Artificial intelligence and its hidden costs: ecological limits and digital coloniality in Brazil

Ricardo Miranda dos Santos

Postdoctoral Researcher in Architecture and Urbanism at UNIVAG.
Centro Universitário de Várzea Grande (UNIVAG).
ricardomiranda4@hotmail.com
https://orcid.org/0000-0002-4840-8916

Sandra Medina Benini

PhD in Architecture and Urbanism (UPM) and PhD in Geography (FCT/UNESP).
Centro Universitário de Várzea Grande (UNIVAG).
sandra.benini@univag.edu.br
https://orcid.org/0000-0002-7109-8717

Allan Leon Casemiro da Silva

PhD in Agribusiness and Development (UNESP).
allan.leon@unesp.br
https://orcid.org/0000-0002-2397-3492

Inteligência artificial e seus custos ocultos: limites ecológicos e colonialidade digital no Brasil

RESUMO

Objetivo – Analisar criticamente a inteligência artificial a partir de sua base material e ecológica, com foco na expansão dos data centers e em seus impactos ambientais, territoriais e políticos no Brasil, evidenciando o paradoxo entre as promessas de sustentabilidade da IA e a intensificação de seu metabolismo energético e hídrico.

Metodologia – O estudo adota abordagem qualitativa e crítico-analítica, fundamentada em revisão bibliográfica interdisciplinar, articulando contribuições da ecologia política, da economia ecológica, dos estudos críticos da tecnologia e do direito ambiental, além da análise de relatórios técnicos, documentos institucionais e matérias jornalísticas especializadas.

Originalidade/relevância – O artigo se insere no debate sobre os limites ecológicos da inteligência artificial ao evidenciar a colonialidade digital associada à territorialização dos data centers no Sul Global, preenchendo uma lacuna teórica ao articular infraestrutura digital, justiça ambiental e dependência tecnológica no contexto brasileiro.

Resultados – Os resultados indicam que a expansão da infraestrutura da IA no Brasil intensifica pressões sobre energia, água e território, reproduzindo assimetrias globais de poder e deslocando custos socioambientais para territórios periféricos, ao mesmo tempo em que os benefícios econômicos e decisórios permanecem concentrados em corporações transnacionais.

Contribuições teóricas/metodológicas – O artigo contribui ao reposicionar a inteligência artificial como infraestrutura ecológica e fenômeno político-territorial, oferecendo uma leitura crítica que supera abordagens tecnossolucionistas e incorpora o conceito de limites ecológicos como critério analítico central.

Contribuições sociais e ambientais – A pesquisa reforça a necessidade de integrar justiça ambiental e justiça digital nos processos de governança da IA, destacando a importância de políticas públicas que considerem impactos territoriais, participação social e critérios vinculantes de sustentabilidade na regulação de data centers.

PALAVRAS-CHAVE: Inteligência artificial. Data centers. Justiça ambiental.

Artificial intelligence and its hidden costs: ecological limits and digital coloniality in Brazil

ABSTRACT

Objective – To critically analyze artificial intelligence from its material and ecological foundations, focusing on the expansion of data centers and their environmental, territorial, and political impacts in Brazil, highlighting the paradox between AI's sustainability promises and the intensification of its energy and water metabolism.

Methodology – The study adopts a qualitative and critical-analytical approach, grounded in an interdisciplinary literature review that articulates contributions from political ecology, ecological economics, critical technology studies, and environmental law, complemented by the analysis of technical reports, institutional documents, and specialized journalistic sources.

Originality/relevance – The article contributes to debates on the ecological limits of artificial intelligence by revealing the digital coloniality associated with the territorialization of data centers in the Global South, addressing a theoretical gap by linking digital infrastructure, environmental justice, and technological dependency in the Brazilian context.

Results – The findings indicate that the expansion of AI infrastructure in Brazil intensifies pressures on energy, water, and territory, reproducing global power asymmetries and displacing socio-environmental costs onto peripheral territories, while economic benefits and decision-making power remain concentrated in transnational corporations.

Theoretical/methodological contributions – The article contributes by repositioning artificial intelligence as an ecological infrastructure and a political-territorial phenomenon, offering a critical perspective that moves beyond technosolutionist approaches and incorporates ecological limits as a central analytical criterion.

Social and environmental contributions – The research underscores the need to integrate environmental justice and digital justice within AI governance processes, emphasizing the importance of public policies that account for territorial impacts, social participation, and binding sustainability criteria in the regulation of data centers.

KEYWORDS: Artificial intelligence. Data centers. Environmental justice.

La inteligencia artificial y sus costos ocultos: límites ecológicos y colonialidad digital en Brasil

RESUMEN

Objetivo – Analizar críticamente la inteligencia artificial a partir de sus bases materiales y ecológicas, con énfasis en la expansión de los centros de datos y sus impactos ambientales, territoriales y políticos en Brasil, evidenciando la paradoja entre las promesas de sostenibilidad de la IA y la intensificación de su metabolismo energético e hídrico.

Metodología – El estudio adopta un enfoque cualitativo y crítico-analítico, basado en una revisión bibliográfica interdisciplinaria que articula aportes de la ecología política, la economía ecológica, los estudios críticos de la tecnología y el derecho ambiental, complementada con el análisis de informes técnicos, documentos institucionales y materiales periodísticos especializados.

Originalidad/relevancia – El artículo se inserta en el debate sobre los límites ecológicos de la inteligencia artificial al evidenciar la colonialidad digital asociada a la territorialización de los centros de datos en el Sur Global, cubriendo un vacío teórico al articular infraestructura digital, justicia ambiental y dependencia tecnológica en el contexto brasileño.

