant loads from several facilities, soil contamination may result from activities accumulated over many years, and forest damage may be influenced by several interconnected acts. It is not sufficient for the public prosecutor merely to show that the environment has been damaged; the consequence must be linked to the defendant's conduct in accordance with the elements of the charged offence. A standard requiring a single pollution source and mathematical certainty may prevent liability for pollution arising from multiple sources. Conversely, a causal link based only on conjecture would diminish protection of the defendant's rights. Causation must therefore be assessed through a body of data demonstrating consistency among the type of pollutant, the defendant's activity, the timing of the event, the pathway of dispersion, and the ecological consequence, without abandoning the purpose of criminal procedure to discover material truth through a fair process.[14]

Previous studies have addressed particular aspects of environmental criminal-law enforcement. Daniel, Hawari, and Handayani examined the reorientation of enforcement through deferred prosecution agreements, particularly as a means of encouraging compliance and environmental restoration.[15] Pardede and Santoso analysed the use of restorative justice in handling environmental crimes and the limits of its application to the interests of victims and the damaged environment.[16] Kusuma, Yanuari, and Pratama focused on integrating environmental restoration costs into criminal fines so that sanctions do not end with the punishment of the offender.[17] These three studies strengthen the discussion of enforcement policy, settlement, and restoration, but they do not connect the expansion of evidence under Article 235 paragraph (1) of the 2025 Criminal Procedure Code with procedural standards for assessing the reliability of scientific evidence and the causation of ecological loss. This unexamined area constitutes the research gap addressed by this article.

The need to reform criminal procedure is also connected with information disclosure, policy supervision, and access to environmental data. Adequate information assists communities,

[13] Hariman Satria, "Penerapan Pidana Tambahan Dalam Pertanggungjawaban Pidana Korporasi Pada Tindak Pidana Lingkungan Hidup," *Jurnal Yudisial* 10, no. 5 (2017): 155–71, https://doi.org/https://doi.org/10.29123/jy.v10i2.18.

[14] Eddy O.S. Hiariej, *Teori Dan Hukum Pembuktian* (Jakarta: Erlangga, 2012).

[15] Azam Hawari, Deni Daniel, and Marsya Mutmainah Handayani, "Reorientasi Penegakan Hukum Pidana Lingkungan Hidup Melalui Perjanjian Penangguhan Penuntutan," *Jurnal Hukum Lingkungan Indonesia* 6, no. 1 (2019): 72–96, https://doi.org/https://doi.org/10.38011/jhli.v6i1.148.

[16] Josua Navirio Pardede and Wahyu Yun Santoso, "Refleksi Kritis Terhadap Konsep Keadilan Restoratif Dalam Penanganan Tindak Pidana Lingkungan Hidup Di Indonesia," *Jurnal Hukum Lingkungan Indonesia* 8, no. 2 (2022): 263–86, https://doi.org/https://doi.org/10.38011/jhli.v8i2.390.

[17] Daffa Prangsi R. W. Kusuma, Fira Saputri Yanuari, and Rizki Iman Faiz Pratama, "Urgensi Integrasi Biaya Pemulihan Lingkungan Dalam Sanksi Pidana Denda," *Jurnal Hukum Lingkungan Indonesia* 8, no. 2 (2022): 287–309, https://doi.org/https://doi.org/10.38011/jhli.v8i2.413.

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investigators, and experts in tracing pollution sources and testing business compliance.[18] Experience in the palm-oil sector shows that governance decisions and licensing documents can affect the effectiveness of supervision.[19] In the energy sector, complete technical data are required to assess technological changes and their environmental effects. The handling of waste imports also demonstrates the considerable evidentiary importance of transportation documents, the origin of goods, and control over the material. Changes in the circumstances of a business entity, including bankruptcy, must not eliminate the legal basis for carrying out restoration obligations. Taken together, these circumstances show that criminal proof is influenced by data quality, the governance of activities, and the continuity of environmental policy.[20]

On that basis, this article addresses two issues. First, it examines the status and challenges of scientific evidence in establishing a causal relationship between the defendant's conduct and ecological loss. Second, it examines the direction of criminal-procedure reform required so that the assessment of scientific evidence can produce legal certainty and ecological justice.

