AI AND ENVIRONMENTAL LAW: BEYOND CLIMATE GOVERNANCE

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Abstract

Artificial intelligence (hereinafter referred to as 'AI') is emerging as a transformative tool in environmental regulation, offering new opportunities to monitor, enforce, and advance climate governance. Yet, the rapid integration of AI into environmental decision-making exposes significant legal gaps that demand reform. This essay identifies six areas where law must evolve to ensure AI supports climate objectives responsibly and equitably. First, regulatory frameworks should explicitly mandate or permit AI use in environmental monitoring, for instance by embedding satellite data analysis within permit conditions. Second, transparency requirements must compel AI developers to disclose the energy consumption and carbon footprint of their systems, echoing the approach of the European Union (hereinafter referred to as 'EU') Artificial Intelligence Act. Third, "green AI" standards—such as an eco-certification scheme—could incentivise energy-efficient algorithm design. Fourth, reforms to data access are necessary to strengthen open-data laws and foster global agreements on emissions and satellite data sharing. Fifth, liability regimes must be updated to address AI-induced errors in environmental governance, potentially through strict liability mechanisms. Finally, sustainability should be embedded within AI ethics and regulatory principles to align technological innovation with ecological imperatives. Collectively, these reforms highlight the need for interdisciplinary collaboration—law, technology, and policy must converge to guide AI's role in advancing environmental sustainability.

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Introduction

Climate change has been a long-concerned issue that is globally challenging which necessitates innovative solutions across borders and disciplines. As such, AI is increasingly being applied to monitor and mitigate climate change. For example, satellites can track emissions, while algorithms can help people utilize energy more efficiently.

This study seeks to discover how AI technologies relate to environmental legislation and policy in the United Kingdom (hereinafter referred to as 'UK') and globally. It places AI-driven technologies into current climate frameworks such as the Paris Agreement, United Nations Framework Convention on Climate Change (hereinafter referred to as 'UNFCCC'), EU climate law, and the UK net-zero legislation which examines the legal and governance ramifications. Furthermore, it examines the pros and cons of Al for climate governance by analysing case studies such as Oxford's hyperspectral methane detection and the Climate TRACE emissions-tracking consortium. This paper also seeks to examine UK initiatives like "AI for Net Zero" alongside global frameworks including the Paris Agreement, the UNFCCC, and the proposed EU AI Act. Besides that, this paper addresses issues of ethics and responsibility, specifically on challenges such as algorithms, data security, and the energy consumption of AI itself. Finally, this paper identifies gaps in the current legal framework and proposes reforms to ensure that the benefits of AI can be harnessed safely and effectively to support the achievement of climate targets.

Climate Governance and Framework

Climate change is governed by a growing legal framework that includes international treaties, national legislation and emergent policy initiatives. The UNFCCC[2] and its 2015 Paris Agreement[3] is an important component. Article 4.2 of the Paris Agreement[4] states that almost all nations must submit Nationally Determined Contributions (NDCs) to reduce greenhouse gas (GHG) emissions. Furthermore, the Paris Agreement establishes an effective structure for transparency that requires parties to report their emissions and progress annually. In other words, states must make legally enforceable commitments to keep warming "well below 2'C," although the regulations rely on self-reporting and monitoring. Hence, Al can make these systems more reliable and accountable by providing independent emissions data. For

[2] United Nations Framework Convention on Climate Change (adopted 9 May 1992, entered into force 21 March 1994) 1771 UNTS 107.
[3] Paris Agreement (adopted 12 December 2015, entered into force 4 November 2016) [2016] UNTS 54113.
[4] *Ibid*, art 4.2.

example, at the COP28 (2023),[5] parties specifically acknowledged AI in climate technology. Besides that, the Technology Mechanism also initiated a campaign called "#A|4GlimateAction", assigning the UNFCCC's Technology Executive Committee and CTCN to investigate AI's role in mitigation and adaptation, particularly in developing nations. This development suggests that the international climate regime is starting to use Al as a climate tool.

The EU's Green Deal and European Climate Law (Regulation 2021/1119)[6] stated that the EU must be carbon neutral by 2050 and net-zero emission by the middle of the century, with an interim target for 2030. Member states must incorporate climate objectives in their policies for each sector. The EU has always been a leader in Al regulation. The proposed EU Al Act (COM(2021)206)[7] is a risk-based legislation that will regulate Al in all areas; however, it does not focus specifically on climate change. It also includes provisions requiring high-powered AI models such as the "foundation models" that enable ChatGPT to disclose their energy consumption. However, some experts argue that the Act overlooks AI's environmental impacts in favour of focusing on its effects on individuals. The Act does not mandate any reduction of environmental footprints beyond requirements for transparency and adherence to voluntary standards. Scholars have observed this discrepancy: the EU Charter of Fundamental Rights (Art. 37)[8] stipulated that EU policy must account for environmental protection, whereas the draft Al Act imposed no binding environmental obligations on Al providers. The EU's climate regulations, such as the Emissions Trading System Renewable Energy Directive, primarily target traditional sectors and do not specifically address digital technologies. Therefore, under the current EU law, Al based climate tools clearly do not fall under a single regulatory framework.