Resultados – Los resultados indican que la expansión de la infraestructura de la IA en Brasil intensifica las presiones sobre la energía, el agua y el territorio, reproduciendo asimetrías globales de poder y desplazando los costos socioambientales hacia territorios periféricos, mientras que los beneficios económicos y las instancias de decisión permanecen concentrados en corporaciones transnacionales.

Contribuciones teóricas/metodológicas – El artículo contribuye al reposicionar la inteligencia artificial como infraestructura ecológica y fenómeno político-territorial, ofreciendo una lectura crítica que supera enfoques tecnosolucionistas e incorpora el concepto de límites ecológicos como criterio analítico central.

Contribuciones sociales y ambientales – La investigación refuerza la necesidad de integrar la justicia ambiental y la justicia digital en los procesos de gobernanza de la IA, destacando la importancia de políticas públicas que consideren los impactos territoriales, la participación social y criterios vinculantes de sostenibilidad en la regulación de los centros de datos.

PALABRAS CLAVE: Inteligencia artificial. Centros de datos. Justicia ambiental.

1 INTRODUCTION

In recent decades, artificial intelligence (AI) has been presented as a symbol of a supposedly immaterial, efficient, and process-optimizing informational economy. Associated with the metaphor of the "cloud," AI is often portrayed as an ethereal technology, based on abstract flows of data and algorithms, detached from physical infrastructures, territories, and natural resources. This narrative, widely disseminated through corporate, institutional, and media discourses, contributes to the naturalization of the expansion of the digital economy as an environmentally neutral—or even intrinsically sustainable—process.

However, such representation operates as an ideological device of concealment, since far from being immaterial, artificial intelligence depends on a complex physical-industrial infrastructure that is intensive in electricity, water, critical minerals, and large territorial extensions. As Crawford (2021) argues, the "cloud" metaphor deliberately erases the materiality of data centers, extractive chains, and energy systems that sustain the continuous operation of algorithmic models. Thus, the more "intelligent" and sophisticated the technology becomes, the more intensive its material base is, deepening ecological and territorial pressures on a global scale.

It is within this context that the environmental paradox of artificial intelligence emerges: while AI is promoted as a tool capable of addressing the climate crisis—through applications in environmental monitoring, energy optimization, and the management of complex systems—its expansion depends on the intensification of the energy and material metabolism of the contemporary economy. This paradox is not incidental but structural, as AI develops within a logic of continuous growth characteristic of digital capitalism, which tends to shift ecological limits into the realm of technical management rather than confronting them as political and social constraints.

In Brazil, this contradiction takes on particularly significant contours, as the country has been progressively incorporated into the global geography of artificial intelligence as a strategic territory for the installation of data centers. This positioning is driven by factors such as the relative availability of energy, a significant presence of renewable sources, access to water resources, and a favorable geopolitical location. This insertion, however, is not neutral. It positions Brazilian territory as a functional infrastructure for the expansion of global digital capitalism, absorbing socio-environmental costs associated with intensive energy and water consumption, land-use reconfiguration, and regulatory flexibilization, while decision-making centers, data control, and value appropriation remain concentrated in large transnational corporations.

Against this backdrop, the central objective of this article is to critically analyze artificial intelligence from its material and ecological foundations, focusing on the

expansion of data centers and their environmental and territorial impacts in Brazil. The study seeks to demonstrate that the sustainability associated with AI cannot be assessed solely in terms of technical efficiency or voluntary commitments to carbon neutrality, but must instead be understood as a political, distributive, and territorial issue, linked to choices concerning ecological limits, energy priorities, and socio-environmental justice.

From a methodological standpoint, the article adopts a qualitative and critical-analytical approach, grounded in an interdisciplinary literature review that articulates contributions from critical technology studies, ecological economics, political ecology, and environmental law. National and international academic articles, technical reports, institutional documents, and specialized journalistic materials were analyzed as complementary empirical support. The analysis is based on a critical perspective that rejects technosolutionism and emphasizes the materiality of technology, the territorialization of impacts, and the power asymmetries that structure the contemporary digital economy.

In this sense, the study offers a critical analysis grounded in decolonial thought by situating the expansion of AI infrastructure within the context of unequal relations between the Global North and the Global South. This perspective allows artificial intelligence to be understood not merely as a technological innovation, but as a phenomenon embedded in historical dynamics of dependency, extractivism, and coloniality, now reconfigured through resource-intensive digital infrastructures.

The article is organized into five sections in addition to this introduction. The first analytical section discusses artificial intelligence as an ecological infrastructure, highlighting the invisibilized materiality of data centers and the centrality of energy and water as ecological limits. The subsequent section examines the reconfiguration of Brazilian territory resulting from the expansion of data centers, emphasizing spatial concentration, the discourse of "green processing," and associated socio-environmental conflicts. The fourth section deepens the discussion of the environmental paradox of AI, addressing the promises and limits of environmental applications. Finally, the fifth section examines the challenges of environmental regulation and AI governance in Brazil, articulating them with the notions of digital coloniality, environmental justice, and technological sovereignty.

By shifting the debate on artificial intelligence from a strictly technical field to the realm of the political ecology of technology, this article argues that addressing the environmental paradox of AI requires more than algorithmic innovation. It requires recognizing that sustainability, if taken seriously, must operate as a structuring limit to technological development, rather than merely as a discursive promise that legitimizes the continuous expansion of digital infrastructure.

2 ARTIFICIAL INTELLIGENCE AS ECOLOGICAL INFRASTRUCTURE

Artificial intelligence (AI) is often presented as the ultimate expression of a supposedly immaterial informational economy, associated with flows of data, algorithms, and abstract processes, detached from physical supports, technical infrastructures, and concrete territories. This representation, widely disseminated in corporate, institutional, and media discourses, has been subject to critical scrutiny for operating as an ideological device of concealment, insofar as it renders invisible the material, energetic, and ecological bases that sustain the functioning of algorithmic systems (Coeckelbergh, 2020; Crawford, 2021).

