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ARTICLE

Integrating Neurolaw in Environmental Crimes and Strengthening Victim Protection in Criminal Liability Discourse

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Abstract

The increasing complexity of environmental crimes, often perpetrated by corporate actors and facilitated through systemic negligence, has challenged traditional models of criminal responsibility. While conventional criminal law relies on the assessment of mens rea the subjective mental element of guilt this approach often proves inadequate in addressing the nuanced realities of environmentally harmful behavior, which may arise from collective decision-making, cognitive impairments, or moral disengagement. In response, the emerging field of neurolaw introduces neuroscientific insights into legal reasoning, offering an interdisciplinary perspective on how neurological conditions and cognitive processes influence criminal culpability. This research explores the potential of integrating neurolaw into the adjudication of environmental crimes, particularly in evaluating criminal liability in cases involving indirect or diffuse intent. Through normative legal analysis, statutory and conceptual approaches, and comparative reflection on practices in jurisdictions such as the United States, Italy, Germany, and Brazil, the study investigates how neurocognitive evidence such as functional brain imaging and neuropsychological evaluations may complement existing doctrines in Indonesian criminal and environmental law. The analysis includes a critical examination of Indonesia's Criminal Code (KUHP), Law No. 32/2009 on Environmental Protection and Management, and the principle of strict liability, assessing their compatibility with a neurolaw-informed framework. Importantly, this research also emphasizes the need to strengthen victim protection in the discourse of environmental criminal liability. While neurolaw has been primarily applied to analyze the cognitive condition of offenders, it must not obscure the rights of victims both human and ecological. The study argues for a balanced approach that incorporates neuroscientific considerations without undermining justice for affected communities, future generations, or non-human victims of ecological harm. By aligning neurolaw with victim-centered environmental justice principles, the research proposes a more holistic model of criminal accountability that advances fairness, scientific integrity, and ecological restoration.

Keywords
Neurolaw; Criminal Liability; Environmental Crimes; Victim Protection; Neuroscience and Law.

Abstrak
Semakin kompleksnya kejahatan lingkungan yang sering dilakukan oleh aktor korporasi dan difasilitasi oleh kelalaian sistemik telah menantang model pertanggungjawaban pidana tradisional. Hukum pidana konvensional yang bertumpu pada penilaian mens rea unsur subjektif dari kesalahan pidana sering kali tidak memadai dalam menjelaskan realitas perilaku merusak lingkungan yang muncul dari pengambilan keputusan kolektif, gangguan kognitif, atau moral disengagement. Sebagai respons atas keterbatasan tersebut, bidang ilmu baru bernama neurohukum (neurolaw) hadir dengan menawarkan perspektif interdisipliner yang mengintegrasikan temuan ilmu saraf ke dalam logika hukum untuk memahami bagaimana kondisi neurologis dan proses kognitif memengaruhi kesalahan pidana. Penelitian ini mengeksplorasi potensi integrasi pendekatan neurolaw dalam proses peradilan terhadap kejahatan lingkungan, khususnya dalam mengevaluasi pertanggungjawaban pidana pada kasus-kasus yang melibatkan intensi yang tidak langsung atau tersebar. Melalui metode penelitian hukum normatif dengan pendekatan perundang-undangan, konseptual, dan perbandingan, studi ini menelaah kemungkinan penerapan bukti neurokognitif seperti pencitraan otak fungsional dan evaluasi neuropsikologis untuk melengkapi doktrin hukum yang berlaku dalam sistem hukum pidana dan lingkungan di Indonesia. Analisis juga mencakup tinjauan kritis terhadap KUHP, Undang-Undang No. 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, serta prinsip strict liability, dan bagaimana kesemuanya dapat bertransformasi dalam kerangka hukum yang berbasis neurosains. Secara khusus, penelitian ini juga menekankan pentingnya memperkuat perlindungan korban dalam diskursus pertanggungjawaban pidana lingkungan. Meskipun neurolaw selama ini lebih banyak digunakan untuk menilai kondisi kognitif pelaku, pendekatan ini tidak boleh mengaburkan hak-hak korban baik korban manusia, komunitas terdampak, generasi mendatang, maupun korban non-manusia seperti ekosistem dan satwa liar. Penelitian ini menyerukan pendekatan yang seimbang, di mana pertimbangan neurosains tidak mengurangi keadilan bagi korban, melainkan mendukung tercapainya keadilan ekologis yang utuh. Dengan menyelaraskan neurolaw dengan prinsip-prinsip keadilan berbasis korban, studi ini menawarkan model pertanggungjawaban pidana yang lebih ilmiah, manusiawi, dan berorientasi pada pemulihan lingkungan.

Kata Kunci
Neurolaw; Tanggung Jawab Pidana; Kejahatan Lingkungan; Perlindungan Korban; Ilmu Saraf dan Hukum.

Introduction

The Environmental crimes have evolved into one of the most serious and complex forms of criminality on a global scale. These crimes not only damage ecosystems but also create long-term impacts on human health, social stability, and a country's economic resilience.[1] According to a 2020 report by Interpol and the United Nations Environment Programme (UNEP), environmental crimes have become the fourth largest category of transnational crime globally, with estimated losses ranging from USD 110 to 281 billion annually. These crimes include illegal wildlife trade, unlawful deforestation, transboundary hazardous waste dumping, and deliberate industrial pollution. This phenomenon reflects the strong interconnection between ecological degradation and the weaknesses of criminal justice systems that remain unresponsive to new and emerging challenges.[2]

In conventional criminal law, the determination of criminal responsibility is based on the principle of *mens rea*, which requires evidence of intent, negligence, or malicious purpose behind the perpetrator's actions. This principle has long served as the foundation for establishing whether an individual can be held criminally accountable. However, in the context of modern environmental crimes particularly those involving corporate actors or policymakers proving *mens rea* is not a straightforward matter. Environmental offenses are often carried out collectively, structurally embedded, and obscured within indirect administrative or corporate decisions. This creates significant challenges for law enforcement in identifying who bears individual criminal responsibility and to what extent intent or negligence can be established.

A clear example of this complexity can be seen in the 2019 Brumadinho disaster in Brazil, where a tailings dam owned by the mining company Vale SA collapsed, killing over 270 people and causing widespread ecological devastation.[3] Investigations revealed that company officials had long been aware of the dam's structural risks prior to the incident. Nevertheless, proving individual intent or personal negligence proved difficult due to the hierarchical and collective nature of the decision-making process. In such circumstances, the traditional doctrine of *mens rea* focused on individual mental states is insufficient to identify the primary perpetrators or distinguish between systemic failures and personal fault. Amid these challenges, a new approach has emerged in criminal law known as neurolaw. Neurolaw is an interdisciplinary field that combines neuroscience with legal studies, particularly in understanding how brain conditions, cognitive processes, and neurological functions may influence legal responsibility. Technological developments such as Functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG),

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[1] Sailesh Mehta and Prisca Merz, "Ecocide – A New Crime Against Peace?," *Environmental Law Review* 17, no. 1 (March 2015): 3–7, https://doi.org/10.1177/1461452914564730.

[2] Bonnie Rippingille, "Editorial: Beyond All Boundaries the Meteoric Rise of Environmental Crime," *Journal of Financial Crime* 30, no. 5 (November 30, 2023): 1113–16, https://doi.org/10.1108/JFC-10-2023-311/FULL/PDF.