The novelty of this research lies in formulating the relationship between the more open evidentiary model established by Article 235 paragraph (1) of the 2025 Criminal Procedure Code and the need for a specific mechanism to validate scientific evidence in environmental criminal cases. Scientific evidence is not treated merely as expert testimony or a document, but as a sequence beginning with sample integrity, methodological reliability, data disclosure, and the testing of expert opinion, and ending with its connection to the causation of ecological loss. From that sequence, the article formulates stronger judicial screening, the use of court-appointed independent experts, proportionate duties to disclose technical data, and guidelines for assessing scientific evidence. All proposals remain situated within a criminal evidentiary system that protects the presumption of innocence and the public prosecutor's duty to prove the charge.

B. Methods

This research is normative legal research with a prescriptive character. It applies statutory and conceptual approaches. Primary legal materials include the 1945 Constitution of the Republic of Indonesia, Law Number 32 of 2009 concerning Environmental Protection and Management, Law Number 20 of 2025 concerning the Criminal Procedure Code, and regulations relating to environmental quality standards and environmental evidence. Secondary legal materials consist of

[18] Nadira Tatyana and Achmad Ramadhandy Y. Putra, "Pemenuhan Hak Atas Akses Informasi Lingkungan Hidup Dan Partisipasi Publik Terhadap Pencemaran Udara DKI Jakarta," *Jurnal Hukum Lingkungan Indonesia* 8, no. 2 (2022): 372–401, https://doi.org/https://doi.org/10.38011/jhli.v8i2.420.

[19] Adrianus Eryan, "Dari Inpres Moratorium Sawit Hingga Kebijakan Tata Kelola Industri Sawit Presiden Jokowi: Studi Kasus Penerbitan SK Pelepasan Kawasan Hutan PT Hardaya Inti Plantations Di Buol, Sulawesi Tengah," *Jurnal Hukum Lingkungan Indonesia* 6, no. 1 (2019): 1–18, https://doi.org/https://doi.org/10.38011/jhli.v6i1.122.

[20] Muki T. Wicaksono and Malik, "Konteks Politik Hukum Di Balik Percepatan Penetapan Hutan Adat: Catatan Ke Arah Transisi 2019," *Jurnal Hukum Lingkungan Indonesia* 4, no. 2 (2018): 25–46, https://doi.org/https://doi.org/10.38011/jhli.v4i2.60.

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journal articles, methodological books, and prior studies addressing environmental crimes, corporate criminal liability, causation, and scientific evidence, while tertiary legal materials are used to clarify terminology. The legal materials were collected through library research. They were analysed qualitatively by interpreting and harmonising criminal-procedure norms with the evidentiary requirements of ecological loss, after which prescriptions were formulated through coherent legal argumentation.[21]

C. Results and Discussion

1. Status and Challenges of Scientific Evidence in Constructing Causation in Environmental Crimes

The status of scientific evidence in environmental criminal cases must be understood through the function of each form of evidence rather than merely through the form of the document. Under Article 235 paragraph (1) of the 2025 Criminal Procedure Code, laboratory test results may be submitted as documents, automated monitoring data and satellite imagery may constitute electronic evidence, samples may be treated as physical evidence, and explanations of the methods and results of testing may be presented through expert testimony. Consistency among these forms provides a basis for the judge to determine whether pollution or environmental destruction actually occurred. A single test result ordinarily cannot stand alone because its value depends on sampling records, location, time, preservation procedures, the examining laboratory, the methodological standard, and comparison with the applicable environmental quality standard. In this arrangement, the expanded evidentiary regime connects the object or data examined with the scientific explanation and the elements of the offence.[22]

The criminal evidentiary system continues to treat lawful evidence and judicial conviction as interconnected elements. Conviction cannot replace evidence, while technical data cannot be accepted automatically merely because an expert presents them. The method used must correspond to the issue examined, the time of the event, the environmental medium, and the purpose of the test. The judge assesses whether the expert opinion was developed through a procedure capable of being tested, rather than independently determining the truth of a scientific discipline.[23]

The validity of scientific evidence is determined by at least five elements. The expert must possess competence relevant to the object of examination. The sample must be traceable from the moment it is collected, stored, transported, and tested. The method of examination must have a scientific basis and clear operating procedures. The result must be capable of explanation, comparison, and,

[21] Peter Mahmud Marzuki, *Penelitian Hukum* (Jakarta: Kencana, 2017).