The **Climate Change Act 2008**, as amended,[9] is the primary legislation in the UK addressing climate change. It establishes a 2050 net-zero target, carbon budgets, and mandatory reporting requirements. The UK Government's Net Zero Strategy[10] and subsequent regulations encourage innovation but do not mandate the use of AI. The United

[5] UNFCCC, 'Technology Mechanism Launches #AI4ClimateAction Campaign' (COP28, 2023) <https://unfccc.int/news/technology-mechanism-launches-ai4climateaction-campaign> accessed 18 August 2025.
[6] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality [2021] OJ L243/1.
[7] Proposal for a Regulation of the European Parliament and of the Council on laying down harmonized rules on artificial intelligence (Artificial Intelligence Act) COM (2021) 206 final.
[8] Charter of Fundamental Rights of the European Union [2012] OJ C326/39, Art 37.
[9] Climate Change Act 2008 (as amended), s 1.
[10] UK Government, 'Net Zero Strategy: Build Back Greener' (2021) <https://www.gov.uk/government/publications/net-zero-strategy> accessed 18 August 2025.

Kingdom's White Paper on Al Regulation, "A Pro-Innovation Approach"[11] sets out principles to ensure that AI regulation is reliable. Notably, it calls for environmental sustainability to be made a core Al value, but the government declined to adopt this proposal. The White Paper specifies that "environmental sustainability" is not explicitly included among the Al principles, and instead, it is expected to apply existing environmental legislation. Consequently, the UK government currently treats AI and climate as largely separate policy domains. Nevertheless, the government has funded climate and AI-related initiatives, such as the AI for Net Zero programme, which links AI to climate objectives.

There are currently no international treaties that explicitly address AI and the environment together, and no global standards exist that mandate the development of "green AI". The OECD[12] and UNESCO[13] are examples of multilateral organizations that have issued soft-law instruments on trustworthy AI, primarily concerning its societal impacts. However, limited guidance has been provided on AI's implications for climate change. Non-governmental groups such as the Global Partnership on AI and the Centre for AI and Digital Policy are only beginning to consider climate-related dimensions of AI ethics. In summary, no comprehensive legal frameworks currently integrate climate treaties with emerging AI legislation. This regulatory gap presents both opportunities and challenges, which will be examined below.

AI Technologies in Environmental Monitoring and Action

Al encompasses data analytics, machine learning, neural networks, and computer vision which can identify patterns in large datasets or images that are imperceptible to humans.[14] In an environmental context, Al can enhance monitoring through satellites and sensors that find pollutants,[15] modeling through climate or ecosystem simulation,[16] and optimization through energy grids and logistics.[17] The United Nation Environment Programme (hereinafter referred to as 'UNEP') has noted that Al's capacity to "detect patterns in data" could make it highly

[11] UK Government, 'A pro-innovation approach to AI regulation' (*White Paper*, 2023) <https://www.gov.uk/government/publications/ai-regulation-a-pro-innovation-approach> accessed 18 August 2025.
[12] OECD, 'OECD Principles on AI' (2019) <https://www.oecd.org/ai/ai-principles/> accessed 18 August 2025.
[13] United Nations Educational Scientific and Cultural Organization (UNESCO), 'Recommendation on the Ethics of Artificial Intelligence' (2021) <https://unesdoc.unesco.org/ark:/48223/pf0000381137> accessed 18 August 2025.
[14] Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (4th edn, Pearson 2021) 35–40
[15] European Space Agency, 'AI for Earth Observation' (2023) <https://www.esa.int/Applications/Observing_the_Earth> accessed 18 August 2025.
[16] IPCC, 'Climate Change 2022: Mitigation of Climate Change' (2022) WGIII AR6, ch 4.
[17] International Energy Agency, 'Digitalization and Energy' (2017) <https://www.iea.org/reports/digitalisation-and-energy> accessed 18 August 2025.

valuable for environmental monitoring and informed decision-making.[18] Indeed, Al is already being applied in environmental initiatives: UNEP has used Al to detect methane leaks from oil and gas infrastructure.[19] Simultaneously, private and academic groups are employing machine learning to improve the dispatch of renewable energy and to model deforestation risk.[20]

Al is now being used as satellite and hyperspectral images to track emissions.[21] At Oxford University, researchers created a machine-learning system that can spot methane plumes in satellite data. Methane is a greenhouse gas that stays in the air for less time than CO2, but it traps about 80 times more heat over the span of 20 years.[22] Old sensors often miss methane leaks, but the Oxford system can identify methane signals and adjust for interference from the atmosphere.[23] It worked over 21.5% better than the earlier method at finding large leaks.[24] New satellites from ESA, NASA, and private companies will soon make it possible to monitor methane almost everywhere in real time.[25] With AI, these satellites can map methane from pipelines and farms around the world without needing people to operate them directly.

Climate TRACE is another prominent example as it is a global and nonprofit coalition that leverages AI and satellite data to produce an independent greenhouse gas inventory.[26] The initiative gathers information from more than 300 satellites, spectral imaging systems, and other remote sensing technologies, and then applies machine learning to attribute emissions to specific facilities such as power plants and corporations.[27] It has developed an open-source database of emissions (including CO2, methane, N20, and more) from 2015 to 2022 for more than 350 million assets. Climate TRACE's method is important because it "pairs satellite and remote sensing data with artificial intelligence to find emitting activities and figure out how much greenhouse gas is being released."[28] This has made it possible for case studies like the "STARRS" project, where subnational governments used Climate TRACE to get precise regional emissions inventories (2015-2021) to fill in gaps in sparse