[3] Luiz Henrique Silva Rotta et al., "The 2019 Brumadinho Tailings Dam Collapse: Possible Cause and Impacts of the Worst Human and Environmental Disaster in Brazil," *International Journal of Applied Earth Observation and Geoinformation* 90 (August 1, 2020): 1–7, https://doi.org/10.1016/J.JAG.2020.102119.

and Positron Emission Tomography (PET) enable scientists to map brain activity and detect neurological impairments that would otherwise remain invisible. In the context of criminal law, these neuroscientific data can be used to assess whether a defendant possessed intact mental capacity at the time of committing a crime.[4]

Although most applications of neurolaw to date have focused on crimes against persons, the approach holds significant relevance for environmental crimes. This is because many perpetrators of environmental offenses do not act with explicit malice but are often caught within corporate decision-making structures shaped by pressure, economic bias, or psychological conditions that impair moral control. For example, a study by Vohs and Baumeister (2016) demonstrated that decision fatigue can diminish moral capacity and ethical reasoning especially within large organizations where executives must make hundreds of decisions daily. In such a context, corporate leaders may make environmentally destructive decisions not out of malicious intent, but due to dysfunctions in their evaluative capacity that accumulate over time. In addition, there is the condition known as moral disengagement, referring to a psychological disconnect between one's actions and their moral consequences. This phenomenon is frequently found in organizational structures that shield individuals from the direct effects of their decisions. In the infamous 1984 Bhopal gas disaster involving the Union Carbide chemical company, which killed thousands due to toxic gas leakage, many executives claimed ignorance of the technical policies that led to the incident.[5] Subsequent studies showed that in complex organizations, individuals often experience psychological detachment from the ecological outcomes of their decisions. In this regard, neurolaw may help explain how specific brain structures and cognitive patterns support moral disengagement within the context of environmental crime.

From a regulatory perspective, Indonesia's criminal justice system has not explicitly addressed the application of neuroscience in criminal proceedings, including in environmental cases. The current Indonesian Criminal Code (KUHP) still adheres to the classical doctrine of individual moral fault as the basis for criminal responsibility. Likewise, Law No. 32 of 2009 on Environmental Protection and Management primarily relies on administrative approaches and the doctrine of strict liability, particularly for cases of pollution and ecological damage.[6] While the strict liability principle facilitates prosecution by eliminating the need to prove intent, this approach does not address the neurological dimensions of the offender and fails to provide space for integrating neuroscience into culpability assessments.

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[4] Zico Junius Fernando et al., "Neurolaw: A Concept in Development and Enforcement of Criminal Law in Indonesia," *Jambura Law Review* 7, no. 1 (2025): 55–87, https://doi.org/10.33756/JLR.V7I1.24144.

[5] I. Eckerman, "Bhopal Gas Catastrophe 1984: Causes and Consequences," *Encyclopedia of Environmental Health, Volume 1-5* 1 (January 1, 2011): 302–16, https://doi.org/10.1016/B978-0-444-52272-6.00359-7.

[6] Mayer Hayrani DS, "Perkembangan Hukum Pidana Lingkungan Hidup," *Jurnal Legislasi Indonesia* 15, no. 4 (2018): 333, http://www.mongabay.

This issue becomes even more complex when viewed through the lens of victim protection. In many environmental crime cases, victims are not limited to directly affected individuals but include Indigenous communities, vulnerable populations, future generations, and even non-human entities such as rivers, forests, or endangered species. However, in practice, criminal law remains overly focused on the offender, often failing to allocate sufficient space for victim recovery and justice. When neurolaw is used to demonstrate that a perpetrator suffers from neurological impairments and is therefore not fully responsible, serious ethical and legal questions arise regarding whether justice for victims can still be meaningfully ensured. Can ecological justice and victims' rights be safeguarded amid a deeper understanding of the perpetrator's neurobiological condition?

Within this framework, it is essential to develop a criminal law approach to environmental harm that is grounded in victim-centered justice a system that considers not only the condition of the perpetrator but also prioritizes the rights of victims to justice, reparation, and recognition. This approach has gained traction in countries such as Canada and New Zealand, where criminal justice systems provide space for victim impact statements in environmental cases. In the Netherlands, courts have even recognized ecological communities as legal victims in industrial pollution cases, paving the way for non-human entities to receive legal protection. In the Indonesian context, this approach remains at an early stage. The Witness and Victim Protection Agency (LPSK) has begun expanding its mandate to include victims of environmental crimes, but its normative scope remains largely limited to human victims. No specific legal instruments currently exist that clearly grant legal protection status to Indigenous communities or the environment as victims. Under such conditions, it becomes critically important to ensure that the use of neurolaw in assessing a perpetrator's criminal responsibility is not exploited to weaken or obscure the position of victims. Another issue that must be addressed is the relationship between neurolaw and corporate liability. In environmental crimes, the primary offender is often a legal entity or corporation, which, by law, does not possess a brain or neurological capacity. However, the decisions leading to environmental harm are made by real individuals behind the corporate veil. In such cases, neurolaw can serve as a tool for investigating the motives and decision-making capacities of individuals at the managerial or executive level. Thus, neuropsychological evaluations may provide supporting evidence in assessing to what extent individuals within a corporate structure can be held criminally liable.

Method

This research adopts a normative legal research method, focusing on the analysis of legal norms, principles, and doctrines as the primary object of study.[7] The normative approach is employed to examine the legal aspects of criminal liability in environmental

[7] Pidari Sinaga et al., "Kejahatan Biodiversitas Dan Urgensi Peran Hukum Pidana Dalam Sektor Agraria," *Jurnal Pembangunan Hukum Indonesia* 6, no. 2 (June 27, 2024): 210–42, https://doi.org/10.14710/JPHI.V6I2.210-242.

crimes through the lens of neurolaw, emphasizing how neuroscience can contribute to the assessment of mens rea and culpability in environmental offenses. To achieve a comprehensive and structured legal analysis, the study integrates three main approaches: the statutory approach, the conceptual approach, and the comparative approach.[8] The statutory approach involves the examination of relevant national legislation, such as Indonesia's Environmental Protection and Management Law (Law No. 32 of 2009), the Criminal Code (KUHP), and international instruments related to environmental crimes and neurolegal developments. The conceptual approach is used to explore and clarify the legal concepts of criminal responsibility, mental capacity, and ecological justice, particularly in relation to neuroscience and its implications in criminal law. The comparative approach is employed to analyze how other jurisdictions such as the United States, Germany, Italy, and Brazil have integrated neuroscientific evidence into criminal adjudication, including its application in cases involving environmental harm. The nature of this research is descriptive-prescriptive.[9] It is descriptive in the sense that it systematically outlines and explains the existing legal norms, doctrinal interpretations, and practical developments surrounding neurolaw and environmental criminal liability. It is prescriptive in offering normative recommendations for legal reform, particularly in Indonesia, to better integrate neuroscientific insights into the assessment of criminal responsibility in environmental cases. The data used in this research consists primarily of secondary legal materials, including statutory texts, court decisions, scholarly articles, books, and reports from international organizations. In analyzing the collected data, this study utilizes content analysis as its main analytical method.[10] Through this method, the research examines patterns, meanings, and normative values embedded in legal texts and relevant jurisprudence, aiming to identify gaps, assess legal coherence, and propose reform-oriented solutions. Overall, this research methodology enables a rigorous, theory-driven, and context-sensitive examination of how neurolaw can be meaningfully incorporated into environmental criminal justice to enhance fairness, accountability, and ecological protection.

