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The environmental impact of artificial intelligence: challenges for the legal protection of ecosystems

Impacto ambiental de la inteligencia artificial: desafíos para la protección jurídica de los ecosistemas

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ABSTRACT

The development and use of artificial intelligence has impacted the life of society, it has benefited in different areas, however, it has also posed new environmental challenges that require reflection. The objective of this research was to analyze the main environmental effects caused by the development and operation of artificial intelligence systems, likewise, it sought to examine the legal protection of ecosystems in the face of the challenges generated by this technology. The methodology used was a research with a qualitative approach, analytical and dogmatic-legal methods were used, the technique used was documentary. The findings showed that artificial intelligence generates a significant impact on ecosystems and that Mexico's regulatory frameworks in environmental matters have limitations in addressing the risks that arise from the development and use of AI. It was concluded that the development of artificial intelligence poses a new dimension of environmental risks that requires modifying the current legal protection of ecosystems.

Keywords: artificial intelligence; environmental impact; legal protection; ecosystems.

RESUMEN

El desarrollo y uso de la inteligencia artificial ha impactado en la vida de la sociedad, ha beneficiado en distintos ámbitos, sin embargo, también ha planteado nuevos desafíos ambientales que exigen una reflexión. El objetivo de esta investigación fue analizar las principales afectaciones ambientales que origina el desarrollo y operación de sistemas de inteligencia artificial, así mismo, se buscó examinar la protección jurídica de los ecosistemas frente a los desafíos que genera esta tecnología. La metodología que se empleó fue una investigación con enfoque cualitativo, se utilizaron los métodos analístico y dogmático-jurídico, la técnica empleada fue documental. Los hallazgos evidenciaron que la inteligencia artificial genera un impacto significativo sobre los ecosistemas y que los marcos regulatorios de México en materia ambiental tienen limitaciones para abordar los riesgos que derivan del desarrollo y uso de la IA. Se concluyó que el desarrollo de la inteligencia artificial plantea una nueva dimensión de riesgos ambientales que obliga a modificar la protección jurídica actual de los ecosistemas.

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Palabras clave: inteligencia artificial; impacto ambiental; protección jurídica; ecosistemas.

INTRODUCCIÓN

Artificial intelligence (AI) has been rapidly incorporated into productive, educational, administrative, scientific and government activities. Its applications allow processing large volumes of information, automating decisions, recognizing patterns and generating content; However, these capabilities depend on a physical infrastructure made up of data centers, telecommunications networks, specialized processors, devices and cooling systems. Therefore, AI should not be analyzed as an exclusively intangible resource. Its life cycle demands electricity, water and raw materials, and produces emissions and waste that can be transferred between territories and stages of the technological chain (1,2).

The environmental debate intensified with the expansion of general-purpose models and generative systems. Training large-scale models concentrates a visible part of the computational consumption, but repeated inference by millions of users can become an equally relevant cumulative load. Kaack et al. explained that the relationship between AI and climate change is ambivalent: technology can favor mitigation and adaptation, although its infrastructure also generates emissions and material pressures (3). De Vries warned that the accelerated growth of generative AI could drive up data center electrical demand if increased usage outweighs efficiency improvements (4).

The environmental footprint is not uniform. Luccioni et al. found that generative tasks tend to consume more energy than classificatory tasks, but they also observed important variations between models, architectures, and output types (5). Patterson et al. showed that hardware efficiency, processing location, and carbon intensity of the power grid can substantially modify training emissions (6). Dodge et al. They added that carbon intensity changes depending on the region and the time of execution, so that two equivalent computational loads do not necessarily produce the same impact (7). These differences prevent attributing a single figure to every AI application.

The discussion cannot be limited to carbon either. Data centers require direct water for certain cooling systems and indirect water to generate electricity. In addition, the manufacturing of servers and accelerators requires minerals, chemicals, and intensive industrial processes. The frequent replacement of equipment increases the volume of electronic waste and shifts part of the damage to territories where materials are extracted or waste is received. Bender et al. noted that the race for ever-larger models must be examined along with its environmental and distributional costs, as the benefits and burdens do not necessarily fall on the same populations (8).

This materiality poses a problem for environmental law. The ordinances were built mainly around identifiable industrial sources, territorially delimited projects and pollutants susceptible to direct measurement. Instead, an AI application may distribute its processing across multiple data centers, use cloud services located outside the jurisdiction, and rely on global supply chains. Fragmentation makes it difficult to identify the person responsible, define the limit of the evaluation and determine which authority should demand information, preventive measures or reparation. The lack of

corporate transparency aggravates this difficulty, because much data on energy, water, emissions and hardware renewal is not disclosed using comparable criteria.