[18] UNEP, *Frontiers 2022: Noise, Blazes and Mismatches* (2022) 45.
[19] UNEP, 'Methane Alert and Response System (MARS)' (2023) <https://www.unep.org/explore-topics/energy/what-we-do/methane-alert-and-response-system-mars> accessed 20 August 2025.
[20] David Rolnick et al, 'Tackling Climate Change with Machine Learning' (2022) *ACM Computing Surveys* 55(2) 1–96.
[21] John Shawe-Taylor et al, 'AI for Earth Observation' (2023) *Nature Machine Intelligence* 5(3) 123–130.
[22] IPCC, 'Climate Change 2021: The Physical Science Basis' (2021) AR6 WG1, ch 5.
[23] Yuzhong Zhang et al, 'Quantifying Methane Point Sources with Machine Learning' (2022) Science 377(6609) 156–160
[24] *Ibid*.
[25] European Space Agency, 'Copernicus Hyperspectral Imaging Mission' (2024) <https://www.esa.int/Applications/Observing_the_Earth/Copernicus> accessed 18 August 2025.
[26] 'About Climate TRACE' (*Climate TRACE*, 2023) <https://climatetrace.org/about> accessed 10 June 2024.
[27] Climate TRACE, Global Emissions Inventory: Methodology (2023) <https://climatetrace.org/methodology> accessed 10 June 2024.
[28] *Ibid* (emphasis added).

self-reported data. At COP27, Al Gore talked about Climate TRACE and how it speeds up climate action by giving people access to impartial, clear emissions data.[29]

These Al gadgets claim they will go beyond national surveillance limits. Satellite-Al can show that a country's official inventory is missing a major emitter. A paper from UCLA's law schools stated that methane satellites offer "unprecedented transparency and accountability".[30] For example, NASA's EO-1 Hyperion satellite famously observed the Aliso Canyon methane blowout from space in 2015. The EO-1 hyperspectral captured an image of a methane plume in 2015-16.[31] It was the first time emissions from a single facility were detected from space. With AI-enhanced monitoring, regulators and the public can "see" pollution in ways that were previously inconceivable.[32]

Al can assist with policy-making and enforcement beyond detection. This is because AI algorithms can analyze large environmental databases to identify high-risk areas, predict where infractions are likely to occur, and determine how to allocate inspection resources efficiently.[33] For instance, Al can analyze satellite imagery or social media illegal dumping or deforestation. A study from the London Schools of Economics states that Al's primary function is to help enforcement agencies identify problematic areas, such as pollution hotspots, more quickly by providing real-time data.[34] UK companies are developing Al-powered self-driving robots for sustainable farming: lightweight drones and rovers can continuously map fields, reducing fertilizer use and crop waste, thereby promoting more environmentally friendly practices.

<u>Case Study: Hyperspectral Methane Detection</u>

Methane is responsible for about 15% of the current warming, yet reducing methane levels can have short-term advantages for the climate. Oxford's hyperspectral methane detector is a good example of how AI and the law work together. The method uses spectroscopy to find the molecular signature of methane in sunlight that has been reflected off. This progress is especially important for enforcing emissions rules. In many places (UK, EU, US), oil and gas companies must keep an eye on leaks as part of their environmental permits, but if they do not find them, they need not report them. The EU's Methane Strategy (2020) says that gas

[29] Al Gore, Speech at COP27 (United Nations Climate Change Conference, Sharm El-Sheikh, 8 November 2022).
[30] UCLA School of Law, 'Methane Satellites and Accountability' (2021) 34(2) Environmental Law Review 45, 47.
[31] NASA Jet Propulsion Laboratory, 'EO-1 Hyperion Satellite Detects Methane Plume' (Press Release, 16 December 2015).
[32] UCLA School of Law (n 5) 49.
[33] LSE Grantham Research Institute, 'AI in Environmental Enforcement' (Policy Report, March 2023) 12.
[34] *Ibid*, 15.

facilities should be watched,[35] and the US EPA's new standards (2023) say that leaks should be found and fixed on a regular basis.[36] Satellite tools that use AI could do these things better. Regulators may add this kind of technology to permits, such as requiring corporations to send in emission data that has been validated by satellites. As another option, authorities could utilize the technology as "remote inspectors" to evaluate the accuracy of self-reported data. UCLA's guide to satellite methane says that governments should use these data to "improve climate policies, enforce emissions regulations, and speed up efforts to reduce methane." [37]

Agriculture is a major source of methane, along with oil and gas. Satellites can now also detect pollutants arising from rice cultivation and livestock farming. These technological capabilities raise important legal questions: if a satellite-Al system identifies an undisclosed methane leak, can such evidence be used for enforcement? Under the UK legislation, environmental regulators generally have the discretion to use any reliable form of evidence; however, they need to change the rules to allow remote-sensing proof. There are no laws in other countries that bans cross borders observations of emissions which are controlled by the Outer Space Treaty. As a result, this causes problems with data sharing. For example, a state can argue with a reading from a foreign satellite provider unless there is an acknowledged way to share data. The UK sets an example through the invention of innovative systems for trading emissions and getting environmental permits including highways for keeping an eye on tech. Therefore, the laws were not written with Al in mind and certain standards such as the lack of satellite data accuracy were not clearly laid out. This shows a gap in the law where Al can make strong evidence, but the law needs to be amended to include it.