Artificial intelligence depends on a complex, territorialized physical-industrial infrastructure that is intensive in natural resources—most notably electricity, water, and critical minerals—whose extraction, processing, and use generate significant environmental and social impacts across global production chains (Galaz et al., 2021; Stacciarini; Gonçalves, 2025).

The expression "ecological infrastructure" should be understood in a concrete, rather than merely metaphorical, sense. It constitutes an analytical framework that reconstructs AI as a sociotechnical system coupled to continuous flows of energy and matter, whose stability depends on biophysical conditions (energy availability, hydrological regimes, and the integrity of extractive chains) as well as institutional arrangements (regulation, planning, incentives, and governance). In this perspective, "ecology" does not function as a passive background, but as a condition of possibility for algorithmic computation: industrial-scale computing converts electricity into processing and, inevitably, into dissipated heat, rendering demands for cooling, water, and materials structural rather than incidental. Shifting the analytical focus from the "algorithm" to infrastructural metabolism repositions AI within the realm of systemic risks and planetary limits, in which environmental impacts are not peripheral externalities but constitutive dimensions of the digital development model (Galaz et al., 2021).

Moreover, the materiality of AI cannot be reduced to the data center building as an isolated unit. It extends to an infrastructural ecology composed of fiber-optic networks, submarine cables, routers, towers, electricity transmission and distribution systems, water intake and treatment facilities, as well as logistical chains that ensure the circulation and accelerated replacement of equipment (Coeckelbergh, 2020; Crawford, 2021).

This technical-territorial assemblage is decisive because AI operates under connectivity and latency requirements that often induce additional investments in telecommunications backbones and energy redundancies, thereby expanding the material footprint of the so-called "digital." Consequently, the "cloud" metaphor

functions less as an image of lightness and more as a regime of heavy infrastructure, whose opacity tends to dissociate sites of symbolic consumption (interfaces and services) from sites of material production (energy, water, mining, and waste), reinforcing asymmetries and processes of invisibilization (Coeckelbergh, 2020; Crawford, 2021).

From this perspective, AI cannot be understood solely as an informational technology, but rather as an ecological-industrial arrangement inscribed in the contemporary socioeconomic metabolism and deeply entangled with the structural dynamics of the environmental and climate crisis (Crawford, 2021; Ferrari, 2023).

Data centers constitute the material core of this algorithmic economy and the backbone of the expansion of artificial intelligence. As strategic infrastructures, they concentrate high-performance servers, massive data storage systems, low-latency communication networks, complex security apparatuses, and sophisticated cooling systems, operating continuously and uninterruptedly. This heavy materiality demonstrates that the expansion of AI cannot be analyzed exclusively through the lens of technological innovation or computational efficiency, but instead requires a critical approach capable of incorporating its structural ecological costs and its territorial, energy, and water-related implications (Stacciarini; Gonçalves, 2025).

2.1 The Invisible Materiality of AI

The metaphor of the "cloud" contributes to the invisibilization of the infrastructure that sustains AI, reinforcing the notion of the dematerialization of digital production. Data centers, however, are large-scale, strongly territorialized facilities that require extensive physical areas, direct connections to electricity transmission systems, and continuous access to water resources for equipment cooling.

> The energy consumption of a data center can be broken down into information technology (IT) equipment systems (50%, including servers, storage equipment, and network devices), air-conditioning and cooling systems (37%, of which approximately 25% correspond to air-based cooling systems and about 12% to air supply and return systems), power distribution systems (10%), and auxiliary lighting systems (3%). It is evident that the energy consumption of air-conditioning and cooling systems alone accounts for more than one third of the total energy consumption of a data center (Liu et al., 2020, p. 273).

The requirement for continuous operation (24 hours a day, seven days a week) constitutes a central element of this materiality. Unlike other industrial uses, data centers cannot tolerate interruptions without significant operational risks, which makes them highly dependent on stable and predictable sources of electricity. This

characteristic directly conflicts with simplified narratives of the energy transition that rely predominantly on intermittent renewable sources, such as solar and wind power. As noted by Soares (2025), the need for firm energy to sustain AI has reopened debates on complementary energy sources, including nuclear power, revealing the technical and environmental limits of an energy transition disconnected from demand analysis.

In this context, the centrality attributed to energy efficiency—commonly expressed through metrics such as Power Usage Effectiveness (PUE)—reveals significant limitations as a strategy for containing energy consumption (Martínez-Vargas, 2024). Although reductions in PUE indicate improvements in the relative performance of systems, such advances do not necessarily translate into a reduction in the absolute electricity consumption of data centers. Recent studies indicate that the intensification of computational capacity and the scaling up of digital infrastructures have been accompanied by an increase in total energy demand. In this regard, facilities that previously operated at capacity levels between 5 MW and 10 MW have, since 2022, reached installed capacities ranging from 20 MW to 50 MW, reflecting an accelerated process of operational expansion. This dynamic can be understood in light of the so-called rebound effect, according to which gains in technical efficiency tend to be offset—or even nullified—by the expansion of use and production scale (Martínez-Vargas, 2024).

In the Brazilian context, recently published data indicate that the share of data centers in national electricity consumption is expected to grow rapidly over the course of the decade. According to a survey conducted by *MIT Technology Review Brasil*, the proportion of energy consumed by these facilities may increase from approximately 1.7% in 2024 to around 3.9% of total national consumption by 2029. This represents more than a doubling of the current share and suggests that the energy demand of data centers may surpass that associated with public lighting at the national scale (Schuck, 2025).