In Mexico there are applicable legal foundations, including the constitutional right to a healthy environment, the preventive principles of environmental legislation and the rules on impact assessment, water, energy and waste. However, these provisions do not establish specific metrics for the footprint of AI systems or homogeneous reporting obligations for their suppliers and operators. The problem does not consist of a total absence of regulations, but rather their insufficient articulation in the face of a digital infrastructure that combines global impacts with local effects on watersheds, electrical networks, soil, biodiversity and communities.

From this situation, the following research problem was formulated: in what way do the environmental impacts associated with the life cycle of AI challenge the legal instruments available to protect ecosystems, especially in the Mexican context? The general objective was to analyze the main environmental impacts derived from the development and operation of AI systems and evaluate the challenges they pose for the legal protection of ecosystems. In a complementary manner, we sought to identify the most relevant impact dimensions, examine the scope of regulatory instruments and propose criteria for preventive, proportional and verifiable governance.

The study started from the assumption that general environmental regulation offers bases for intervention, but is insufficient when it is not accompanied by technical information, life cycle delimitation and differentiated duties for developers, cloud providers, data center operators and institutional users. The research is relevant because it connects two discussions that usually appear separate: the sustainability of digital infrastructure and the legal protection of ecosystems. This articulation allows us to avoid both a technophobic reading, which ignores the contributions of AI, and a techno-solutionist vision that ignores its physical and social costs.

LITERATURE REVIEW

Materiality and life cycle of artificial intelligence

Environmental assessment of AI requires looking at its entire life cycle. Ligozat et al. proposed to include equipment production, training, inference, storage, data transmission and end of life, because a measurement limited to operational consumption can hide impact transfers to materials, water or waste (1). This perspective also allows us to distinguish the built-in fingerprint of the hardware from the fingerprint produced during its use. The first includes extraction, manufacturing and transportation; the second depends on the power, utilization intensity and conditions of the data center.

Van Wynsberghe differentiated AI for sustainability from AI sustainability (9). The first uses algorithms to address environmental problems; The second asks whether technological development itself respects ecological integrity and social justice. This distinction is decisive: a tool intended to monitor forests is not automatically sustainable if it uses disproportionate infrastructure, prolongs extractive chains or displaces damage to vulnerable communities. Environmental legitimacy depends on comparing verifiable benefits with direct, indirect and cumulative costs.

Energy, emissions and scale effects

Power consumption varies depending on model size, architecture, hardware, tuning, number of queries, and data center efficiency. Desislavov et al. observed continued improvements in inference efficiency, but cautioned that expanded use may neutralize them through a rebound effect (10). Xiao et al. projected that grid efficiency, location, and decarbonization decisions significantly alter the energy, water, and carbon trajectories of AI servers (11). Therefore, efficiency per operation does not guarantee an absolute reduction if the number of services and the frequency of use increase.

Emissions depend on the electricity consumed and the source that produces it. Temporal scheduling and geographic selection of loads can reduce carbon intensity (7), while designing more efficient models and data centers decreases consumption per task (6). However, Bender et al. and Dauvergne questioned whether business efficiency in itself is equivalent to sustainability, since it can stimulate greater production and hide inequalities in the distribution of costs (8,12). The measurement must report consumption, location, electrical matrix, scope of emissions and assumptions used.

Water, minerals and electronic waste

Mytton explained that water analysis of data centers must differentiate extraction and consumption, as well as direct and indirect use (13). The same volume takes on different meanings depending on watershed availability, climate, cooling technology, and competition with human or ecosystem uses. A global figure can be misleading if it is not related to local water stress. This justifies territorial evaluations, dissemination of water efficiency and participation of potentially affected communities.

The material dimension includes critical minerals, semiconductors, batteries, wiring and ancillary equipment. Manufacturing concentrates chemical and energy impacts, while accelerated renewal increases electronic waste. The Global E-waste Monitor documented that the growth of this waste exceeds formal collection and recycling capacity in numerous regions (14). The circular economy must prioritize durability, repair, reuse, material recovery and extended responsibility, without assuming that recycling eliminates all the harms of primary extraction.