Case Study: Climate TRACE's Global Emissions Mapping

Hyperspectral methane looks at one gas, whereas Climate TRACE looks at the bigger picture of emissions. Its machine-learning platform combines a lot of different data sources, such as the locations of power plants, the amount of fuel used by factories, the amount of traffic, and satellite thermal images, to figure out how much GHGs each country produces in each sector. It has made separate lists of all the countries who signed the Paris Agreement and also

[35] EU Commission, EU Methane Strategy (COM/2020/663) Annex II.
[36] US Environmental Protection Agency, Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review (2023) 88 FR 35870.
[37] UCLA School of Law (n 5) 52.

included information about energy, industry, agriculture, land usage, and more. Climate TRACE is important as it "provides the world's first comprehensive accounting of GHG emissions based primarily on direct, independent observation".[38]

The Paris Agreement has a better transparency system that depends on the country's report,[39] and Climate TRACE does an audit. For instance, Climate TRACE found that most countries do not disclose all the emissions from their coal plants when they compare them to data from other sources. NGOs and some states in the US are utilizing the statistics to put pressure on polluters and make decisions on the policy. Moreover, investors and financial regulators also use its data to look at "financed emissions" in loan portfolios and investments climate trace. Climate TRACE could have an impact on responsibility and due diligence in the legal sense. For example, a corporation that says it has low emissions might be disputed if satellite-Al data shows otherwise.

However, there are problems with implementing Climate TRACE in law. Sovereign states may reject outside audits and there is no global enforcement body to make them act on the data. If there is a disagreement between countries over emissions (for trade, border adjustment taxes, etc.), can Al-derived statistics be used? The UNFCCC might deal with this by making rules for how to use remote-sensing data in national inventories. The proposed Carbon Border Adjustment Mechanism in the EU may eventually consider emissions data from other parties. As of now, Climate TRACE's adaptability to change encourages "data-driven decarbonization" even though it does not have the power of law. The case study demonstrates that AI-driven openness can surpass geographical and political barriers, establishing a shared factual foundation for climate policy. Thus, this shows how important it is for laws to detect and control these new sources of data.

UK and Global Policies on AI and Climate Law

The development and deployment of AI bring environmental expenses, including significant energy consumption for model training and hardware manufacturing effects. This tension between potential benefits and environmental risks has prompted varying levels of policy attention at global levels.[40]

[38] Climate TRACE, 'Global Emissions Inventory Launch' (Press Release, 15 September 2023).
[39] Paris Agreement (2015), Art 13.
[40] Kate Crawford, *Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence* (Yale University Press 2021).

The UK has positioned itself as a leader in AI innovation, with several funding programmes aimed at aligning AI research with environmental objectives. The “AI for Net Zero” initiative, administered through UK Research and Innovation (UKRI), supports projects that apply AI to accelerate progress towards the UK’s legally binding net-zero greenhouse gas emissions target by 2050.[41] This funding call encourages applications in areas such as energy efficiency, renewable energy integration, and emissions monitoring.[42]

Complementing this, the Department for Science, Innovation and Technology (DSIT) offers grants for AI-driven climate solutions. These grants target applied innovation in sectors like precision farming, which uses AI to optimise crop yields and reduce agricultural emissions, and smart energy management systems, which enhance grid stability and enable demand-side flexibility.[43] The combined effect of UKRI and DSIT programmes is to stimulate cross-sector collaborations that translate AI research into tangible climate benefits.

Regulatory frameworks, however, reveal a gap. The UK’s AI White Paper, published as a pro-innovation strategy, proposes a decentralised, sector-based regulatory approach that prioritises fostering innovation over imposing strict compliance burdens.[44] While this approach has been welcomed by industry stakeholders, it notably does not explicitly address AI’s environmental impacts. There is no requirement, for instance, for developers to disclose the energy usage or carbon footprint of large-scale AI models.[45] This omission means that environmental considerations remain an indirect concern, potentially addressed through broader environmental regulations rather than AI-specific rules.

The European Union’s most significant legislative intervention is the EU AI Act, which adopts a risk-based regulatory framework.[46] AI systems are classified into prohibited, high-risk, limited-risk, and minimal-risk categories, with compliance obligations increasing according to risk level. Foundation models — large, general-purpose AI systems — will face transparency requirements, including limited obligations to disclose energy consumption.[47]

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[41] UK Research and Innovation (UKRI), ‘AI for Net Zero’ <https://www.ukri.org/what-we-offer/our-main-funds/ai-for-net-zero/> accessed 10 August 2025.

[42] UK Research and Innovation (UKRI), ‘Artificial Intelligence Research to Enable UK’s Net Zero Target’ (*Funding Call*, 2024) <https://www.ukri.org/opportunity/artificial-intelligence-research-to-enable-uks-net-zero-target/> accessed 10 August 2025.

[43] Department for Science, Innovation and Technology (DSIT), ‘Funding for AI and Climate Innovation’ (2023) <https://www.gov.uk/government/organisations/department-for-science-innovation-and-technology> accessed 10 August 2025.

[44] Department for Science, Innovation and Technology, *AI Regulation: A Pro-Innovation Approach* (White Paper, March 2023).

[45] *Ibid*.

[46] Regulation of the European Parliament and of the Council Laying Down Harmonized Rules on Artificial Intelligence (Artificial Intelligence Act) COM (2021) 206 final.

[47] *Ibid*, Art 52.

Nonetheless, critics argue that these measures are insufficient. Hauke Hille notes that the Act fails to address AI's environmental footprint in a meaningful way, focusing instead on safety, fundamental rights, and transparency.[48] According to Hille, this omission risks allowing the rapid expansion of AI infrastructure without parallel efforts to mitigate its environmental costs.

Beyond the EU, international climate governance frameworks have begun to engage with AI in a more exploratory capacity. Under the United Nations Framework Convention on Climate Change (UNFCCC), the Technology Mechanism launched the #AI4ClimateAction initiative at COP28.[49] This programme aims to identify and promote AI applications in climate adaptation, mitigation, and resilience. It operates primarily as a knowledge-sharing and capacity-building effort rather than a binding regulatory framework.