This expansion trend raises issues that go beyond the mere technical optimization of digital infrastructures. The narrative of so-called "sustainable computing" often rests on the assumption that efficiency gains—whether through technical indicators or the incorporation of renewable energy sources into the electricity mix—would be sufficient to mitigate the sector's energy impacts (Hilty; Aebischer, 2014). However, the absolute growth in consumption demonstrates that such relative gains are not, in themselves, capable of containing the intensification of pressure on the electricity system. In other words, even under conditions of improved operational efficiency, the expansion of the computational park tends to generate a net increase in energy demand, underscoring the need for broader reflections on energy planning, governance, and the very limits of technical sustainability in the sector.

2.2 Energy and Water as Ecological Limits

In this context, energy cannot be treated merely as a technical input, but rather as a contested ecological resource, whose allocation involves political, economic, and territorial choices. At the global scale, data centers have accounted for approximately 2.4% of total electricity consumption over the past decade, with projections indicating continued growth in the coming years (Fernandes et al., 2023). In the specific case of AI-oriented data centers, consumption tends to be even higher due to the computational intensity of machine learning models and the need for real-time processing (Nusdeo et al., 2025).

Beyond the energy dimension, water emerges as a strategic resource that is frequently underestimated—or even rendered invisible—in public debates on the expansion of data centers. Server cooling processes require substantial volumes of water, both directly, through cooling systems, and indirectly, through the electricity generation mix that sustains these infrastructures. As noted by Furtado and Cunha (2024), estimates for the year 2022 indicate that major technology corporations consumed billions of liters of water in their data center operations. According to Fernandes et al. (2023), both the training and the day-to-day operation of large language models involve significant water consumption, even though it is often treated as a secondary externality.

This situation makes the existence of ecological limits more explicit when the water–energy–climate nexus is considered in an integrated manner. The intensification of extreme climate events, rising average temperatures, and increasing hydrological variability tend to increase the thermal load of computational systems, thereby intensifying reliance on artificial cooling mechanisms (Furtado; Cunha, 2024). As a result, a perverse feedback loop emerges, in which rising ambient temperatures simultaneously increase electricity and water consumption, deepening pressure on already stressed natural resources and exposing the fragility of strategies that rely exclusively on technical efficiency as a response to the contemporary ecological crisis.

Depending on the design of cooling systems, part of this water use materializes as evaporation and, in some cases, as thermal effluents, producing territorially situated impacts that remain invisible when the debate is confined to "data" and "algorithms." Thus, even when part of water consumption is indirect (via electricity generation), its socio-environmental effects are concrete and tend to fall more heavily on territories marked by vulnerability and water stress (Nusdeo et al., 2025; Fernandes et al., 2023).

In Brazil, this issue assumes particularly sensitive contours. In a context characterized by recurrent water crises and the intensification of climate change impacts, the expansion of infrastructures that require continuous cooling tends to place additional pressure on already overburdened river basins (Godoy et al., 2024). Even

when part of water consumption is indirect and associated with electricity generation, its territorial effects are tangible, reinforcing socio-environmental inequalities and intensifying disputes over access to water (Schuck, 2025).

The water controversy, in turn, is not merely technical but distributive and institutional. In contexts of relative scarcity, large-scale enterprises' access to water and energy may compete with essential urban uses, agriculture, and ecosystem maintenance, reconfiguring water rights and amplifying territorial disputes. From a corporate perspective, water demand is often treated as a manageable requirement through innovation and efficiency; from an environmental justice perspective, it becomes a mechanism for producing asymmetries, as resource allocation tends to reflect unequal capacities for bargaining and regulatory influence. In countries marked by structural inequalities, such as Brazil, these disputes render the hidden costs of digital infrastructure more visible and challenge the assumption that the expansion of AI is automatically compatible with sustainability (Schuck, 2025; Crawford, 2021).

Additionally, attempts to mitigate energy impacts through the expansion of renewable energy sources shift the problem to another dimension of the ecological crisis: the intensification of critical mineral extraction. As demonstrated by Stacciarini and Gonçalves (2025), the energy transition and the expansion of AI share a growing dependence on strategic minerals, whose production chains are associated with environmental degradation, territorial conflicts, and geopolitical asymmetries. Energy and water thus emerge not merely as inputs, but as structural ecological limits that strain the notion of an artificial intelligence compatible with the premises of environmental sustainability.

3 DATA CENTERS AND THE RECONFIGURATION OF BRAZILIAN TERRITORY

The expansion of data centers in Brazil has frequently been presented as evidence of technological modernization and competitive integration into the global digital economy. This discourse, reiterated by both public and private actors, associates the installation of these infrastructures with notions of progress, innovation, and sustainable development. However, such a narrative tends to obscure a deeper process: Brazilian territory has been progressively reconfigured to meet the energy, logistical, and environmental demands of artificial intelligence (AI), assuming a strategic yet structurally subordinate role within the global geography of digital capitalism.

Far from constituting merely a "promising case," Brazil has consolidated itself as a functional territory for the expansion of this infrastructure, absorbing significant socio-environmental costs that remain, to a large extent, invisible in public debate and insufficiently internalized in decision-making processes (Nusdeo et al., 2025). This

territorial functionality manifests itself in the availability of energy, the provision of water, urban space, and regulatory flexibilization—elements that are fundamental to the continuous operation of data centers.

This reconfiguration unfolds within a historical context marked by persistent global asymmetries, in which countries of the Global South play the role of providers of natural resources, energy, and territory for infrastructures that sustain informational and economic flows largely controlled by major transnational corporations. In the case of AI, this dynamic takes on new contours, as digitalization—often portrayed as a process of dematerialization—intensifies the materiality of production, increasing demand for electricity, freshwater, and physical infrastructure, and reinscribing historical inequalities within a new technological grammar (Stacciarini; Gonçalves, 2025).