[22] Zico Junius Fernando et al., "Geo-Forensic Criminal Law: Strengthening Environmental Criminal Evidence in the Mining Sector Through Geospatial Technology," *Simbur Cahaya* 33, no. 1 (2026): 97–120, https://doi.org/https://doi.org/10.28946/sc.v33i1.5840.

[23] M. Yahya Harahap, *Pembahasan Permasalahan Dan Penerapan KUHAP: Pemeriksaan Sidang Pengadilan, Banding, Kasasi, Dan Peninjauan Kembali* (Jakarta: Sinar Grafika, 2018).

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where possible, retesting. The expert's conclusion must also remain within the scope of the data examined. These five elements prevent a court from assessing an opinion merely on the basis of the expert's degree, position, or affiliation. Open criteria also enable the parties to challenge a method or dataset in a focused manner and assist judges in maintaining consistency across judgments.[24]

The question of causation arises after the existence of pollution or damage has been established. In a material offence, the public prosecutor must demonstrate that the prohibited consequence is connected with the defendant's conduct. That connection may be formed through evidence of the type of pollutant, the characteristics of the production process, the disposal pathway, the time of the event, the direction of flow, the dispersion pattern, the concentration of the substance, and the correspondence between the substance and the suspected source. Technical evidence is not assessed in isolation. Production records may show when a particular material was used, monitoring data may explain changes in environmental quality, and site inspections may reveal a possible route of pollutant movement. Environmental audits, waste-management documents, and maintenance records may strengthen or weaken the evidentiary sequence. Documented compliance records and technical changes assist the judge in distinguishing events originating from the defendant's activities from changes caused by other factors.[25]

Causation in environmental cases is not always singular. There may be multiple pollution sources, consequences may develop through long-term accumulation, and natural conditions may influence dispersion.[26] A court must distinguish scientific uncertainty from an absence of evidence. Uncertainty may remain even where a relationship is supported by data, whereas an absence of evidence indicates that the relationship does not yet have an adequate basis. This distinction prevents doubt from being used excessively while ensuring that conviction continues to rest on evidence that can be justified.

Cases involving corporations add another evidentiary layer because the physical act must be connected with organisational policies, orders, omissions, or failures of supervision. Scientific evidence explains the form of damage and its possible source, while corporate documents show who controlled the activity, knew of the risk, received reports, or determined the response. Electronic mail, minutes of meetings, production records, incident reports, and maintenance histories may connect managerial decisions with events at the site. Corporate control of technical information must not be used to obstruct law enforcement. Environmental obligations must also

[24] Fransiscus NR and Yovita Arie Mangesti, "Bridging the Epistemic Gap: Reconstructing the Regulation of Scientific Evidence in Indonesia's Anti Corruption Judiciary," *DiH: Jurnal Ilmu Hukum* 22, no. 1 (2026): 100–119, https://doi.org/https://doi.org/10.30996/dih.vi.132640.

[25] Sapto Hermawan and Athariq Wibawa, "Audit Lingkungan Di Indonesia Dan Pembelajaran Dari Amerika Serikat Dan Malaysia," *Jurnal Hukum Lingkungan Indonesia* 8, no. 2 (2022): 402–30, https://doi.org/https://doi.org/10.38011/jhli.v8i2.392.

[26] Mahrus Ali, "Model Kriminalisasi Berbasis Kerugian Lingkungan Dan Aktualisasinya Dalam Undang-Undang 32 Tahun 2009 Tentang Perlindungan Dan Pengelolaan Lingkungan Hidup," *Bina Hukum Lingkungan* 5, no. 1 (2020): 21–39, https://doi.org/https://bhl-jurnal.or.id/index.php/bhl/article/view/123.