[8] Emelia Kontesa and Zico Junius Fernando, "Reclaiming Our Roots: Agrarian Law's Battle Against Land Grabbing," *Lex Scientia Law Review* 8, no. 2 (November 30, 2024): 1–10, https://doi.org/10.15294/LSLR.V8I2.10681.

[9] Ria Anggraeni Utami & Zico Junius Fernando Agusalim, "Green Victimology: Sebuah Konsep Perlindungan Korban Dan Penegakan Hukum Lingkungan Di Indonesia," *Bina Hukum Lingkungan* 7, no. 1 (October 2022): 60–79, https://doi.org/10.24970/BHL.V7I1.302.

[10] Zico Junius Fernando et al, "Eco-Democracy: Advancing Sustainable Governance Through Green Politics," *Proceeding APHTN-HAN* 2, no. 1 (December 31, 2024): 231–72, https://doi.org/10.1126/SCIENCE.AAL4863.

Result & Discussion

A. Reconstructing Mens Rea in Environmental Crimes through Neuroscientific Insights

Following The concept of *mens rea*, or the guilty mind, has long served as a cornerstone of criminal law in determining individual culpability. Traditionally, this doctrine is grounded in the assumption that human agents possess rational capacities, can weigh consequences, and choose freely between lawful and unlawful acts. However, the rise of complex environmental crimes committed by corporate entities, bureaucratic actors, and individuals within hierarchical structures challenges this foundational idea. Environmental crimes, unlike conventional offenses, often unfold over long durations, involve collective decision-making, and produce diffuse harms whose effects are not immediately visible. This multidimensional character of environmental harm complicates the attribution of individual criminal intent, thus rendering traditional models of *mens rea* increasingly insufficient. In recent decades, neuroscience has offered novel insights into human behavior, particularly in understanding the neurological substrates of intention, emotion, cognition, and impulse control.[11] The field of neurolaw seeks to bridge the gap between legal responsibility and neurological functioning by introducing evidence from neuroimaging and cognitive science into the adjudication of criminal liability.[12] Studies have demonstrated that damage or dysfunction in the prefrontal cortex the brain region responsible for decision-making, future planning, and moral reasoning can significantly impair an individual's capacity to act with full awareness or intent. For instance, lesions in the ventromedial prefrontal cortex have been associated with increased risk-taking, diminished empathy, and poor foresight, all of which are relevant to the perpetration of environmental harm.

In the context of environmental crime, these findings raise important questions about the internal states of actors involved in environmentally harmful conduct. Consider, for example, the case of decision-makers within a corporation who approve toxic waste dumping despite being aware of its potential ecological consequences. While such actions may appear deliberate, neuroscientific literature suggests that individuals under sustained stress, pressure from superiors, or habituation to unethical norms may experience moral disengagement. Albert Bandura's theory of moral disengagement posits that individuals can cognitively restructure their moral compass to justify harmful behavior, often through mechanisms such as euphemistic labeling ("controlled release" instead of "toxic spill"), displacement of responsibility, or diffusion of responsibility within a group. This process may not be consciously orchestrated but rather driven by underlying neural adaptations.

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[11] Nigel Eastman and Colin Campbell, "Neuroscience and Legal Determination of Criminal Responsibility," *Nature Reviews Neuroscience 2006 7:4* 7, no. 4 (March 16, 2006): 311–18, https://doi.org/10.1038/nrn1887.

[12] Georgia Martha Gkotsi, Jacques Gasser, and Valérie Moulin, "Neuroimaging in Criminal Trials and The Role of Psychiatrists Expert Witnesses: A Case Study," *International Journal of Law and Psychiatry* 65 (2019), https://doi.org/10.1016/j.ijlp.2018.05.007.

Neurological studies support this theory. Research using functional Magnetic Resonance Imaging (fMRI) has shown that repeated exposure to morally questionable acts can lead to desensitization in the amygdala and reduced activation in the anterior cingulate cortex, both of which play roles in emotional response and error detection.[13] In environmental decision-making contexts, this neural desensitization could explain how individuals continue to participate in ecologically destructive activities without experiencing cognitive dissonance or guilt. It also problematizes the legal assumption that harmful environmental acts are necessarily accompanied by conscious and rational intention.

The case of the 2019 Brumadinho dam collapse in Brazil provides a real-world illustration. Executives from the mining company Vale SA were charged for authorizing continued use of a structurally compromised tailings dam, which ultimately collapsed, killing over 270 people and causing widespread environmental devastation. Internal reports revealed that engineers and managers had access to risk assessments indicating imminent danger, yet corporate operations proceeded. From a legal standpoint, these facts satisfy a form of reckless or knowing mens rea. However, a neurolaw-informed analysis might probe deeper into the cognitive and neuropsychological factors that shaped the executives' perceptions and decision-making processes. Were their risk assessments influenced by habituation to regulatory leniency? Were there neurological indicators of impaired moral judgment due to chronic exposure to corporate incentives or stress? While these questions do not negate liability, they challenge the simplicity of attributing intent in the traditional sense.

Another dimension of neurolaw relevant to environmental crimes is the role of executive function disorders, which can impair judgment and increase impulsivity. Individuals with Frontal Lobe Syndrome or damage to the dorsolateral prefrontal cortex may struggle with long-term planning, risk evaluation, and moral reasoning all faculties critical in environmental compliance. While such conditions are often associated with violent or overtly antisocial behavior, recent clinical literature has begun to explore their subtler manifestations in white-collar crime, including fraud, regulatory violations, and corporate negligence. This suggests that neuropsychological assessments could reveal underlying deficits in decision-making that are masked by the professional demeanor of environmental offenders.

The corporate structure itself presents unique challenges to attributing *mens rea*. In many environmental crimes, actions are fragmented across departments and individuals, creating a diffusion of responsibility. Neuroscientific research into group behavior and collective decision-making has shown that responsibility is often perceived as lower when outcomes are shared, a phenomenon known as the "bystander effect" in cognitive psychology. When applied to corporate crime, this can produce a culture where no

[13] Adrian M Owen, Russell Epstein, and Ingrid S Johnsrude, "FMRI: Applications to Cognitive Neuroscience," in *Functional Magnetic Resonance Imaging: An Introduction to Methods*, ed. Peter Jezzard, Paul M Matthews, and Stephen M Smith (Oxford University Press, 2001), 312–329, https://doi.org/10.1093/acprof:oso/9780192630711.003.0017.

individual feels fully accountable.[14] Neuroimaging studies indicate that areas of the brain associated with moral reasoning are less active when individuals believe their actions are subsumed within a group. Such findings complicate the assignment of individual guilt in environmental crimes committed by organizations.[15]

Furthermore, the influence of cognitive biases such as optimism bias, confirmation bias, and motivated reasoning may be amplified in environmental contexts where economic gain conflicts with ecological risk. Neuroscience has documented how these biases are rooted in neural circuitry involving the reward system, particularly the striatum and orbitofrontal cortex.[16] Executives may unconsciously prioritize short-term profits due to heightened dopaminergic responses to financial incentives, even when presented with data indicating long-term ecological harm. The legal system, which often presumes a capacity for rational risk assessment, may overlook how neurobiological factors distort judgment in high-stakes environmental decisions.