Thus, the decisive question is not merely whether Brazil should host data centers, but under what conditions this process takes place, who defines territorial priorities, and how costs and benefits are socially distributed. The following sections examine three interrelated dimensions of this reconfiguration: (i) Brazil as an energy frontier for AI, (ii) the rhetoric of "green processing," and (iii) socio-environmental conflicts and associated forms of territorial injustice.

3.1 Brazil as an Energy Frontier for AI

The growth of data centers in Brazil has accelerated in recent years, driven by factors such as the expansion of the digital market, tax incentives, the relative availability of energy, and a strategic geopolitical position. Dora Kaufman (2024) highlights that major technology companies have announced multibillion-dollar investments in the country: Microsoft alone has announced investments of approximately USD 2.7 billion in cloud and AI infrastructure in Brazil over a three-year period, signaling the centrality of Brazilian territory in the expansion of computing at a global scale.

This movement has direct repercussions for national energy consumption. Recent surveys indicate that energy consumption associated with data centers is expected to more than double by the end of the decade, increasing from approximately 8.2 TWh to over 18 TWh per year, surpassing even national consumption associated with public lighting (Schuck, 2025). Kaufman (2025b) reinforces this diagnosis by noting that the energy consumption of large-scale data centers currently operating in Brazil already approaches the total electricity consumption of entire states, such as Tocantins, underscoring the magnitude of this demand.

The installation of these infrastructures reveals a clear pattern of spatial concentration, particularly along metropolitan corridors and in strategic areas with privileged access to electricity, water, and telecommunications infrastructure. The São Paulo Metropolitan Region, in particular, stands out as the main hub. Kaufman (2024)

draws attention to the case of Barueri, a municipality that hosts one of the largest data center complexes in the world, illustrating how certain urban territories come to perform critical functions within the global digital economy.

This spatial concentration deepens regional and territorial inequalities while simultaneously intensifying pressures on already saturated urban systems, especially with regard to energy and water demand. Although it is often argued that proximity to consumption centers and transmission networks reduces losses and increases efficiency, such reasoning overlooks the cumulative impacts of this concentration on territory, including infrastructure overload, conflicts over water use, and heightened socio-environmental vulnerability (Fernandes et al., 2023).

In this context, Brazil's energy matrix—historically characterized by a high share of renewable sources—has been mobilized as a legitimizing element for the expansion of data centers. Dominant discourse portrays the country as a "natural" destination for large-scale data processing due to its supposed comparative environmental advantage. However, as Kaufman (2024) warns, this narrative ignores the fact that "clean" energy is not unlimited and that its appropriation by highly consumption-intensive sectors may generate regressive redistributive effects, shifting ecological and social costs onto populations that do not directly benefit from the digital services produced.

3.2 The Rhetoric of Green Processing

The notion of green processing occupies a central position in the institutional and corporate rhetoric associated with the expansion of data centers in Brazil. According to this discourse, the combination of renewable energy, technological efficiency, and voluntary commitments to carbon neutrality would make it possible to reconcile the expansion of AI with environmental sustainability. However, this narrative tends to function more as a discursive strategy of legitimation than as an effective recognition of ecological limits (Crawford, 2021).

A key element of this "green" discourse is the spatial and political dissociation between the sites of digital service consumption and the sites where infrastructure is installed. Kaufman (2024) observes that the perception of AI's environmental impacts is hindered by the material and symbolic distance between interface and infrastructure: the convenience of digital services obscures the territorial concentration of energy, water, and land required to sustain them. This dissociation contributes to the normalization of infrastructural growth as inevitable, while concrete conflicts—such as water permits, environmental licensing, grid expansion, and water restrictions—remain confined to technical arenas that are largely impermeable to public debate.

The argument of clean energy as a competitive advantage also tends to obscure the growing complexity of the national electricity system (Kaufman, 2025a). The

requirement for a continuous, stable, and predictable energy supply—a defining characteristic of data center operations—poses structural challenges to the integration of intermittent renewable sources, such as solar and wind power. To manage this tension between variable supply and constant demand, mechanisms such as curtailment[1]—that is, the forced reduction of renewable generation during periods of excess production — have been employed, revealing internal contradictions within the energy model that underpins the expansion of digital infrastructures (Soares, 2025).

The normalization of curtailment, however, raises critical concerns. Rather than being treated as a symptom of structural imbalances between production and demand, it comes to function as an instrument for rationalizing overproduction, enabling the continued expansion of data centers without confronting debates over energy limits, priorities of use, and distributive justice (Fernandes et al., 2023). In this way, green processing tends to mask the displacement of impacts rather than eliminate them.

3.3 Socio-environmental Conflicts and Territorial Injustice

The expansion of data centers across Brazilian territory deepens socio-environmental conflicts that remain insufficiently explored in both the academic literature and public debate. One of the most sensitive aspects concerns pressure on water resources. Server cooling requires significant volumes of clean, cold water, a technical condition that is indispensable to prevent corrosion and overheating of equipment (Kaufman, 2024).

Kaufman (2025a) cites studies estimating, for example, that generating a single text response by advanced AI models may involve hundreds of liters of water when cooling systems are taken into account. However, conflicts are not limited to water alone. The densification of data centers can place strain on urban infrastructure (energy supply, traffic, noise, and land use), while also inducing changes in zoning regulations and municipal priorities oriented toward attracting investment.

Although such enterprises are often claimed to increase tax revenues and modernize local economies, critical literature indicates that direct employment opportunities are relatively limited and highly specialized, and that a significant share of value capture occurs in extraterritorial layers (software, intellectual property, data governance, and global value chains). This makes the proportionality between localized ecological costs and local benefits uncertain (Kaufman, 2025a).

---

[1] The IEA Wind Task 25 report (2025) indicates that curtailment typically occurs during periods when electricity production exceeds demand or when there is grid congestion, and that, although it may facilitate the integration of flexible renewable sources, excessive volumes of wasted energy can signal systemic inefficiencies.