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remain traceable when the company's structure or financial position changes, so that the objective of restoration is not lost merely because the status of the legal entity has changed.[27]

Conflicting expert opinions must be resolved through open examination of the methods used. The parties must have an opportunity to examine the underlying data, procedures, assumptions, and limits of each expert's conclusion. A judge may ask why a sampling point was chosen, whether contamination was possible, what the error rate was, whether the result can be repeated, and whether the method is accepted within the relevant scientific community. When the disagreement is profound and the case depends on a particular technical issue, the court may use an independent expert or an interdisciplinary panel. Such an expert does not replace the parties' evidence but provides an explanation that is not tied to a litigation interest.[28]

Ecological proof also includes the assessment of loss. Loss may consist of clean-up costs, lost ecosystem services, declining resource productivity, habitat restoration, and effects on communities. Developments in green finance demonstrate efforts to measure environmental risk in economic decision-making.[29] Carbon labelling illustrates how information about environmental effects may be used at the product level. Energy policy likewise creates different measurement needs depending on the source and technology involved.[30] In criminal cases, such valuation helps explain the seriousness of the consequence and the basis of restoration, but it does not replace proof of the elements of the offence.

Differences in capacity between law-enforcement institutions and corporations affect the quality of proof. A company may possess laboratories, consultants, production records, and more complete monitoring data, whereas investigators may face limits of budget, time, and access to the site. Delay in entering the scene may alter sample conditions, water flow, or pollutant concentrations. Electronic documents may also be moved, updated, or become unavailable if they are not secured promptly. Criminal procedure must therefore allow prompt site examination, early preservation of data, and orders to produce relevant information. Disclosure duties must remain confined to data related to the case, be recorded transparently, and be open to examination by the defendant. A balanced arrangement enables the prosecutor to obtain evidence without depriving

[27] Dicki Agri Kurniawan and Zainal Arifin Hoesein, "Rekonstruksi Pemidanaan Korporasi Dalam Kejahatan Lingkungan Hidup Sebagai Langkah Strategis Pembaharuan Hukum Nasional," *Judge: Jurnal Hukum* 6, no. 3 (2025): 550–62, https://doi.org/https://doi.org/10.54209/judge.v6i03.1566.

[28] Munir Fuady, *Doktrin-Doktrin Modern Dalam Pembuktian Hukum Acara Dan Eksistensinya Di Indonesia* (Bandung: Citra Aditya Bakti, 2014).

[29] Destara Sati, "Refleksi Keuangan Hijau Di Indonesia Dan Proyeksi Taksonomi Hijau Sebagai Kebijakan Pintar," *Jurnal Hukum Lingkungan Indonesia* 8, no. 2 (2022): 339–71, https://doi.org/https://doi.org/10.38011/jhli.v8i2.442.

[30] Zuhda Mila Fitrana, Dhea Veranica Isabella, and Lupita Sari, "Legislasi Hijau Regional (Regional Green Legislation) Untuk Mencapai Tujuan Pembangunan Berkelanjutan Sektor Energi 2030," *Jurnal Hukum Lingkungan Indonesia* 8, no. 2 (2022): 431–54, https://doi.org/https://doi.org/10.38011/jhli.v8i2.394.

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the investigated party of the right to challenge its authenticity, relevance, and manner of acquisition.[31]

The expansion of evidence under Article 235 paragraph (1) of the 2025 Criminal Procedure Code provides a broader normative basis but does not remove methodological problems. The principal challenge is how the court can ensure that scientific evidence is lawful, relevant, reliable, and sufficient to establish a causal relationship. Without assessment guidelines, a large volume of data does not necessarily produce certainty.