Incorporating neuroscientific evidence into environmental criminal cases raises both epistemological and procedural challenges. Legally, there is tension between the deterministic implications of neuroscience and the normative framework of free will and individual agency. Courts are cautious about introducing neuroevidence, fearing it may undermine moral responsibility or be misused to excuse culpability. Nonetheless, neurolaw does not seek to absolve environmental offenders but to provide a more textured understanding of *mens rea*, especially in complex cases involving ambiguous intent, systemic pressures, and cognitive impairment. As neuroscience continues to evolve, legal scholars and practitioners must grapple with how such evidence can inform not only sentencing but also the threshold of criminal responsibility itself. In sum, the reconstruction of *mens rea* in environmental crimes through neuroscientific insights invites a rethinking of foundational legal assumptions. It challenges the dichotomy of guilty versus innocent minds by introducing a spectrum of cognitive states, influenced by both individual neurobiology and environmental conditioning. This emerging perspective holds promise for refining the tools of legal analysis, promoting ecological accountability, and achieving a more humane and scientifically grounded approach to environmental criminal justice.

[14] Jennifer A Chandler, "The Use of Neuroscientific Evidence in Canadian Criminal Proceedings," *Journal of Law and the Biosciences* 2, no. 3 (November 1, 2015): 550–79, https://doi.org/10.1093/jlb/lsv026.

[15] Gui Xue et al., "Brain Imaging Techniques and Their Applications in Decision-Making Research.," *Xin Li Xue Bao. Acta Psychologica Sinica* 42, no. 1 (February 2010): 120–37, https://doi.org/10.3724/SP.J.1041.2010.00120.

[16] Eryn Brown, "The Brain, The Criminal and The Courts," Knowable Magazine, 2019, https://knowablemagazine.org/article/mind/2019/neuroscience-criminal-justice.

B. Legal Framework and Limitations of Integrating Neurolaw into Environmental Criminal Liability

The Indonesian legal system, like many other civil law jurisdictions, relies heavily on doctrinal and codified foundations for assessing criminal responsibility. In the context of environmental crimes, two primary instruments serve as the legal basis: the Indonesian Criminal Code (Kitab Undang-Undang Hukum Pidana or KUHP) and Law No. 32 of 2009 on Environmental Protection and Management (Undang-Undang Perlindungan dan Pengelolaan Lingkungan Hidup).[17] While both establish criminal liability for ecological harm, they do not yet incorporate or recognize the relevance of neurocognitive conditions in shaping culpability. This creates both limitations and opportunities for legal reform, particularly in light of evolving insights from neurolaw.

Under the KUHP, criminal liability is traditionally grounded in the classical dichotomy of *actus reus* and *mens rea*, wherein an unlawful act must be accompanied by a guilty mind. The structure of the code presumes that offenders possess rationality, volition, and capacity to discern the wrongfulness of their actions. There is little room within this framework to evaluate impairments in cognitive function, neurodevelopmental disorders, or neuropsychological influences that may impact decision-making. The absence of explicit provisions for such assessments reflects a broader resistance within the code to embrace interdisciplinary approaches that challenge the free will paradigm. In contrast, Law No. 32 of 2009 introduces a partial shift by embracing principles such as *strict liability* and the *precautionary principle*. Under the law, environmental violators can be held responsible without the need to prove intent or negligence. This doctrine represents a pragmatic move to overcome evidentiary hurdles in prosecuting environmental crimes, especially when damage is caused by corporate actors. However, it also limits the scope for considering neurocognitive factors, since liability attaches irrespective of mental state. As a result, this regime simplifies prosecution but sidelines any nuanced understanding of culpability that neurolaw might offer.

Despite these limitations, there are entry points for integrating neurolaw into the existing legal framework. One such opportunity lies in the sentencing phase. Judges in Indonesia are empowered by Article 197 of the Criminal Procedure Code (KUHAP) to consider mitigating and aggravating factors in determining punishment. Neurocognitive impairments, once verified through expert testimony or medical examination, could inform sentencing decisions. This approach has precedent in international criminal law, where mental incapacity or diminished responsibility is often considered at sentencing even if not determinative of guilt. Another avenue is through the expansion of forensic protocols. Currently, forensic psychiatry is occasionally used in Indonesia for defendants suspected

[17] Triwanto, "Penyelesaian Sengketa Lingkungan Hidup Menurut Undang Undang Nomor 32 Tahun 2009," *Wacana Hukum* VIII, no. 1 (2009): 86–102.

of mental illness, particularly in violent crimes. However, environmental crimes especially those involving corporate officials rarely invoke psychiatric or neuropsychological evaluations. Updating forensic procedures to include neurocognitive assessments, particularly in cases involving ambiguous intent or complex decision-making chains, would enable a more individualized and just application of criminal law.

Furthermore, ethical and legal debates surrounding the use of neuroscientific evidence in courts remain unresolved. Critics argue that neuroevidence may be overly deterministic, risk misinterpretation by judges unfamiliar with scientific nuance, or infringe upon privacy rights. These concerns are valid and warrant procedural safeguards. Nonetheless, outright exclusion of such evidence may perpetuate injustice, particularly in cases where defendants suffer from verifiable neurological conditions affecting their capacity to comply with environmental regulations. Regulatory reform could address this by establishing clear admissibility standards, protocols for expert testimony, and guidelines for judicial interpretation of neuroscientific data. The inclusion of neurolaw in environmental criminal adjudication also necessitates a shift in prosecutorial strategy. Prosecutors must be trained not only to assess material evidence of environmental damage but also to recognize when a defendant's cognitive profile may influence culpability. This does not imply leniency but rather a commitment to proportional justice. For instance, a corporate manager suffering from early-stage frontotemporal dementia who approves environmentally harmful practices under impaired judgment should not be equated, in moral or legal terms, with a fully competent actor engaged in deliberate harm. Finally, the integration of neurolaw requires coordination with international standards and comparative practices. The Rome Statute of the International Criminal Court recognizes mental disease or defect as a ground for excluding criminal responsibility (Article 31). Though environmental crimes are not yet categorized as core international crimes, the principles of fair trial and individualized responsibility remain applicable. Indonesia could draw from jurisdictions such as Germany or Italy, where neuroimaging and cognitive evaluations have been cautiously introduced in complex criminal cases. In sum, while the Indonesian legal framework currently lacks explicit accommodation for neurolaw in environmental cases, it possesses doctrinal, procedural, and normative avenues through which such integration can evolve. Reforming forensic procedures, judicial training, evidentiary rules, and sentencing guidelines are key steps toward a legal system that not only punishes environmental harm but also understands the cognitive conditions under which it occurs.

C. Comparative Reflections on the Use of Neuroscience in Criminal Trials Involving Environmental Harm

The global emergence of neurolaw has led to varying degrees of integration of neuroscientific evidence in criminal adjudication across legal systems. Countries such as the United States, Italy, Germany, and Brazil offer valuable comparative insights into how courts and legal institutions have grappled with the incorporation of neuroscience particularly neuroimaging in assessing criminal responsibility. These jurisdictions, although differing in legal traditions and procedural rules, provide case studies that may inform the potential adaptation of neurolaw in the context of environmental crimes in Indonesia. In the United States, neurolaw has gained considerable traction, particularly within the adversarial criminal justice system that allows for broad evidentiary inclusion. Neuroscientific evidence, including fMRI scans and structural imaging, has been introduced in cases involving both violent and white-collar crimes. One of the earliest landmark cases was *People v. Weinstein* (1992), where a PET scan was used to support a claim of diminished responsibility due to brain dysfunction. While this case did not involve environmental harm, it established the precedent for neuroimaging as admissible evidence.[18] More recently, neurolaw has been employed to assess culpability in cases involving corporate fraud, negligence, and regulatory violations offenses that share structural similarities with environmental crimes. In *United States v. Semrau* (2010), neuroscientific lie detection methods were tested in court, although ultimately excluded due to reliability concerns. Despite such limitations, U.S. courts have increasingly recognized that neurobiological impairments may affect *mens rea*, particularly under sentencing guidelines that allow mitigation based on cognitive deficits. The U.S. Supreme Court, in *Roper v. Simmons* (2005) and *Miller v. Alabama* (2012), also cited neuroscience research on adolescent brain development to limit harsh sentencing, signaling the judiciary's openness to brain-based arguments in determining culpability.[19]