The relationship between water, energy and materials shows that the indicators must be interpreted together. A cooling system can reduce direct water use and at the same time increase the electricity required; A lower carbon network may depend on sources with different water or territorial impacts. Similarly, a more efficient processor may incorporate a high manufacturing footprint that is only offset by remaining in service for a sufficient period. These trade-offs justify multi-criteria analysis and avoid declaring a solution sustainable based on a single favorable result.

Environmental benefits and sustainable governance

AI can contribute to climate forecasting, power grids, precision agriculture, deforestation detection, biodiversity conservation, and disaster response. Rolnick et al. They systematized applications with potential for mitigation and adaptation, but insisted on collaboration with sector specialists and the evaluation of real effects (15). Tomlinson et al. showed that environmental comparison depends on the functional unit and the alternative considered, so claims about AI superiority must delimit task, quality and life cycle (16).

Zhao argued that sustainable AI requires preventive regulation, corporate responsibility and verifiable reporting (17). Francisco and Linnér observed that international organizations often present AI as a tool for sustainable development, although this narrative can underestimate conflicts, uncertainties and power relations (18). Batool et al. identified fragmented governance between organizational, national and international levels (19). Pagallo concluded that the European Regulation contains several environmental mechanisms, but their scope is unequal and still requires articulation with sectoral environmental law (20).

The literature converges on three governance requirements. The first is transparency about resources and methodological limits; the second is proportionality, so that obligations increase with scale and risk; and the third is participation, especially when infrastructure competes for water, energy or territory. These demands complement post-damage liability with preventive measures by design. They also allow us to distinguish between low-impact applications and operations capable of producing cumulative pressures, preventing all AI from receiving identical legal treatment.

METHOD

The research adopted a qualitative approach, non-experimental design and analytical-documentary scope. Analytical and dogmatic-legal methods were used. The first allowed the environmental footprint of AI to be decomposed into energy, climate, water, material and residual dimensions; The second made it possible to interpret norms, principles and instruments applicable to the protection of ecosystems and assess their sufficiency in the face of the identified risks. The study did not attempt to estimate a universal footprint or establish causal relationships, but rather to integrate scientific and legal evidence to construct a critical explanation of the problem.

The documentary search included publications published between 2021 and 2026, with priority for articles indexed in Scopus and essential institutional or regulatory documents. Terms in Spanish and English related to artificial intelligence, environmental impact, sustainable AI, energy consumption, carbon emissions, water footprint, electronic waste, ecosystem protection, environmental law and AI governance were consulted. Peer-reviewed articles with direct relation to the materiality of AI, its environmental applications or its regulation were incorporated; The Mexican Constitution, environmental legislation, international instruments and the European Regulation on Artificial Intelligence were also included.

Duplicate documents, texts without editorial traceability, purely promotional publications and works that mentioned sustainability without analyzing environmental or legal effects were excluded. The selection was intentional and thematic, typical of a narrative review with legal analysis, so it did not follow a systematic review protocol nor does it claim bibliometric exhaustiveness. This precision avoids attributing to the procedure a level of reproducibility that does not correspond to its design. Scientific sources were cross-checked with editorial publications and DOI records to reduce identification errors.

The extraction was carried out using a matrix that recorded authorship, year, object, type of evidence, environmental dimension, findings, limitations and possible legal relevance. Subsequently, thematic

coding was applied in four axes: infrastructure, energy and emissions; water, materials and waste; environmental benefits of AI; and legal governance. The comparison looked for coincidences, disagreements and conditions that explained the variation between studies. In the legal dimension, prevention, precaution, information, participation, impact assessment, responsibility and circular economy were examined.

The analysis was carried out in three moments. First, the impacts supported by evidence and their main variation factors were identified. Second, each impact was linked to potentially applicable legal instruments in Mexico. Third, the findings were contrasted with international governance proposals. The research used publicly accessible documents and did not involve people, animals or personal data; Therefore, informed consent was not required. Academic integrity, attribution of sources, and prudent presentation of results were respected.

RESULTS

Identified environmental dimensions

The analysis identified five interrelated dimensions: energy, emissions, water, materials and electronic waste. Its intensity does not depend exclusively on the number of parameters in a model. Architecture, hardware, training duration, tuning tasks, inference frequency, data center, power source, and equipment lifespan are also involved. This result confirms that the footprint must be expressed through a set of indicators and not through a single aggregate figure (1,5-7,10).