2. Reforming Criminal Procedure Policy to Ensure Legal Certainty and Ecological Justice

The preparation of guidelines for assessing scientific evidence in environmental criminal cases is necessary to provide a clear framework for judges, public prosecutors, investigators, experts, and defendants. The guidelines should regulate expert competence, methodological suitability, requirements for collecting and storing samples, chain of custody, laboratory documentation, data disclosure, error rates, the possibility of retesting, and the assessment of conflicting expert opinions. The guidelines should also accommodate the different characteristics of water, air, soil, waste, and ecosystem damage, each of which requires different forms of examination. Their function is to determine the minimum questions that must be answered before a scientific result is used as the basis of a judgment. Through such standards, the parties can identify the matters that must be proved, while judges have an examination framework that can be applied consistently without taking over the expert's role.[32]

The need for such guidelines can be explained through Lawrence M. Friedman's legal system theory, which views the operation of law through legal substance, legal structure, and legal culture. In the context of scientific evidence, legal substance concerns the rules and standards governing the reliability and admissibility of scientific evidence. Legal structure concerns the capacity of investigators, public prosecutors, judges, laboratories, and experts to apply those standards. Legal culture concerns the way legal actors understand and assess scientific evidence in the law-enforcement process. These three elements provide a framework in which the expansion of evidentiary forms is supported by clear assessment standards, capable institutions, and professional practices that place scientific reliability at the centre of evidentiary examination.[33]

The judge's screening function, or judicial gatekeeping, should also be strengthened. Before assessing an expert's conclusion as a whole, the judge may examine the suitability of the expert's

[31] Litya Surisdani Anggraeniko, Auliah Ambarwati, and Feby Reski Utami, "Admissibility of Digital Evidence in Indonesia: Criminal– Civil Implications for the Chain of Custody and Evidentiary Validity," *Priviet Social Sciences Journal* 6, no. 4 (2026): 481–94, https://doi.org/https://doi.org/10.55942/pssj.v6i4.1566.

[32] Prasetyo Utomo and Zakki Adlhiyati, "Kedudukan Bukti Ilmiah Dalam Penyelesaian Perkara Perdata Lingkungan Hidup," *Verstek: Jurnal Hukum Acara* 14, no. 1 (2026): 81–90, https://doi.org/https://doi.org/10.20961/jv.v14i1.98523.

[33] Wanodyo Sulistyani, "The Admissibility of Scientific Expert Evidence Under Indonesian Criminal Justice System," *Sriwijaya Law Review* 3, no. 2 (2019): 152–61, https://doi.org/https://doi.org/10.28946/slrev.Vol3.Iss2.215.pp152-161.

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qualifications, the relevance of the field of expertise, the data underlying the opinion, and the testability of the method used. This preliminary examination ensures that expert opinions presented before the court have a scientifically accountable basis. The judge may require the expert to explain the source of the data, the procedures used, the limits of the conclusion, and the possibility of retesting. The screening function keeps the examination focused on evidentiary quality and scientific reliability.[34]

Within Friedman's framework, judicial gatekeeping is related to the strengthening of legal structure and legal culture.[35] Judges require sufficient capacity to assess whether an expert opinion is supported by appropriate data and methodology. The culture of evidentiary assessment should also focus on the scientific basis of expert opinions, so that assessment rests on the quality of the evidence rather than academic titles, professional positions, or institutional affiliation. This approach assists courts in assessing expert testimony through transparent and measurable considerations.

A mechanism for independent experts appointed by the court should also be developed. This mechanism may be used when a technical issue has a decisive effect on the outcome of a case and the experts presented by the parties provide substantially different explanations. The court may select an expert from an interdisciplinary list based on relevant expertise, professional record, absence of conflicts of interest, and willingness to disclose the methods and data underlying the opinion.[36] Before the appointment, the parties should be given an opportunity to submit reasoned objections. A court-appointed expert remains under oath, may be examined by the public prosecutor and the defendant, and has no authority to determine whether the charge has been proved. The expert's opinion also does not bind the judge.[37] The role of the independent expert is limited to explaining technical issues, clarifying methodological differences, and assisting the court in understanding the limits of scientific certainty. This model can maintain balance when one party has substantially greater technical and financial resources.

The independent expert mechanism also strengthens legal structure by giving courts access to scientific assistance when complex methodological disputes arise. Its implementation requires clear procedural rules concerning qualifications, appointment procedures, conflicts of interest, disclosure obligations, and the limits of expert authority. These rules form part of legal substance,

[34] Katalin Sulyok, "Science, Epistemology and Legitimacy in Environmental Disputes – The Epistemically Legitimate Judicial Argumentative Space Katalin," *Leiden Journal of International Law* 37, no. 1 (2024): 139–66, https://doi.org/https://doi.org/10.1017/S0922156523000559.