Italy presents a civil law example of neurolaw integration with notable implications. In the high-profile *Stefano Ferraro* case (2011), the defense introduced neuroimaging evidence to argue that a frontal lobe abnormality reduced the defendant's moral judgment capacity. Although the case involved a violent offense, it opened the door for neuroscientific considerations in assessing criminal intent. Italian scholars such as Andrea Lavazza and Giuseppe Sartori have since advanced the theoretical foundation for using

[18] Cristina Scarpazza et al., "The Role of Neuroscience in the Evaluation of Mental Insanity: On the Controversies in Italy," *Neuroethics* 11, no. 1 (2018): 83–95, https://doi.org/10.1007/s12152-017-9349-0.
[19] Jay D. Aronson, "Brain Imaging, Culpability, and the Juvenile Death Penalty," *Psychology, Public Policy, and Law* 13, no. 2 (May 2007): 115–42, https://doi.org/10.1037/1076-8971.13.2.115.

neuroscience to evaluate legal responsibility, including within the realm of environmental regulation and corporate crime.[20]

Germany, with its strict evidentiary standards, has cautiously approached neurolaw but nonetheless recognizes mental incapacity and cognitive dysfunction as valid mitigating factors. The German Penal Code (Strafgesetzbuch) allows for the reduction or exclusion of criminal liability if the defendant's capacity to understand or control behavior is significantly impaired due to mental disorders (Section 20–21). Although environmental crimes are typically prosecuted under administrative and corporate liability frameworks, German academic discourse increasingly advocates for recognizing neuropsychological evaluations in cases involving high-level decision-making failures that lead to ecological harm. The 2021 decision by the Federal Constitutional Court (BVerfG) on climate inaction further emphasized intergenerational justice, potentially expanding the scope for neurolaw-informed accountability frameworks.

Brazil, which has faced numerous environmental disasters, offers a compelling case study in how neurolaw might be integrated into environmental crime litigation. In the aftermath of the Brumadinho dam collapse, Brazilian legal scholars began exploring the potential use of neuroscientific tools to evaluate the cognitive responsibility of corporate actors. While no neuroevidence was formally admitted in that case, the national debate on culpability, corporate culture, and moral blindness sparked interest in how neurolaw could assist in dissecting complex corporate decision-making processes. Brazil's legal system, influenced by both civil and common law elements, provides procedural flexibility for the introduction of expert testimony, including from neuroscientists.

These comparative experiences yield several important insights for the Indonesian context. First, they illustrate the importance of judicial openness to interdisciplinary evidence, particularly in cases involving systemic harm and indirect culpability. Second, they demonstrate how neuroscience can assist not in absolving guilt but in contextualizing responsibility, especially where traditional *mens rea* doctrines fall short. Third, they underscore the necessity of clear evidentiary standards, judicial training, and ethical safeguards to ensure that neuroevidence is used judiciously. For Indonesia, adopting best practices from these jurisdictions would require a stepwise approach. This includes introducing guidelines for the admissibility of neuroscientific evidence, developing a cadre of forensic neuropsychologists, and incorporating neurolaw modules into judicial and prosecutorial training. Additionally, Indonesia's environmental legal framework could benefit from explicit provisions allowing cognitive evaluations in cases involving high-level policy decisions or regulatory failures that result in ecological harm. In this way, the integration of neurolaw into environmental criminal law does not merely emulate foreign practices but adapts them to the unique challenges and normative commitments of the

[20] Elisabetta Sirgiovanni, Gilberto Corbellini, and Cinzia Caporale, "A Recap on Italian Neurolaw: Epistemological and Ethical Issues," *Mind and Society* 16, no. 1–2 (November 1, 2017): 17–35, https://doi.org/10.1007/S11299-016-0188-1.

Indonesian legal system. By reflecting on comparative models, Indonesia has the opportunity to craft a scientifically informed, ethically grounded, and ecologically responsive framework for criminal accountability in the Anthropocene era.

D. Victim Protection in the Neurolaw Discourse on Environmental Crimes

While the primary focus of neurolaw has been on evaluating the mental state and cognitive capacity of offenders, a victim-centered perspective remains largely underexplored in this evolving field, particularly in the context of environmental crimes. Environmental offenses often involve wide-ranging and long-term damage that affects not only individuals but entire communities, ecosystems, and even future generations. As neurolaw introduces greater complexity into the determination of criminal liability, including possibilities of diminished responsibility due to neurological impairment, it is essential to ensure that such developments do not inadvertently marginalize the rights and voices of victims. Victims of environmental crimes frequently include vulnerable populations such as Indigenous communities, rural residents dependent on natural resources, and people living in proximity to industrial sites. These individuals may suffer from loss of livelihood, health deterioration due to toxic exposure, forced displacement, and cultural disintegration. Moreover, environmental crimes also give rise to non-human victims, including endangered species, forest ecosystems, and water bodies that are irreparably damaged. Yet, the legal framework in many jurisdictions, including Indonesia, rarely acknowledges these entities within the domain of victim protection. In Indonesia, the Witness and Victim Protection Agency (LPSK) primarily operates within the scope of protecting victims of violent crime, sexual violence, or terrorism. While there have been discussions on expanding its mandate to include victims of corporate and environmental harm, such initiatives remain nascent. The Environmental Law (Law No. 32 of 2009) does recognize the right to a healthy environment, but it does not explicitly define or provide procedural mechanisms for the protection and rehabilitation of victims of ecological crime. This regulatory vacuum becomes even more problematic when neurolaw is introduced to potentially mitigate the culpability of offenders, especially those in powerful corporate or political positions.

The potential danger is twofold: first, the increasing reliance on neuroscientific evidence to explain the cognitive impairments or diminished moral capacity of environmental offenders might shift attention away from the impact on victims; second, without legal safeguards, neurolaw may be strategically employed to evade criminal liability in ways that undermine justice for communities devastated by pollution, deforestation, or toxic waste. In such a scenario, victims are doubly marginalized first by the crime itself, and second by legal narratives that prioritize offender psychology over community harm. To counterbalance this risk, a victim-centered neurolaw approach must be developed. Such an approach would integrate neuroscientific insights without compromising the rights of victims. This includes the institutionalization of *victim impact statements* in environmental criminal proceedings, allowing affected individuals and communities to articulate the social,

cultural, and psychological consequences of ecological harm. In countries like Canada and New Zealand, victim impact statements have become standard practice, even in non-violent crime cases, ensuring that sentencing decisions reflect both offender culpability and victim suffering. Incorporating restorative justice mechanisms into neurolaw-informed environmental proceedings may also serve to re-center victims in the legal process. Restorative justice emphasizes repair, accountability, and community healing. In the context of environmental crime, this could include community rehabilitation programs, ecological restoration projects, or formal apologies by corporations acknowledging their wrongdoing. Importantly, restorative mechanisms can be designed in ways that remain compatible with neurolaw findings recognizing cognitive impairment without sacrificing the need for reparation. Another innovation would be to legally recognize non-human entities as victims with standing in court. Ecuador and New Zealand have both granted legal personhood to rivers and forests, enabling lawsuits to be filed on their behalf. In an Indonesian context, particularly in areas with rich Indigenous cosmologies like Papua, Kalimantan, or Bali, integrating traditional environmental wisdom with legal personhood frameworks could offer a culturally resonant and ecologically progressive model of victim protection.