The United Nations Environment Programme (UNEP) has similarly highlighted AI's environmental risks. Its 2024 report urges policymakers to establish clearer sustainability criteria for AI development, including energy efficiency benchmarks, recycling protocols for hardware, and lifecycle carbon accounting.[50] UNEP stresses that without such measures, the carbon footprint of AI could undermine its potential contributions to climate solutions.

While the Paris Agreement provides the overarching international framework for climate action, it contains no direct references to AI.[51] This absence reflects the Agreement's technology-neutral approach, leaving parties to determine their own strategies for integrating AI into their climate policies.

At the global governance level, initiatives tend to focus on ethical guidance rather than binding environmental obligations. The Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) have issued AI ethics guidelines that include sustainability principles, but these are non-binding.[52] They encourage member states and organisations to promote "Green AI" — the development of models and infrastructures with minimal environmental impact — but stop short of mandating compliance.

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[48] Hauke Hille, 'Why the EU AI Act Does Not Protect the Environment' *SustAIn Magazine* (AlgorithmWatch, 2022) <https://algorithmwatch.org/en/ai-act-environment/> accessed 10 August 2025.

[49] UNFCCC, '#AI4ClimateAction: Harnessing Artificial Intelligence for Climate Solutions' (*COP28 Initiative*, 2023) < https://unfccc.int> accessed 10 August 2025.

[50] United Nations Environment Programme (UNEP), *AI Has an Environmental Problem* (2024).

[51] Paris Agreement (adopted 12 December 2015, entered into force 4 November 2016) UNTS vol 3156.

[52] OECD, *OECD Principles on Artificial Intelligence* (2019); UNESCO, *Recommendation on the Ethics of Artificial Intelligence* (2021).

Paul Collins of the LSE Centre for Public Affairs notes that AI's role in environmental regulation is currently underdeveloped in formal governance structures.[53] He argues that while AI can enhance monitoring and enforcement in environmental law — for example, by detecting illegal deforestation or tracking industrial emissions — the absence of enforceable environmental standards for AI systems themselves represents a missed opportunity.

The divergence between the UK's innovation-focused strategy and the EU's risk-based regulatory approach illustrates the broader policy debate: whether AI should be governed primarily to encourage technological growth or to manage its risks — environmental and otherwise. In the UK, government-backed funding for AI in climate applications is robust, but without mandatory environmental safeguards, there is no guarantee that the AI sector's net environmental impact will be positive.[54] The EU, while more prescriptive in regulation, has only begun to address AI's environmental externalities, leaving substantial scope for future legislative refinement.[55]

Internationally, the lack of binding commitments on "Green AI" means that progress depends heavily on voluntary compliance and market incentives. Global soft-law instruments, like OECD and UNESCO guidelines, set important norms but lack enforcement mechanisms.[56] Meanwhile, climate-specific initiatives such as #AI4ClimateAction and UNEP's recommendations remain advisory.[57]

Ethical and Technical Challenges

The deployment of AI also presents a complex array of ethical and technical challenges. These challenges, if unaddressed, risk undermining both the legitimacy and effectiveness of AI applications in environmental governance. Key issues include bias and fairness, transparency, data security, energy and carbon footprint, and accountability.

AI systems are only as unbiased as the data on which they are trained. Environmental AI models often rely on satellite imagery, sensor data, and historical environmental records. If the datasets disproportionately represent certain geographic regions, socioeconomic

[53] Paul Collins, 'AI and Environmental Regulation: Missed Opportunities' (LSE Centre for Public Affairs, 2023).
[54] DSIT (n 42).
[55] EU AI Act (n 7).
[56] OECD (n 11); see also UNESCO (n 12).
[57] UNEP (n 11).

contexts, or environmental conditions, the AI's outputs will reflect these biases.[58] For example, an AI model trained predominantly on data from industrialised nations may produce less accurate or even misleading results when applied in developing regions.[59] This raises the risk that certain communities—often those most vulnerable to climate impacts—could be overlooked in environmental monitoring or policy interventions. Addressing this challenge requires not only diversifying training datasets but also embedding fairness metrics into AI development pipelines to ensure equitable outcomes across different regions and populations.[60]

Many AI systems, particularly those based on deep learning architectures, operate as "black boxes," making it difficult to trace how specific outputs or decisions are generated.[61] In the context of environmental regulation, this opacity poses a significant governance problem. Regulatory decisions—such as identifying polluters, predicting deforestation risks, or assessing climate policy impacts—must be explainable to policymakers, affected industries, and the public. Without transparency, there is a danger that AI-driven decisions could be contested or ignored, undermining trust in the system.[62] The adoption of explainable AI (XAI) methods can help illuminate how models arrive at their conclusions, but these techniques are still maturing and often involve trade-offs between interpretability and accuracy.[63] Policymakers will need to establish minimum transparency standards to ensure that AI tools used in environmental decision-making are held accountable.