In energy and emissions, the evidence agreed that inference deserves the same attention as training when an application reaches large scale. Efficiency improvements reduce unit consumption, but the aggregate effect can increase if users, queries and products multiply (4,10,11). A strong spatial and temporal dependence was also identified: the carbon intensity changes with the electrical grid and with the processing time (6,7). Therefore, reports must distinguish absolute energy, task efficiency, operational scope emissions and embodied emissions.

In water, the documents reviewed showed that cooling is only part of the problem. There is also indirect consumption associated with electricity generation and component manufacturing. The environmental risk depends on the basin and not only on the global volume. An efficient facility in average terms can be problematic in a region subject to drought or with competition between human supply, agriculture and conservation (11,13). The water efficiency indicator must be accompanied by territorial and seasonal information.

In materials and waste, the main result was the need to expand the limits of the system. Mining and refining minerals, manufacturing semiconductors, and replacing servers produce burdens that rarely appear in AI disclosures. Rapid hardware evolution can shorten the economic lifespan of still functional equipment. This pattern increases the risk of waste export and informal treatment, with effects on soil, water and health (1,14). Table 1 summarizes the core evidence and its regulatory implication.

Table 1. Evidence synthesis and regulatory implications

Source	Dimension	Relevant finding	Legal implication
Ligozat et al. (1)	Life cycle	The footprint includes manufacturing, use and end of life	Require limits, indicators and traceability of the full cycle
Luccioni et al. (5)	Energy per task	Consumption varies between generative and classification tasks	Avoid single metrics; report model, task and volume
Xiao et al. (11)	Energy, water and carbon	Efficiency, location and network modify the environmental trajectory	Incorporate territorial evaluation and scenarios
Mytton (13)	Water	The risk depends on consumption, extraction and water context	Report basin, seasonality and cooling technology
Global E-waste Monitor (14)	Waste	Generation exceeds formal recycling	Strengthen circularity and extended responsibility

Note. Prepared by the authors based on the sources cited.

Scope and gaps in legal protection

The legal analysis showed that Mexico has a regulatory base, but not an integrated regime for the environmental footprint of AI. The Constitution recognizes the right to a healthy environment (21), and the General Law of Ecological Balance and Environmental Protection incorporates policy, prevention and evaluation instruments (22). The General Law for the Prevention and Comprehensive Management of Waste offers tools for materials and technological waste (23). However, these standards do not define specific obligations to measure digital models, cloud services or supply chains.

Four operational gaps were identified. First, there is no uniform and mandatory methodology for energy, carbon, water and materials. Second, the information usually remains in the hands of private providers and is published in aggregate form. Third, the cross-border distribution of processing makes it difficult to attribute impacts and responsibilities. Fourth, traditional environmental assessment focuses on physical facilities and may not capture the demand induced by specific digital services. Table 2 relates these gaps to available legal instruments and strengthening measures.

The UNESCO Recommendation recognizes environmental protection within the ethics of AI and promotes the reduction of impacts, although it lacks direct enforceability (24). European Regulation 2024/1689 requires documentation and contemplates environmental considerations, but its structure based on security risks and fundamental rights does not replace environmental law (25). The Escazú Agreement provides principles of information, participation and environmental justice relevant to communities affected by data centers or extractive chains (26). The joint result points to an articulated regulation, not an isolated AI law.

An additional result was the absence of an automatic correspondence between technological actor and impact. The developer decides architecture and size; the cloud provider controls some of the hardware, location and power; the data center operator manages cooling and infrastructure; and the institutional user determines frequency and purpose. Responsibility must be assigned according to knowledge, control and prevention capacity. An undifferentiated obligation could leave the main

impacts unanswered or impose burdens on those who do not have the information or powers to reduce them.

Table 2. Problems for the legal protection of ecosystems against AI in Mexico

Problems derived from AI	Environmental impact	Legal loopholes	Legal framework where it should be established
Water demand in data centers	Cooling and electricity can increase pressure on watersheds and other users	Mandatory metrics, data by basin and cumulative evaluation are missing	Political Constitution of the United Mexican States and applicable environmental legislation
Energy demand and emissions	Impact depends on consumption, electrical matrix, scale and location	There is no uniform reporting of energy and emissions by service	Environmental, energy and impact assessment legislation
Generation of electronic waste	Soil, water and air pollution	Traceability, reuse and extended responsibility are insufficient	Legislation on waste and circular economy
Lack of environmental transparency	The lack of comparable data prevents assessing impacts and alternatives	Lack of verifiable disclosure and independent audit	Environmental legislation and reporting obligations
Lack of specific regulation of AI and the environment	Environmental standards were designed for traditional industrial activities	There is general regulation, but there is a lack of specific and technical articulation	Environmental legislation and future AI regulation

Note. Prepared by the authors based on the legal analysis conducted.