[35] Mark A. Behrens and Andrew J. Trask, "Federal Rule of Evidence 702: A History and Guide to the 2023 Amendments Governing Expert Evidence," Texas A&M Law Review 12, no. 1 (2024): 43-75, https://doi.org/10.37419/LR.V12.I1.2

[36] Mahrus Ali, "Hukum Pidana Sebagai Last Resort Dalam Undang-Undang Perlindungan Dan Pengelolaan Lingkungan Hidup" 27, no. 1 (2020): 68–86, https://doi.org/https://doi.org/10.20885/iustum.vol27.iss1.art4.

[37] Gandar Mahojwala Paripurno, "Prinsip Pencemar Membayar Untuk Mendorong Akses Kompensasi Di Kebijakan ASEAN Dalam Kasus Polusi Kabut Asap Lintas Batas," *Jurnal Hukum Lingkungan Indonesia* 4, no. 2 (2018): 111–28, https://doi.org/https://doi.org/10.38011/jhli.v4i2.63.

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while the professional understanding that experts assist judicial assessment forms part of legal culture.[38]

A proportionate obligation for corporations to disclose technical data is also required. Production data, emission records, self-monitoring results, maintenance records for waste-treatment facilities, and communications relating to an incident may be ordered to be produced when relevant to the case. The public prosecutor remains responsible for proving the charge, while corporations are required to provide relevant information under their control. Trade secrets unrelated to the case may remain protected. Clear rules on data disclosure strengthen legal substance by defining the scope of information that may be obtained and the procedural safeguards applicable to its use.[39]

A limited reversal of the burden of proof may be applied to specific facts that are clearly within corporate control, such as the authenticity of operational records or the condition of pollution-control installations at the time of the incident. Its application must be regulated by legislation, clearly limited, and consistent with the presumption of innocence. The public prosecutor must continue to establish an initial factual basis connecting the defendant's activities with the pollution or environmental damage. Environmental case resolution should also address restoration and prevention. The polluter-pays principle places the costs arising from pollution on the party responsible for causing it. Integrating restoration costs into sanctions can connect criminal responsibility with the ecological damage that occurred. Preventive instruments such as a deposit-refund system demonstrate that ecological responsibility can be designed before waste reaches the environment. The relationship among sanctions, prevention, and restoration should remain adapted to the elements of the case under examination.[40]

The scientific capacity of law-enforcement officers should also be improved. Environmental-judge certification may include sampling design, basic ecotoxicology, satellite imagery, investigative auditing, basic statistics, and the assessment of ecological loss. Investigators and public prosecutors require joint protocols to preserve evidentiary value from the initial stage of investigation through trial. Knowledge of the relationship between development projects and environmental risk helps law-enforcement officers identify the data that must be secured. Studies of natural-resource policy can also improve their capacity to assess the relationship among licensing, business activities, and ecological consequences. Administrative environmental judgments may be used as comparative material for understanding how courts assess licences and technical data. Coastal cases also provide

[38] Irawati Puteri, Rizkina Aliya, and Satria Afif Muhammad, "Penerapan Plastic Deposit Refund System Sebagai Instrumen Penanggulangan Pencemaran Limbah Plastik Di Wilayah Perairan Indonesia," *Jurnal Hukum Ling* 4, no. 2 (2018): 129–50, https://doi.org/https://doi.org/10.38011/jhli.v4i2.64.

[39] Indonesian Center for Environmental Law, "Catatan Akhir Tahun 2017: Kebijakan Pemerintahan Jokowi-JK Tahun 2017—Ambisi Megaproyek, Minim Perlindungan Lingkungan," *Jurnal Hukum Lingkungan Indonesia* 4, no. 2 (2018): 151–82, https://doi.org/https://doi.org/10.38011/jhli.v4i2.67.

[40] Antonius Aditantyo Nugroho, "Analisis Putusan PTUN NO. 7/g/LH/2019/PTUN.BNA Antara Walhi Melawan Gubernur Aceh Atas Penerbitan Izin Pinjam Pakai Kawasan Hutan Untuk Pembangunan PLTA Tampur" 6, no. 1 (2019): 126–44, https://doi.org/https://doi.org/10.38011/jhli.v6i1.152.