Environmental AI frequently depends on interconnected satellite networks, Internet of Things (IoT) devices, and large-scale sensor systems.[64] These data streams, while essential for real-time environmental monitoring, also present substantial cybersecurity risks. If compromised, satellite or sensor data could be altered or disrupted, leading to false assessments or delayed responses to environmental threats.[65] Furthermore, certain environmental datasets may contain sensitive geospatial information—for example, on the locations of endangered species or indigenous lands—raising privacy and ethical

[58] Crawford (n 39) 104.
[59] Abeba Birhane, 'Algorithmic Colonization of Africa' (2020) 7(2) *SCRIPTed* 389.
[60] Suresh Venkatasubramanian and John P Dickerson, 'Fairness and Abstraction in Sociotechnical Systems' (2019) *Proceedings of FAT* 59.
[61] Jenna Burrell, 'How the Machine "Thinks": Understanding Opacity in Machine Learning Algorithms' (2016) 3(1) *Big Data & Society* 1.
[62] Mireille Hildebrandt, 'Law as Computation in the Era of Artificial Legal Intelligence: Speaking Law to the Power of Statistics' (2018) 68(1) U Toronto LJ 12.
[63] Finale Doshi-Velez and Been Kim, 'Towards a Rigorous Science of Interpretable Machine Learning' (2017) arXiv:1702.08608.
[64] Sara Degli-Esposti et al, 'Internet of Things and Environmental Sustainability' (2018) Environmental Innovation and Societal Transitions 82.
[65] National Cyber Security Centre (UK), 'Cyber Threat to Satellite Operations' (NCSC 2021).

considerations regarding data sharing.[66] Secure data infrastructure, robust encryption protocols, and clear governance frameworks for data access are critical to maintaining both data integrity and public trust.

The environmental cost of AI itself cannot be overlooked. Training large machine learning models requires vast amounts of computational power, which in turn consumes significant energy and water for cooling data centres.[67] Current research indicates that the training of a single large-scale AI model can generate several hundred tonnes of CO_2 emissions, depending on the energy mix used.[68] This presents a paradox: AI designed to protect the environment may, in the process, contribute to environmental degradation. Data centres are already major global energy consumers, and the rapid expansion of AI will likely increase these demands.[69] Strategies such as “green AI” design principles, renewable-energy-powered data centres, and efficiency-optimised model architectures must be integrated into AI development if its climate benefits are to outweigh its environmental costs.[70]

Determining liability when AI systems make errors or cause harm remains an unsettled legal issue. If an AI system fails to detect illegal logging or incorrectly identifies a non-polluting entity as a violator, who bears responsibility—the developer, the operator, or the regulatory authority?[71] The lack of clear accountability frameworks can create legal uncertainty and hinder adoption. In environmental governance, where decisions can have significant economic and societal impacts, establishing clear lines of responsibility is crucial. Legal reforms may be necessary to define liability in cases of AI malfunction or misjudgement, particularly for systems used in enforcement contexts.[72]

While technical and ethical concerns often focus on bias and explainability, environmental AI raises distinct accountability challenges. If an AI system fails — for example, missing a methane leak or misclassifying illegal deforestation as compliant land use — who should be held legally responsible? Is it the AI developer, the system operator, or the

[66] Kristen Walker Painemilla et al, ‘Indigenous Peoples and Conservation: From Rights to Resource Management’ (IUCN 2010).
[67] Emma Strubell, Ananya Ganesh and Andrew McCallum, ‘Energy and Policy Considerations for Deep Learning in NLP’ (2019) arXiv:1906.02243.
[68] Sasha Luccioni, Alexandre Lacoste and Hugo Lombaert, ‘Estimating the Carbon Footprint of BLOOM, a 176B Parameter Language Model’ (2022) arXiv:2211.02001.
[69] International Energy Agency, Data Centres and Energy – Tracking Report (IEA 2022).
[70] Roy Schwartz et al, ‘Green AI’ (2019) arXiv:1907.10597.
[71] Gerhard Wagner, ‘Robot Liability’ (2019) 69(2) Oxford Journal of Legal Studies 1.
[72] Woodrow Barfield and Ugo Pagallo (eds), *Research Handbook on the Law of Artificial Intelligence* (Edward Elgar 2018) 233.

regulatory authority relying on the data? Current laws provide little guidance, especially in cases involving cross-border environmental harm.[73]

Legal Gaps and Reform Ideas

One of the most significant gaps in current environmental governance is the lack of explicit provisions that enable — or require — the use of AI for monitoring and enforcement purposes. While many regulatory agencies have begun experimenting with AI informally, few laws directly address its role in official decision-making.[74] This ambiguity can deter regulators from adopting AI tools, as they may fear procedural challenges or disputes over admissibility of AI-derived evidence.[75]

Reform should begin by explicitly allowing, and in certain high-priority contexts mandating, the use of AI for environmental monitoring and enforcement.[76] This could include integrating AI-based satellite data analysis into permit conditions for large industrial projects, enabling real-time detection of emissions breaches or illegal land use. Official recognition of AI evidence — akin to admissibility rules for digital evidence — would help streamline enforcement actions and reduce litigation delays.[77]

A notable precedent is the European Space Agency's Copernicus programme, which uses satellite-based Earth observation for environmental monitoring.[78] However, without statutory mandates, such tools remain underutilised. Legal provisions could require regulators to integrate AI systems into compliance inspections, especially where continuous monitoring can replace sporadic, labour-intensive site visits.[79]

Mandating AI use would also promote consistency, as AI can analyse vast datasets without the variability of human interpretation. Nonetheless, safeguards would be needed to ensure algorithmic fairness and protect against bias, especially where environmental decisions affect vulnerable communities.[80]