Victim-centered neurolaw also demands that expert testimony be balanced. While neuroscientific experts may testify on the mental state of defendants, equal emphasis must be placed on environmental and social science experts who can provide evidence of victim impact. This multidisciplinary integration ensures that court proceedings are not skewed toward the mitigation of offender responsibility but also account for the full spectrum of harm caused by environmental crime. Finally, international human rights frameworks can reinforce the alignment of neurolaw with victim protection. The UN Basic Principles and Guidelines on the Right to a Remedy and Reparation for Victims (2005) outline the rights of victims to equal access to justice, adequate reparation, and guarantees of non-repetition. Environmental victims human and non-human must be understood within this broader framework, especially when neurolaw challenges conventional pathways to justice. Incorporating these international standards into national environmental and criminal legislation would ensure a more balanced, ethical, and equitable approach.

Integrating victim protection into the evolving discourse of neurolaw is not merely a theoretical or ethical preference it is a normative imperative rooted in fundamental principles of justice, human rights, and ecological accountability. As neurolaw gains influence in shaping how courts evaluate the culpability of defendants, particularly in complex cases such as environmental crimes, there is a growing risk that the focus on offender cognition and neural dysfunction may inadvertently marginalize the lived experiences and legal standing of victims. This concern is not abstract. It reflects a real and urgent need to correct epistemic imbalances within criminal adjudication by re-centering victims as key legal subjects. Environmental crimes are uniquely situated within this discourse because their harm is not confined to individual victims but often involves entire ecosystems, intergenerational damage, and the destruction of communal ways of life.[21] These crimes affect air, water, land, and biodiversity resources that support not only human existence but also the survival of countless species. Consequently, the victims of environmental crime include both present-day humans and non-human entities, as well as

[21] Vincenzo Ruggiero and Nigel South, "Green Criminology and Dirty Collar Crime," *Critical Criminology* 18, no. 4 (December 21, 2010): 251–62, https://doi.org/10.1007/S10612-010-9122-8/METRICS.

future generations who will inherit degraded landscapes and diminished natural resources. Yet, within existing legal systems, including those exploring neurolaw, victimhood remains narrowly constructed around the immediate, personal, and visible.

The introduction of neuroscientific evidence to mitigate or explain offender behavior poses a dual challenge to victim protection. First, by emphasizing the internal states of the defendant, legal arguments may displace attention from the scale and severity of the harm inflicted. Second, when courts consider reduced culpability based on cognitive impairment, the principle of proportional justice risks being undermined, particularly when applied to powerful corporate or state actors responsible for large-scale environmental degradation. In this context, a victim-centered neurolaw approach does not reject the scientific insights of neuroscience but insists on their integration with restorative and reparative justice mechanisms that recognize the moral and legal weight of harm. A comprehensive victim-centered neurolaw framework must rest on four key pillars: recognition, participation, reparation, and transformation.

Recognition involves expanding the legal definition of victims to include not only direct human sufferers but also affected communities, ecological entities, and generations yet unborn. This requires normative reform. Legal systems must move beyond anthropocentric victimhood and acknowledge the harm to rivers, forests, and wildlife as legally cognizable injuries. Jurisdictions such as Ecuador and New Zealand have pioneered the recognition of the rights of nature, granting legal personhood to the Whanganui River and codifying constitutional protections for Pacha Mama (Mother Earth).[22] These models illustrate how legal recognition can reorient adjudication around ecological harm, even in cases where neuroscience is used to understand the mental state of corporate leaders or regulators.

Participation in legal processes that involve neurolaw requires more than symbolic acknowledgment of victims; it necessitates substantive procedural mechanisms that allow them to actively contribute to the shaping of justice. In environmental crime cases where harm often transcends individual injury and touches upon collective identity, territory, and culture existing procedural norms are frequently insufficient to accommodate the voices of affected communities. The integration of neurolaw, which tends to focus on the cognitive and psychological condition of the perpetrator, risks further marginalizing victims unless accompanied by deliberate legal design that elevates their experiential knowledge and lived realities. Victim impact statements must evolve beyond formulaic submissions and instead become dynamic tools that capture the ecological, cultural, and intergenerational dimensions of harm. These statements can function not only as evidence of suffering but as narrative instruments through which victims reclaim agency and articulate demands for justice. Environmental testimony, particularly from those with ancestral, scientific, or territorial knowledge, offers irreplaceable insights into the extent and meaning of ecological damage insights that cannot be gleaned from forensic reports alone. This is particularly pertinent when the crime affects sacred lands, biodiversity, or community health, where the consequences cannot be measured solely in economic or medical terms. Community consultations are another procedural necessity, especially in contexts where environmental degradation results from decisions made without local consent or transparency. These consultations must be institutionalized not as discretionary outreach but as formal

[22] Catherine J. Iorns Magallanes, "From Rights to Responsibilities Using Legal Personhood and Guardianship for Rivers," *SSRN Electronic Journal*, August 21, 2019, 216–39, https://doi.org/10.2139/SSRN.3270391.

components of the adjudicative process, potentially influencing sentencing, reparations, and post-verdict monitoring. Such mechanisms ensure that the integration of neuroscientific testimony often highly technical and individual-focused is balanced by contextual knowledge about the social and ecological fallout of the crime. Moreover, this participatory model requires a new set of competencies among legal professionals. Judges, prosecutors, and defense attorneys must be equipped not only with a foundational understanding of neuroscience but also with training in victimology, cultural sensitivity, and ecological ethics. This interdisciplinary literacy is essential to prevent the disproportionate privileging of neuro-based arguments at the expense of communal harm. Legal education, therefore, must be recalibrated to produce practitioners capable of navigating both the scientific rigor of neurolaw and the normative imperatives of victim-centered justice. Only through such procedural and pedagogical reforms can participation be rendered meaningful, equitable, and responsive to the multifaceted realities of environmental crime.

Reparation in the context of environmental neurolaw demands a multidimensional approach that goes far beyond the conventional framework of financial compensation. In cases where ecological destruction is intertwined with corporate negligence or impaired executive decision-making, justice must address not only the immediate material losses but also the long-term social, cultural, and ecological impacts suffered by affected communities. Monetary settlements, while important, often fail to capture the depth of harm inflicted upon environments and populations whose lives are intricately linked to natural ecosystems. Ecological restoration emerges as a critical form of reparation, particularly where landscapes, rivers, or biodiversity have been degraded or destroyed. This may include reforestation efforts, habitat reconstruction, pollution clean-up, and species recovery programs. In parallel, community rehabilitation must address the dislocation, health deterioration, and social fragmentation that typically follow large-scale environmental crimes. Reparative strategies might involve rebuilding community infrastructure, providing healthcare and psychosocial support, or revitalizing cultural practices disrupted by ecological harm. Symbolic justice is equally vital, especially for Indigenous peoples and other communities for whom environmental loss is inseparable from spiritual or ancestral identity. Official apologies, public memorials, and recognition of cultural rights can play an important role in acknowledging harm and validating the experiences of those affected. These measures contribute to healing and serve as institutional acknowledgment of wrongdoing critical for rebuilding trust between victims and legal institutions. In cases where neurolaw is used to demonstrate partial incapacity or reduced moral agency, sentencing should be recalibrated not to lessen accountability, but to redirect it toward reparative obligations. Rather than simply reducing prison time, courts can impose duties that actively involve offenders or the institutions they represent in processes that remediate harm. Corporations, in particular, may be ordered to fund long-term environmental monitoring programs to track ecological recovery, support Indigenous stewardship of ecologically or spiritually significant sites, or develop internal reforms to prevent similar harms in the future, such as whistleblower protections or transparent risk-reporting systems. Such reparation-oriented sentencing transforms the function of punishment from retribution to restoration. It aligns legal responses with the principles of ecological justice, ensuring that neurolaw's insights into the cognitive limitations of offenders are not misused as instruments of impunity. Instead, these insights become part

of a broader legal narrative that acknowledges complexity while still affirming the rights, dignity, and reparative claims of victims. Through this balance, the legal system can foster accountability that is not only scientifically informed but also ethically grounded and forward-looking.