DISCUSSION

The results confirm that the materiality of AI must constitute the starting point of legal analysis. This conclusion is in line with Ligozat et al., who advocated a life cycle assessment, and with van Wynsberghe, who distinguished between using AI for sustainable purposes and making AI itself sustainable (1,9). The contribution of this study consists of transferring this distinction to the field of ecosystem protection: it is not enough to prove that an application pursues an environmental benefit; It must also be demonstrated that its design, infrastructure and scale do not generate disproportionate or displaced loads.

In terms of energy, the findings converge with de Vries and Luccioni et al. regarding the potential growth of consumption associated with generative applications (4,5). However, the review qualifies deterministic interpretations. Patterson et al. and Dodge et al. showed that the efficiency of the model, the location and the time of execution significantly alter emissions (6,7). Desislavov et al. They added that the inference becomes central due to its massive repetition (10). Consequently, a standard based only on model size would be insufficient; It should combine absolute consumption, intensity per service, volume of use and electrical matrix.

The comparison with Xiao et al. reinforces the importance of location. Their scenarios show that efficiency, spatial distribution and decarbonization produce different environmental trajectories (11). Legally, this variation supports territorial assessments before authorizing large-scale infrastructure. It also prevents accepting general compensation as an automatic substitute for local prevention. A carbon reduction obtained through a certain electrical source can coexist with greater water pressure;

Therefore, authorities must simultaneously examine energy, water, biodiversity and competing uses of the territory.

The water component agrees with Mytton in that the figures must distinguish extraction, consumption and origin of water (13). The legal contribution is that this distinction must become an obligation of information linked to specific basins. Global corporate averages do not allow us to assess local impacts or guarantee participation. In water-stressed regions, authorization should consider availability, seasonality, cooling technology, technical alternatives and cumulative effects. This requirement does not imply prohibiting data centers, but rather subjecting their location decisions to verifiable environmental criteria.

Regarding materials and waste, the result expands the debate beyond data centers. The Global E-waste Monitor shows a persistent gap between generation and formal recycling (14). If the demand for accelerators reduces the economic life of equipment, the problem cannot be solved solely with energy efficiency. The law must promote durability, repair, reuse, traceability and extended responsibility. The LGPGIR provides a basis, but the specificity of digital components and cross-border chains requires technical standards and customs coordination. It is also necessary to prevent the circular economy from legitimizing unlimited consumption under the promise of future recycling.

The identified environmental benefits are consistent with Kaack et al. and Rolnick et al., who described applications for mitigation, adaptation, and monitoring (3,15). However, Dauvergne warned that promises of efficiency can hide rebound effects and power relations in global chains (12). This tension explains why the evaluation should compare AI with real alternatives and not with a no-intervention scenario. Tomlinson et al. showed that the functional unit changes the result of the comparisons (16); An application can only be considered preferable when it offers equivalent quality and measurable benefits.

In governance, the results support Zhao's proposal for preventive, technologically neutral frameworks supported by corporate reporting (17). At the same time, they agree with Francisco and Linnér that the international narrative of AI for sustainability needs critical examination (18). Batool et al. They showed institutional diversity and regulatory fragmentation (19). For Mexico, this means that the response should not mechanically copy foreign models. It must integrate federal and local powers, environmental standards, energy regulation, water and waste management, and obligations applicable to international suppliers.

The contrast with Pagallo reveals limits in the European reference. Although the AI Regulation incorporates environmental mentions and documentation mechanisms, not all of them have the same force or cover the complete life cycle (20,25). Its usefulness for Mexico lies in showing that technological governance can require traceability and documentation, but the substantive assessment of damages must remain connected to environmental law. UNESCO provides principles of sustainability (24), while Escazú strengthens information, participation and access to justice (26). Articulating these instruments allows us to move from general commitments to enforceable procedures.

Based on the confrontation, a governance scheme with five components is proposed. The first is multivariable measurement of energy, carbon, water, materials and waste. The second is public disclosure with comparable metrics and independent verification. The third is territorial evaluation for high demand infrastructure. The fourth is lifecycle due diligence, including supply chain. The fifth is differentiated responsibility between developers, cloud providers, operators and institutional users. The intensity of the obligations should be proportional to scale, risk, location and control capacity.