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[73] Lilian Edwards, Michael Veale and Irina Brass, 'Who Is Responsible for Automated Environmental Harm?' (2020) Law, Innovation and Technology 1.
[74] Cary Coglianese and David Lehr, 'Regulating by Robot: Administrative Decision Making in the Machine-Learning Era' (2017) 105(5) *Geo LJ* 1147.
[75] Jack Maxwell, 'Artificial Intelligence and Administrative Law: Accountability and Transparency in Algorithmic Governance' (2021) 44(2) *Dal LJ* 389.
[76] Elizabeth Fisher, *Environmental Law: A Very Short Introduction* (OUP 2017) 77.
[77] Mireille Hildebrandt, *Smart Technologies and the End(s) of Law* (Edward Elgar 2015) 143.
[78] European Space Agency, *Copernicus: Europe's Eyes on Earth* (ESA 2022).
[79] Joanne Scott and Lavanya Rajamani, 'EU Climate Change Regulation: A Model for the World?' (2012) 23(3) *EJIL* 529.
[80] Abeba Birhane, 'Algorithmic Injustice: A Relational Ethics Approach' (2021) *Patterns* 1.

While AI can help reduce greenhouse gas emissions indirectly, its own environmental footprint — particularly in terms of energy and water usage for training large models — is often hidden from public scrutiny.[81] Without transparency, policymakers and the public cannot assess whether the environmental benefits of AI outweigh its costs.

A key reform would be to require AI developers, especially those supplying tools for environmental applications, to publicly disclose data on carbon emissions and energy consumption associated with model development and operation. This mirrors Article 51 of the European Union's AI Act, which mandates certain transparency obligations, but goes further by making environmental impact reporting a legal requirement.[82]

Transparency could be enforced through annual sustainability reports, standardised disclosure formats, and independent audits. Public access to this information would allow governments to set thresholds for acceptable environmental costs, thereby incentivising developers to innovate in energy efficiency.[83]

Furthermore, such requirements would empower public procurement bodies to select AI tools based not only on functionality, but also on sustainability performance, creating a market-driven incentive for "low-carbon AI".[84]

To complement transparency measures, legal reform should establish a formal "eco-AI" certification scheme. This standard would recognise AI systems designed and operated with minimal environmental impact, similar to how Energy Star ratings apply to appliances.[85]

Certification criteria could include energy-efficient algorithms, optimised hardware usage, and low-carbon data centres. Developers meeting the standard would benefit from preferential treatment in public procurement, tax incentives, or fast-track regulatory approval for environmental applications.[86]

Such a scheme would align with the growing international push for sustainable technology. For example, research initiatives like 'Green AI' already advocate for

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[81] Crawford (n 39) 205.
[82] European Commission, *Proposal for a Regulation Laying Down Harmonised Rules on Artificial Intelligence (AI Act)* COM (2021) 206 final, art 51.
[83] Sasha Luccioni, Alexandre Lacoste and Hugo Lombaert, 'Estimating the Carbon Footprint of BLOOM' (2022) arXiv:2211.02001.
[84] International Energy Agency, *Data Centres and Energy – Tracking Report* (IEA 2022).
[85] Roy Schwartz et al, 'Green AI' (2019) arXiv:1907.10597.
[86] Barfield and Pagallo (n 71) 322.

efficiency-focused model design, but without legal enforcement, uptake remains voluntary and inconsistent.[87]

An eco-AI certification would also serve as a consumer-facing trust mark, signalling that the tool's environmental benefits are not undermined by excessive resource consumption. This approach could be integrated into existing environmental labelling laws, ensuring consistency and global recognition.[88]

AI's effectiveness in climate governance depends heavily on the quality and availability of data. Yet many jurisdictions lack robust open-data laws for environmental information, particularly for emissions and satellite-based monitoring.[89] This creates a two-tiered system where well-funded private actors can develop cutting-edge AI tools, while public agencies and smaller organisations are left behind.

Legal reform should focus on strengthening open-data laws to ensure that high-quality climate-relevant datasets — including satellite imagery, emissions inventories, and biodiversity records — are freely accessible.[90] This is consistent with the principle of the Aarhus Convention access rights, which guarantees public access to environmental information.[91]

At the global level, treaties or agreements could mandate cross-border sharing of satellite and sensor data for climate purposes, building on models like the Group on Earth Observations (GEO).[92] By establishing international data-sharing frameworks, countries can pool resources and enable AI models to be trained on diverse representative datasets, improving both accuracy and fairness.[93] Importantly, data access rules must also address privacy and security concerns, ensuring that open data is not exploited for harmful purposes, such as targeting vulnerable ecosystems for exploitation.[94] Clear licensing and usage terms can mitigate these risks while maximising the public value of environmental datasets.

Environmental decisions often carry significant legal and economic consequences. When AI tools are involved — whether in predicting flood risk or identifying emissions violations — their errors can have serious impacts, including wrongful enforcement actions

[87] Strubell, Ganesh and McCallum (n 66).
[88] OECD, *Greening with Jobs* (OECD 2017) 56.
[89] David Boyd, *The Environmental Rights Revolution* (UBC Press 2012) 138.
[90] Christina Voigt, 'Access to Information and Environmental Governance' in Geert Van Calster and Leonie Reins (eds), *Research Handbook on EU Environmental Law* (Edward Elgar 2017).
[91] Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (adopted 25 June 1998, entered into force 30 Oct 2001) 2161 UNTS 447.
[92] Group on Earth Observations, *GEO Strategic Plan 2016–2025: Implementing GEOSS* (2016)
[93] Daniel Esty, 'A Blueprint for Climate Cooperation' (2021) *Foreign Affairs* 144.
[94] Kristen Walker Painemilla et al, *Indigenous Peoples and Conservation* (IUCN 2010).

or missed opportunities to prevent harm.[95] Current liability frameworks are ill-equipped to handle these situations, particularly where AI operates with limited human oversight. A robust reform would be to define clear liability rules for AI-induced errors in environmental contexts.[96] One approach is to impose strict liability for developers or operators of AI tools, meaning they would be automatically responsible for harm caused by faulty outputs, regardless of negligence.[97] This would incentivise rigorous testing, validation, and maintenance of AI systems before deployment.