The concept of transformation within a victim-centered neurolaw approach represents a profound reorientation in how law, neuroscience, and justice interact, particularly in the context of environmental harm. Rather than merely applying neuroscientific findings to evaluate individual culpability in traditional crimes, this model reimagines neurolaw as a vehicle for structural change. It demands a departure from punitive frameworks rooted in retribution, toward a legal architecture that prioritizes proactive ecological justice and long-term restoration for both human and non-human victims. In this context, legal consciousness itself must evolve no longer confined to anthropocentric interpretations of harm, but instead capable of recognizing the complex interdependencies between brain, behavior, and biosphere.

At the legislative level, this transformation necessitates the codification of environmental destruction not simply as a regulatory infraction or property violation, but as a crime against nature with its own ontological and juridical standing. This implies redefining victimhood to include not only communities and individuals directly affected by environmental crimes, but also ecosystems, animal species, and future generations. Legislative reforms would need to incorporate neuroscientific insights about decision-making, risk perception, and corporate cognition, particularly in cases involving environmental negligence or ecocide perpetrated by powerful institutions. Within the judiciary, a transformative victim-centered neurolaw approach calls for jurisprudential shifts that validate the claims of ecological victims and recognize the role of cognitive dysfunction, moral blindness, or structural disinhibition in environmental crimes. Courts may increasingly rely on neuroscientific testimony to explain how certain executive decisions especially those involving risk minimization or denial are shaped by neuropsychological biases, affective disconnection, or pathological corporate cultures. Importantly, the judicial system would not treat such evidence as an exculpatory tool but rather as a framework for understanding systemic failures and constructing remedies that emphasize rehabilitation, restitution, and collective responsibility. In the academic realm, the integration of neurolaw into curricula must go beyond its traditional alignment with forensic psychology or criminal defense. Instead, it should be situated within interdisciplinary frameworks that include sustainability science, ethics of care, environmental humanities, and post-human jurisprudence. Such a pedagogical shift would encourage future legal practitioners, judges, and policymakers to consider how brain science interacts with broader ecological systems, sociocultural dynamics, and normative theories of justice. It would also train legal professionals to critically assess the epistemological limits of neuroscience, and to resist its instrumentalization by dominant interests that may exploit it for reductionist or technocratic ends. The transformative model challenges the presumption that neurolaw is a neutral or purely scientific tool. It insists on confronting the normative values embedded in how neuroscientific knowledge is interpreted and applied, particularly in legal systems historically shaped by anthropocentric, extractive, and hierarchical worldviews. By reframing neurolaw as a field not just of evidentiary support but of ethical and political significance, this approach opens space for

reconceiving legal responsibility in ways that align with ecological interdependence, multispecies justice, and the cognitive vulnerabilities of both individuals and institutions.

Examples of legal innovation in this direction are already emerging. In Colombia, the Constitutional Court has recognized the Atrato River as a legal subject with rights to protection, conservation, and restoration.[23] In India, several high courts have declared rivers such as the Ganges and Yamuna as living entities.[24] These legal shifts provide fertile ground for integrating neurolaw without sidelining environmental victims. Similarly, South Africa's post-apartheid restorative justice framework, though not yet extended to environmental crime, offers procedural models for balancing neuro-based defenses with robust victim participation.

In Indonesia, institutional reform could begin with expanding the mandate of LPSK to formally include environmental victims, establishing environmental justice clinics at public universities to assist communities in legal literacy and neurolegal advocacy, and embedding victim-centered principles into judicial guidelines. The National Commission on Human Rights (Komnas HAM) could also develop protocols for recognizing victims of ecological degradation, particularly when such degradation results from regulatory failures linked to impaired decision-making. Crucially, international law provides a foundation for advancing this agenda. The UN Human Rights Council has recognized a clean, healthy, and sustainable environment as a universal human right. The Rome Statute of the International Criminal Court includes environmental destruction as a potential element of war crimes and crimes against humanity. While these frameworks have not yet fully embraced neurolaw, they provide normative anchors for integrating neuroscience into accountability models that are sensitive to victims. From a theoretical standpoint, integrating victim protection into neurolaw aligns with emerging schools of thought such as green criminology, ecological jurisprudence, and feminist legal theory. These traditions challenge the dominance of offender-centric justice and propose relational, contextual, and systems-based approaches. A victim-centered neurolaw would interrogate how neurological discourse interacts with power, privilege, and systemic harm a crucial step in democratizing forensic narratives and resisting technocratic injustice. Though not as a summary but as a continuation of critical reflection, the inclusion of victim protection in neurolaw is not only feasible but necessary. It ensures that neuroscience contributes to justice rather than derails it. By weaving together scientific precision with moral accountability, legal systems can develop models of adjudication that are not only neurologically informed but also ethically responsive to the communities, ecosystems, and futures endangered by environmental crime.

Conclusion

The integration of neurolaw into the adjudication of environmental crimes offers a groundbreaking yet challenging opportunity to enrich the understanding of criminal liability by incorporating neuroscientific insights into the legal determination of mens rea. As environmental crimes become increasingly complex, diffuse, and often embedded within corporate or bureaucratic structures, traditional criminal law paradigms centered on

[23] Iván Vargas-Chaves et al., "El Reconocimiento de Los Derechos de La Naturaleza En Colombia : El Caso Del Río Atrato.," *Jurídicas* 17, no. 1 (January 1, 2020): 13–41, https://doi.org/10.17151/JURID.2020.17.1.2.
[24] Iorns Magallanes, "From Rights to Responsibilities Using Legal Personhood and Guardianship for Rivers."

individual intent and rational agency appear insufficient to capture the nuances of decision-making that leads to ecological harm. Neuroscience provides valuable tools to examine cognitive impairments, moral disengagement, and collective responsibility in ways that can complement, rather than replace, existing legal doctrines. However, the advancement of neurolaw must not come at the expense of victims' rights and ecological justice. This article emphasizes the normative imperative of embedding a victim-centered approach within neurolaw applications in environmental cases. The use of neuroscientific evidence to explain or mitigate offender culpability must be carefully balanced with procedural and substantive mechanisms that recognize the multidimensional harms suffered by victims both human and non-human. Through the incorporation of victim impact statements, legal personhood for nature, and restorative justice frameworks, courts can ensure that neuro-based arguments do not overshadow the lived realities of affected communities and ecosystems. In the Indonesian context, where legal recognition of environmental victims remains limited and neurolaw remains underdeveloped, reform efforts should focus on expanding institutional mandates (such as LPSK), updating procedural rules to admit neuroscientific and ecological expert testimony, and harmonizing legal norms with international human rights and environmental standards. Comparative lessons from the United States, Italy, Germany, Brazil, and other jurisdictions illustrate that the integration of neurolaw into environmental criminal law is both feasible and necessary provided that such integration is guided by ethical vigilance and a commitment to justice. Ultimately, the future of environmental criminal law must rest on an interdisciplinary foundation that respects scientific validity, ensures proportional accountability, and centers the voices and rights of victims. A victim-centered neurolaw framework offers a promising path forward for achieving this balance one that aligns legal innovation with ecological responsibility and human dignity.