Local impacts associated with the installation of data centers are generally minimized or treated as secondary externalities. Neighboring communities rarely participate in decision-making processes, and environmental impact assessments, when they exist, tend to fragment analysis by overlooking the cumulative and synergistic effects of the spatial concentration of these infrastructures. This dynamic reinforces a pattern of territorial injustice, in which the benefits of digital processing—profits, innovation, and services—are appropriated by large global corporations, while environmental costs are borne by specific territories and localized populations.

This asymmetry reveals a central contradiction: while AI is promoted as a vector of efficiency, modernization, and sustainability, its material base reproduces historical inequalities in the appropriation of territory and natural resources. Within this arrangement, Brazil assumes the role of a provider of energy, water, and physical space for the global digital economy, without this necessarily translating into proportional gains in technological sovereignty, socio-environmental justice, or democratic control over this strategic infrastructure (Stacciarini; Gonçalves, 2025).

From this perspective, the dispute is not only environmental but also distributive and democratic: it concerns defining who bears risks and who decides on the conversion of water, energy, and urban space into computational capacity. In this arrangement, Brazil tends to occupy the role of a supplier of energy, water, and territory for the global digital economy, without corresponding gains in technological sovereignty, socio-environmental justice, or democratic governance over strategic infrastructure (Stacciarini; Gonçalves, 2025). The territorial reconfiguration promoted by data centers thus appears less as a form of "neutral modernization" and more as a rearrangement of socio-ecological priorities that may deepen pre-existing inequalities.

4 THE ENVIRONMENTAL PARADOX OF ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) occupies a central position in contemporary narratives surrounding responses to the environmental and climate crisis. In institutional documents, corporate reports, and political discourse, AI is frequently portrayed as a technology capable of correcting human inefficiencies, optimizing complex systems, and offering innovative solutions to global environmental problems. This expectation, however, coexists with a fundamental contradiction: the expansion of AI depends on a material infrastructure that is intensive in energy, water, and mineral extraction, whose operation deepens precisely the processes of ecological degradation that such technologies are purported to mitigate (Crawford, 2021; Kaufman, 2025a).

This paradox is not circumstantial, but structural. It stems from the fact that AI does not develop outside the dominant economic system, but is deeply embedded in

the logic of contemporary capitalism, characterized by accelerated production, continuous expansion of consumption, and the growing financialization of nature. Thus, even when certain AI applications yield localized environmental benefits, their systemic operation tends to reinforce the energy and material metabolism of the global economy, shifting environmental debate into a predominantly technical and depoliticized sphere (Ferrari, 2023).

4.1 AI as an Environmental Tool: Promises, Uses, and Structural Limits

The incorporation of artificial intelligence into environmental agendas has occurred on multiple fronts. Machine learning–based systems have been employed in monitoring deforestation, detecting changes in land use and land cover, identifying patterns of air and water pollution, and forecasting extreme climate events. The ability to process large volumes of data from sensors, meteorological stations, and satellite imagery has significantly expanded the scale and precision of environmental analyses, enabling more rapid and evidence-based responses (Kaufman, 2025a).

In the energy sector, AI applications associated with smart grids are frequently highlighted as key instruments for the energy transition. By optimizing energy distribution, reducing technical losses, and adjusting supply to demand in real time, such systems promise to increase resource-use efficiency and facilitate the integration of renewable energy sources. Similarly, AI has been applied in the design of more energy-efficient buildings, the optimization of industrial processes, and the development of carbon capture and storage technologies (Galaz et al., 2021).

However, a critical examination of these promises reveals significant limitations. First, the environmental gains generated by these applications are sectoral, localized, and context-dependent, whereas the costs associated with the infrastructure that sustains them are global, cumulative, and increasing. The expansion of environmental monitoring, for example, requires greater processing, storage, and data transmission capacity, thereby driving the expansion of data centers and the associated growth in energy consumption (Chen, 2025).

Second, these applications do not challenge the growth pattern that structures the digital economy. On the contrary, by enhancing efficiency and the capacity to manage complex systems, AI often enables the expansion of economic activities that intensify the exploitation of natural resources. As Ferrari (2023) observes, there is a tendency to assign technology the role of compensating for environmental externalities without addressing the structural causes that produce them. In this sense, AI operates more as an instrument of technical mitigation than as a driver of socio-ecological transformation.

4.2 The Rebound Effect, Digital Expansion, and the Illusion of Sustainable Efficiency

The belief that technological advances automatically lead to reductions in natural resource consumption overlooks one of the most established concepts in ecological economics: the rebound effect, also known as the Jevons Paradox (Alcott, 2005; Giampietro; Mayumi, 2018). Originally formulated in the nineteenth century, this concept describes how efficiency gains reduce relative costs and, paradoxically, stimulate an increase in the total consumption of a given resource (Jevons, 1865; Alcott, 2005).

In the context of artificial intelligence, the rebound effect manifests itself with particular intensity. As models become more efficient, faster, and more accessible, their adoption expands across an increasing number of sectors and applications. The reduction in cost per operation does not result in lower overall use of the technology, but rather in its accelerated diffusion, increasing the total volume of data processed and, consequently, demand for energy, water, and physical infrastructure (Crawford, 2021).

This discussion can be further deepened by recognizing that computational efficiency operates within a competitive field of forces, in which performance gains are rapidly converted into new frontiers of demand. The logic identified by Jevons—consumption expansion following efficiency gains—reappears when reductions in the cost of algorithmic operations stimulate the multiplication of applications, the intensification of use, and the expansion of installed capacity (Jevons, 1865; Alcott, 2005).