Alternatively, a hybrid model could allocate liability based on control and responsibility.[98] For example, developers could be liable for design flaws, while regulators or users could bear responsibility for improper use or failure to verify AI outputs.[99] Precedents from product liability law could be adapted to AI, ensuring that victims of AI-related harm have clear avenues for redress.[100] Crucially, liability reform must balance accountability with innovation, avoiding rules so onerous that they discourage beneficial AI applications in environmental governance.

While many AI regulatory frameworks include principles such as fairness, transparency, and accountability, few explicitly address environmental sustainability.[101] This omission undermines the coherence of climate policy, as AI governance and climate governance remain siloed. A key reform would be to add environmental sustainability as a core principle in AI regulatory frameworks and ethics codes.[102] This could be operationalised through mandatory environmental impact assessments (EIAs) for AI systems with significant resource demands, similar to EIAs required for large infrastructure projects.[103]

For example, before approving an AI system for nationwide climate modelling, regulators could require an assessment of its lifecycle emissions, energy use, and potential to reduce — or exacerbate — environmental harm.[104] This approach would make sustainability a design requirement, not an afterthought. Embedding sustainability in AI ethics also has a normative effect, shaping professional culture among AI developers, policymakers, and

[95] Gerhard Wagner, 'Robot Liability' (2019) 39(2) *Oxford JLS* 1.
[96] Lilian Edwards and Michael Veale, 'Slave to the Algorithm? Why a Right to an Explanation Is Probably Not the Remedy You Are Looking For' (2017) 16(1) *Duke L & Tech Rev* 18.
[97] Ugo Pagallo, *The Laws of Robots* (Springer 2013) 91.
[98] Thomas Burri, 'Accountability in the Age of AI' (2020) *J Intl & Comp L* 44.
[99] Roger Brownsword, 'Law, Technology and Society: Re-imagining the Regulatory Environment' (2019) 68 *NCL Rev* 349.
[100] Jane Stapleton, *Product Liability* (Butterworths 1994).
[101] Andrea Bertolini, 'Artificial Intelligence and Civil Liability' (2020) *European Parliamentary Research Service Study.*
[102] Brent Mittelstadt, 'Principles Alone Cannot Guarantee Ethical AI' (2019) 1(1) *Nature Machine Intelligence* 501.
[103] UNEP, *Environmental Impact Assessment Training Resource Manual* (UNEP 2002).
[104] Alan Boyle and Catherine Redgwell, *International Law and the Environment* (4th edn, OUP 2021) 315.

lawyers.[105] By incorporating environmental responsibility as a standard element of ethical compliance, the likelihood increases that AI innovation will align with long-term planetary health.

While each of these reforms addresses a specific gap, their effectiveness depends on their implementation within a coherent legal framework. Mandating AI use without transparency could encourage environmentally harmful systems; transparency without liability might fail to deter negligent deployment; and sustainability principles without strong data access rules could leave AI underpowered for climate applications.[106]

By combining mandates, transparency, standards, data access, liability, and ethics, the legal system can create a virtuous cycle: AI is required where it can do the most good, held accountable for its impacts, designed for minimal harm, and powered by open, high-quality data.[107] This integrated approach ensures that AI is not just a tool for compliance, but a driver of innovation in environmental protection.

Conclusion

Artificial intelligence holds immense promise as a tool to accelerate climate action, from precision agriculture and energy optimisation to monitoring environmental compliance. However, this potential can only be fully realised if the legal framework evolves in tandem with technological advances. At present, gaps in regulation, accountability, and ethical oversight risk undermining the benefits AI could deliver. For AI to become a trusted ally in achieving net zero, the law must proactively address transparency, liability, sustainability, and equitable access to data.

In order to achieve this goal, it requires an interdisciplinary approach which involves lawyers, technologists, policymakers and scientists. They must collaborate “beyond boundaries” to create adaptive regulatory systems that not only keep pace with innovation, but actively shape its direction. This includes embedding environmental sustainability into AI governance principles, mandating disclosure of AI’s carbon footprint, and fostering global agreements for data sharing. By doing so, AI can be developed and deployed in ways that are safe, equitable, and environmentally responsible.

[105] Luciano Floridi and Josh Cowls, ‘A Unified Framework of Five Principles for AI in Society’ (2019) 5(4) *Harv Data Sci Rev.*
[106] Cary Coglianese and Shana Starobin, ‘Machine Learning and Climate Governance’ (2022) 51 *ELR* 10231.
[107] Elizabeth Fisher, Eloise Scotford and Emily Barritt, *Environmental Law: Text, Cases, and Materials* (2nd edn, OUP 2019) 423.

The theme of this Convention underscores the urgency of legal innovation—from local rules to global agreements, from compliance-focused regulation to value-driven ethics. The integration of AI into climate governance is not just a technical challenge, but a societal one, requiring vision, inclusivity, and resilience.

Law students and researchers are uniquely positioned to lead this change. By engaging critically with both the technological and legal dimensions, they can help design the next generation of "climate-tech law," ensuring AI serves as a force for climate justice and the protection of our planet.