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The authors state that there is no conflict of interest in the publication of this article.

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References

Agusalim, Ria Anggraeni Utami & Zico Junius Fernando. "Green Victimology: Sebuah Konsep Perlindungan Korban Dan Penegakan Hukum Lingkungan Di Indonesia." *Bina Hukum Lingkungan* 7, no. 1 (October 2022): 60–79. https://doi.org/10.24970/BHL.V7I1.302.

Aronson, Jay D. "Brain Imaging, Culpability, and the Juvenile Death Penalty." *Psychology, Public Policy, and Law* 13, no. 2 (May 2007): 115–42. https://doi.org/10.1037/1076-8971.13.2.115.

Brown, Eryn. "The Brain, The Criminal and The Courts." Knowable Magazine, 2019. https://knowablemagazine.org/article/mind/2019/neuroscience-criminal-justice.

Chandler, Jennifer A. "The Use of Neuroscientific Evidence in Canadian Criminal Proceedings." *Journal of Law and the Biosciences* 2, no. 3 (November 1, 2015): 550–79. https://doi.org/10.1093/jlb/lsv026.

DS, Mayer Hayrani. "Perkembangan Hukum Pidana Lingkungan Hidup." *Jurnal Legislasi Indonesia* 15, no. 4 (2018): 333. http://www.mongabay.

Eastman, Nigel, and Colin Campbell. "Neuroscience and Legal Determination of Criminal Responsibility." *Nature Reviews Neuroscience 2006 7:4* 7, no. 4 (March 16, 2006): 311–18. https://doi.org/10.1038/nrn1887.

Eckerman, I. "Bhopal Gas Catastrophe 1984: Causes and Consequences." *Encyclopedia of Environmental Health, Volume 1-5* 1 (January 1, 2011): 302–16. https://doi.org/10.1016/B978-0-444-52272-6.00359-7.

Gkotsi, Georgia Martha, Jacques Gasser, and Valérie Moulin. "Neuroimaging in Criminal Trials and The Role of Psychiatrists Expert Witnesses: A Case Study." *International Journal of Law and Psychiatry* 65 (2019). https://doi.org/10.1016/j.ijlp.2018.05.007.

Iorns Magallanes, Catherine J. "From Rights to Responsibilities Using Legal Personhood and Guardianship for Rivers." *SSRN Electronic Journal*, August 21, 2019, 216–39. https://doi.org/10.2139/SSRN.3270391.

Junius Fernando, Zico, Ria Anggraeni Utami, Hamonangan Albariansyah, Rian Sacipto, and -Zico Junius Fernando. "Neurolaw: A Concept in Development and Enforcement of Criminal Law in Indonesia." *Jambura Law Review* 7, no. 1 (2025): 55–87. https://doi.org/10.33756/JLR.V7I1.24144.

Kontesa, Emelia, and Zico Junius Fernando. "Reclaiming Our Roots: Agrarian Law's Battle Against Land Grabbing." *Lex Scientia Law Review* 8, no. 2 (November 30, 2024): 1–10. https://doi.org/10.15294/LSLR.V8I2.10681.

Mehta, Sailesh, and Prisca Merz. "Ecocide – A New Crime Against Peace?" *Environmental Law Review* 17, no. 1 (March 2015): 3–7. https://doi.org/10.1177/1461452914564730.

Owen, Adrian M, Russell Epstein, and Ingrid S Johnsrude. "FMRI: Applications to Cognitive Neuroscience." In *Functional Magnetic Resonance Imaging: An Introduction to Methods*, edited by Peter Jezzard, Paul M Matthews, and Stephen M Smith, 312–329. Oxford University Press, 2001.

https://doi.org/10.1093/acprof:oso/9780192630711.003.0017.

Rippingille, Bonnie. "Editorial: Beyond All Boundaries the Meteoric Rise of Environmental Crime." *Journal of Financial Crime* 30, no. 5 (November 30, 2023): 1113–16. https://doi.org/10.1108/JFC-10-2023-311/FULL/PDF.

Ruggiero, Vincenzo, and Nigel South. "Green Criminology and Dirty Collar Crime." *Critical Criminology* 18, no. 4 (December 21, 2010): 251–62. https://doi.org/10.1007/S10612-010-9122-8/METRICS.

Scarpazza, Cristina, Silvia Pellegrini, Pietro Pietrini, and Giuseppe Sartori. "The Role of Neuroscience in the Evaluation of Mental Insanity: On the Controversies in Italy." *Neuroethics* 11, no. 1 (2018): 83–95. https://doi.org/10.1007/s12152-017-9349-0.

Silva Rotta, Luiz Henrique, Enner Alcântara, Edward Park, Rogério Galante Negri, Yunung Nina Lin, Nariane Bernardo, Tatiana Sussel Gonçalves Mendes, and Carlos Roberto Souza Filho. "The 2019 Brumadinho Tailings Dam Collapse: Possible Cause and Impacts of the Worst Human and Environmental Disaster in Brazil." *International Journal of Applied Earth Observation and Geoinformation* 90 (August 1, 2020): 1–7. https://doi.org/10.1016/J.JAG.2020.102119.

Sinaga, Pidari, Yusriyadi Yusriyadi, Ana Silviana, and Zico Junius Fernando. "Kejahatan Biodiversitas Dan Urgensi Peran Hukum Pidana Dalam Sektor Agraria." *Jurnal Pembangunan Hukum Indonesia* 6, no. 2 (June 27, 2024): 210–42. https://doi.org/10.14710/JPHI.V6I2.210-242.

Sirgiovanni, Elisabetta, Gilberto Corbellini, and Cinzia Caporale. "A Recap on Italian Neurolaw: Epistemological and Ethical Issues." *Mind and Society* 16, no. 1–2 (November 1, 2017): 17–35. https://doi.org/10.1007/S11299-016-0188-1.

Triwanto. "Penyelesaian Sengketa Lingkungan Hidup Menurut Undang Undang Nomor 32 Tahun 2009." *Wacana Hukum* VIII, no. 1 (2009): 86–102.

Vargas-Chaves, Iván, Gloria Amparo Rodríguez, Alexandra Cumbe-Figueroa, and Sandra Estefanía Mora-Garzón. "El Reconocimiento de Los Derechos de La Naturaleza En Colombia : El Caso Del Río Atrato." *Jurídicas* 17, no. 1 (January 1, 2020): 13–41. https://doi.org/10.17151/JURID.2020.17.1.2.

Xue, Gui, Chuansheng Chen, Zhong-Lin Lu, and Qi Dong. "Brain Imaging Techniques and Their Applications in Decision-Making Research." *Xin Li Xue Bao. Acta Psychologica Sinica* 42, no. 1 (February 2010): 120–37. https://doi.org/10.3724/SP.J.1041.2010.00120.

Zico Junius Fernando et al. "Eco-Democracy: Advancing Sustainable Governance Through Green Politics." *Proceeding APHTN-HAN* 2, no. 1 (December 31, 2024): 231–72. https://doi.org/10.1126/SCIENCE.AAL4863.

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