The discussion also identifies limits. The available evidence uses heterogeneous functional units, boundaries and assumptions, which prevents direct comparison of all estimates. Enterprise opacity reduces the availability of primary data. Furthermore, this review was narrative and legal, not systematic or meta-analytical. Therefore, its results organize problems and regulatory criteria, but do not calculate a global footprint or prove causality. Future research should measure specific facilities in Mexico, analyze permits and basins, study waste chains and evaluate the effectiveness of instruments before and after their application.

The practical implications reach authorities, companies and universities. Authorities can incorporate digital annexes in the environmental assessment and footprint criteria in public procurement. Companies can establish inventories by service, absolute goals and external audits, in addition to maintaining evidence about models and suppliers. Universities can include environmental literacy in data science and technology law programs. These actions do not replace regulation, but they generate capacities to interpret indicators, question environmental statements and design solutions that reduce impacts from the first project decisions.

The effectiveness of the proposed scheme will depend on the quality of the data and its possibility of inspection. A voluntary report can improve information, but does not guarantee comparability if each company chooses different metrics, periods and borders. Therefore, it is advisable to establish a minimum content: total energy and per service, emissions according to location, water consumption and extraction, useful life of the hardware, waste generated and accredited destination. Sensitive commercial information can be protected without preventing authorities and society from knowing the indicators necessary to evaluate damage, compliance and progress. It is also necessary to distinguish intensity goals from absolute reductions. An organization can decrease energy per query and simultaneously increase its total consumption due to service expansion. The combination of both indicators allows us to detect the rebound effect and avoids presenting relative efficiency as if it were a net reduction. Finally, independent verification must review not only calculations, but also data quality, exclusions and supplier traceability, because methodological omissions can alter the result more than small differences in precision.

CONCLUSIONS

First. Artificial intelligence has a material base whose footprint includes energy, emissions, water, minerals, equipment manufacturing and electronic waste. The analysis confirmed that this footprint cannot be represented by a universal number, because it changes depending on the model, task, hardware, inference volume, electrical matrix, cooling system and location. Consequently, any legal

or environmental assessment must declare the system boundaries, functional unit, data sources, and included life cycle stages.

Second. Mexican environmental law contains sufficient foundations to recognize and prevent part of the risks, especially through the right to a healthy environment, impact assessment and rules on water and waste. However, it lacks specific metrics and duties that allow attributing the footprint of distributed AI services. The priority should not be to create a general technological ban, but to articulate existing instruments with proportional obligations of measurement, disclosure, territorial evaluation and due diligence for the actors that control infrastructure and decisions.

Third. Regulation must address energy, carbon, water, materials and waste in an integrated manner, since an improvement in one dimension can transfer damage to another. The installation of data centers requires special attention to the basin, the electrical grid and the cumulative effects of the territory. Global corporate indicators are insufficient to protect local communities and ecosystems. Disaggregated data, comparable methodologies, independent verification and participation mechanisms are required to assess alternatives for location, cooling, energy supply, responsible acquisition and management of hardware throughout its useful life.

Fourth. AI can support climate action, conservation, and resource management, but that benefit does not eliminate its own footprint. Each environmental application must be compared with technically viable alternatives, using a functional unit that includes quality, scale and life cycle. The sustainability criterion must require that the verifiable benefit justifies the resources used and that costs are not shifted to territories or populations with less defense capacity. This evaluation prevents both indiscriminate rejection and techno-solutionism without evidence.

Fifth. Environmentally responsible governance of AI requires coordination between environmental law, technological regulation, energy, water, waste and access to information. The study proposes to combine multivariable measurement, public transparency, territorial evaluation, hardware circularity and differentiated responsibility. Due to the narrative and documentary nature of the review, these conclusions are not equivalent to an empirical estimate of the Mexican footprint. It is recommended to develop case studies with primary data, analyze specific projects, incorporate the perspective of potentially affected communities and subsequently evaluate the effectiveness of the regulatory measures adopted.

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CONFLICT OF INTEREST:

Los autores afirman que no existen conflictos de intereses en este estudio y que se han seguido éticamente los procesos establecidos por esta revista. Además, aseguran que este trabajo no ha sido publicado parcial ni totalmente en ninguna otra revista.

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