Within this dynamic, the promise of greater efficiency displaces the debate from its decisive core: the compatibility between continuous growth and ecological limits. Consequently, the contemporary controversy cannot be resolved solely through efficiency engineering; it reintroduces the alternative between paradigms of efficiency and sufficiency—that is, between indefinitely expanding computational capacity or subjecting it to political criteria of priority, restraint, and precaution (Ferrari, 2023).

Recent data reinforce this dynamic. As highlighted by Kaufman (2025a), major technology companies have reported significant increases in water consumption and greenhouse gas emissions in recent years, associated with the expansion of data centers and AI services. Microsoft reported substantial growth in water use and emissions between 2021 and 2022, while Google indicated marked increases in its environmental impacts since 2019, largely related to the intensification of data processing (Kaufman, 2025a).

These data demonstrate that technical efficiency—expressed through indicators such as algorithmic optimization or reduced consumption per operation—does not translate into absolute reductions in environmental impacts. On the contrary, it functions as a condition of possibility for the expansion of digital infrastructure, reinforcing the contradiction between environmental mitigation and continuous growth.

Efficiency, when decoupled from limits, thus becomes an illusion of sustainability, capable of legitimizing the material intensification of the digital economy.

5 ENVIRONMENTAL REGULATION, GOVERNANCE, AND DIGITAL COLONIALITY

The advancement of artificial intelligence and its material infrastructure poses not only technical challenges related to efficiency or innovation, but also exposes the political, institutional, and ecological limits of current regulatory regimes. The central question is not merely how to regulate AI, but who defines the criteria, in the service of which interests, and at what territorial and environmental costs.

The expansion of data centers in Brazil takes place within a context marked by the absence of a specific environmental regulatory framework for this type of infrastructure. Although these facilities involve high levels of energy, water, and land consumption, they continue to be addressed in a fragmented manner under general licensing regulations, often classified as low- or medium-impact activities. This classification reduces environmental requirements and limits cumulative and strategic assessments (Santos et al., 2024).

This regulatory gap facilitates processes of indirect environmental flexibilization, in which the urgency to attract investment, promote technological innovation, and enhance international competitiveness overrides environmental precaution. As Kaufman (2025b) observes, legislative debates on AI regulation in Brazil—particularly in relation to Bill No. 2338/2024—have focused primarily on issues such as fundamental rights, algorithmic transparency, and informational sovereignty, while relegating the ecological dimension of the infrastructure that sustains these systems to a secondary position.

Regulatory fragmentation is also evident in the disconnection between digital, energy, and environmental policies. While official discourse promotes the country as a strategic hub for "green" data centers, there are no robust mechanisms that integrate environmental licensing, water management, energy planning, and territorial governance. This scenario increases the risk of environmental rollback, insofar as systemic impacts are treated as isolated externalities rather than as constitutive elements of the digital development model currently underway (Stacciarini; Gonçalves, 2025).

Brazil's insertion into the global artificial intelligence economy reveals clear features of digital coloniality, in which countries of the Global South assume specific functions within the AI value chain—most notably as providers of energy, water, critical minerals, and physical territory for resource-intensive infrastructures (Coeckelbergh, 2020; Crawford, 2021).

Within this arrangement, decision-making centers—responsible for model development, data appropriation, and profit capture—remain concentrated in major corporations and core countries, while the environmental and social costs of digital materiality are territorialized in peripheral regions. As Stacciarini and Gonçalves (2025) argue, the supposed immateriality of AI conceals an expanded extractivist chain that connects mining, energy, logistics, and waste disposal, reproducing historical patterns of dependency and asymmetry.

The rhetoric of digital sovereignty, frequently mobilized in regulatory debates, proves limited when it fails to incorporate the ecological dimension. Informational sovereignty does not automatically translate into technological or environmental sovereignty, particularly when infrastructure expansion occurs under the control of transnational capital and with limited state capacity to impose effective socio-environmental counterbalances (Kaufman, 2025b).

Digital coloniality thus manifests not only through control over data flows and algorithms, but also through the unequal transfer of ecological impacts, reinforcing a geography of power in which certain territories are converted into zones of environmental sacrifice in order to sustain the expansion of global digital capitalism.

In light of this scenario, it becomes imperative to articulate debates on environmental justice and digital justice, recognizing that AI governance involves deep distributive conflicts. The issue is not merely the protection of individual rights vis-à-vis algorithmic systems, but rather confronting the unequal distribution of environmental risks and harms associated with the infrastructure that enables them (Galaz et al., 2021).

Critical literature has emphasized the limits of corporate self-regulation based on voluntary commitments to sustainability, carbon neutrality, or energy efficiency. While such mechanisms may serve as complementary instruments, they do not replace binding public policies capable of establishing clear limits on infrastructural expansion and ensuring transparency, social participation, and environmental accountability (Crawford, 2021; Santos et al., 2024).

The construction of an environmentally oriented technological sovereignty therefore requires the incorporation of climate justice criteria into decision-making processes regarding data centers and AI. This implies recognizing that not all technological expansion is desirable or sustainable, and that digital planning must be subject to ecological and social limits, rather than guided solely by metrics of efficiency or economic competitiveness (Barroso; Mello, 2024).

Ultimately, the paradox of AI regulation in Brazil lies in the fact that sustainability is frequently invoked as a legitimizing discourse but rarely assumed as a structuring limit. Without confronting this contradiction, the governance of artificial intelligence tends to reproduce—under new technological languages—old forms of inequality, dependency, and environmental injustice.

6 FINAL CONSIDERATIONS

The analysis developed throughout this article demonstrates that artificial intelligence, far from constituting an immaterial or environmentally neutral technology, depends on an ecological infrastructure that is intensive in energy, water, territory, and extractive chains. By making explicit the materiality of data centers and their territorialization in Brazil, the study shows that the expansion of AI deepens pressures on natural resources and urban systems, reinscribing historical inequalities under the grammar of technological innovation. In this sense, the promise of efficiency and sustainability associated with AI proves to be profoundly paradoxical: relative performance gains coexist with absolute growth in energy and water consumption, straining the ecological limits that structure the contemporary environmental crisis.