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lessons concerning territorial characteristics, the movement of biota, and ecosystem connectivity in assessing environmental consequences.[41]

This aspect illustrates the legal structure dimension in Friedman's theory. The effectiveness of scientific evidence depends on institutions and law-enforcement officers that are capable of securing, understanding, and assessing technical information. Investigators need to understand the integrity of samples and data, public prosecutors need to connect scientific findings with the elements of the offence, and judges need to assess methodological reliability and conflicting expert opinions. Strengthening institutional capacity therefore forms an essential part of the scientific-evidence assessment mechanism.

The establishment of a scientific-support centre for investigators, public prosecutors, and courts could further strengthen this structure. The centre could manage lists of experts, laboratory standards, testing protocols, and databases of methods. Digital archiving of examination results and metadata could also help maintain traceability. Every item of data used should remain capable of being disclosed, examined, and challenged by the parties.

The legal culture dimension requires attention because scientific evidence is ultimately assessed by legal actors. A professional culture based on methodological examination encourages investigators, public prosecutors, and judges to examine data sources, methodological reliability, and the limits of expert conclusions. Expert testimony should be assessed on the quality of its scientific foundation. This approach also requires experts to disclose relevant data, explain methodological limitations, and remain within the scope of their competence.

The relationship among legal substance, legal structure, and legal culture shows that the reliability of scientific evidence depends on consistent rules, institutional capacity, and professional practices. Guidelines provide substantive standards for assessment, capable institutions ensure that those standards can be applied, and a professional legal culture directs examination toward the quality of scientific data and methods. These three elements support a validation mechanism that begins with sample integrity, continues through methodological reliability and data disclosure, and proceeds to the assessment of expert opinions and causal relationships.

These reforms are directed toward adapting criminal procedure to ecological harm that is technical, dispersed, and capable of developing cumulatively. Legal certainty is supported by open assessment standards that can be applied consistently. Ecological justice requires scientifically accountable evidence to be properly examined when determining responsibility. The public prosecutor's duty to prove the charge, the defendant's right to examine and challenge evidence, and the presumption of innocence remain the principal safeguards throughout the proceedings. From Friedman's perspective, the reform depends on the alignment of legal substance, legal

[41] Dalila Doman, "Kesesuaian Pengaturan Pemanfaatan Zona Migrasi Biota Laut Dalam Peraturan- Peraturan Daerah Provinsi Dengan UU Tentang Pengelolaan Wilayah Pesisir Dan Pulau-Pulau Kecil (UU WP3K)" 6, no. 1 (2019): 145–53, https://doi.org/https://doi.org/10.38011/jhli.v6i1.118.

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structure, and legal culture in ensuring that scientific evidence is assessed through transparent, testable, and scientifically accountable standards.

D. Conclusion

Scientific evidence plays a decisive role in establishing causation in environmental criminal cases, yet its evidentiary value depends on the reliability of the methods, data, sampling procedures, chain of custody, expert competence, and the possibility of independent verification. The broader evidentiary framework under Article 235 paragraph (1) of the 2025 Criminal Procedure Code provides an important legal basis, but it does not by itself resolve methodological inconsistencies in assessing scientific evidence. This study identifies three interrelated weaknesses through Lawrence M. Friedman's legal system theory: limited scientific capacity among law-enforcement officers as a problem of legal structure, the absence of clear standards for assessing scientific evidence as a problem of legal substance, and the tendency to rely on expert authority rather than the scientific basis of expert opinions as a problem of legal culture. The novelty of this study lies in proposing an integrated scientific-evidence assessment model that simultaneously strengthens these three elements through specific assessment guidelines, improved scientific competence of investigators, prosecutors, and judges, judicial gatekeeping based on methodological reliability, and institutional scientific support. This model places the reliability and testability of scientific evidence at the centre of environmental criminal adjudication while preserving the defendant's right to challenge evidence, the prosecutor's burden of proof, and the presumption of innocence.

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