The Brazilian case illustrates this contradiction with particular clarity. The country's insertion into the global geography of artificial intelligence has occurred largely as a functional territory for the expansion of digital capitalism, absorbing socio-environmental costs associated with the continuous operation of data centers, while decision-making centers, model control, and the appropriation of economic benefits remain concentrated in transnational actors. The mobilization of Brazil's renewable energy matrix as a legitimizing argument for the expansion of these infrastructures tends to obscure territorial conflicts, pressures on water resources, and processes of environmental injustice, by treating sustainability as a discursive attribute rather than as a normative limit.

The article also demonstrates that the environmental paradox of artificial intelligence cannot be resolved through purely technical solutions or voluntary corporate self-regulation commitments. The emphasis on algorithmic efficiency, energy optimization, and so-called "green processing" proves insufficient in light of the rebound effect and the logic of continuous growth that structures the digital economy.

The discussion on regulation and governance reinforces this diagnosis. Although Brazilian legislative debates—exemplified by the public hearings on Bill No. 2338/2024—have advanced in areas such as the protection of fundamental rights, transparency, and informational sovereignty, the environmental dimension of AI infrastructure remains marginalized. This normative gap reveals that the governance of artificial intelligence is, above all, a political and institutional dispute over who decides the direction of technological development, who captures its benefits, and who bears its environmental impacts. Without the explicit incorporation of binding environmental criteria, regulation risks legitimizing an infrastructural expansion that reproduces territorial inequalities and contemporary forms of digital coloniality.

In this context, the principal contribution of this article lies in asserting that the sustainability of artificial intelligence cannot be conceived solely in terms of technical

efficiency, but rather as a political decision about limits. Integrating environmental justice and digital justice requires subjecting the expansion of AI to criteria of precaution, social participation, and territorial planning, recognizing that not every innovation is desirable or compatible with planetary boundaries. Technological sovereignty, in turn, becomes substantive only when articulated with environmental sovereignty, state regulatory capacity, and the democratization of decisions regarding infrastructure, energy, and land use.

Finally, by shifting the debate on artificial intelligence from a strictly technological field to the realm of political ecology, this article argues that addressing the environmental paradox of AI demands more than improving algorithms or diversifying energy sources. It requires a transformation in the very development model that guides the expansion of the digital economy, recognizing that sustainability, if taken seriously, cannot operate merely as a promise, but must function as an effective limit on the contemporary reorganization of territory, nature, and technology.

REFERENCES

ALCOTT, Blake. Jevons' paradox. **Ecological Economics**, v. 54, n. 1, p. 9–21, 2005. DOI: https://doi.org/10.1016/j.ecolecon.2005.03.020

BARROSO, Luís Roberto; MELLO, Patrícia Perrone Campos. Inteligência artificial: promessas, riscos e regulação. Algo de novo debaixo do sol. **Revista Direito e Práxis,** Rio de Janeiro, v. 15, n. 4, p. 1–45, 2024. DOI: https://doi.org/10.1590/2179-8966/2024/84479 .

CHEN, S. How much energy will AI really consume? The good, the bad and the unknown. **Nature,** v.639, n.8053, 2025, p. 22-24, https://doi.org/10.1038/d41586-025-00616-z

COECKELBERGH, Mark. **AI ethics**. Cambridge: MIT Press, 2020.

CRAWFORD, Kate. **Atlas of AI: power, politics, and the planetary costs of artificial intelligence**. New Haven: Yale University Press, 2021.

FERNANDES, André Lucas (coord.); SANTOS, Anicely; LEYENDECKER, Helton; MENDES, Clarissa. **IA, data centers e os impactos ambientais**. Policy Brief. Rio de Janeiro: Instituto de Pesquisa em Direito e Tecnologia do Recife (IP.rec), 2023.

FERRARI, Vanessa. Inteligência artificial: um paradoxo ambiental? **Cadernos Jurídicos da Escola Paulista da Magistratura,** São Paulo, ano 24, n. 65, p. 201–212, 2023.

Disponível em: https://bdjur.stj.jus.br/entities/publication/9e5501a1-4efc-4d8d-9ad7-6876e486799b >. Acesso em: 18 out. 2025.

FURTADO, Renato Guimarães; CUNHA, Simone Evangelista. Inteligência artificial, data centers e colonialismo digital: impactos socioambientais e geopolíticos a partir do Sul Global. **Liinc em Revista,** Rio de Janeiro, v. 20, n. 2, 2024.
DOI: https://doi.org/10.18617/liinc.v20i2.7272 . Disponível em:
https://revista.ibict.br/liinc/article/view/7272. Acesso em: 16 nov. 2025.

GALAZ, V., CENTENO, M. A., CALLAHAN, P. W., CAUSEVIC, A., PATTERSON, T., BRASS, I., BAUM, S., FARBER, D., FISCHER, J., GARCIA, D., MCPHEARSON, T., JIMENEZ, D., KING, B., LARCEY, P., & LEVY, K. Artificial intelligence, systemic risks, and sustainability. **Technology in Society,** 67, Article 101741, 2021.
https://doi.org/10.1016/j.techsoc.2021.101741

GIAMPIETRO, M.; MAYUMI, K. Unraveling the Complexity of the Jevons Paradox: The Link Between Innovation, Efficiency, and Sustainability. **Frontiers in Energy Research**, 6, 2018. https://doi.org/10.3389/fenrg.2018.00026

GODOY, Jeane Aparecida Rombi de; BENINI, Sandra Medina; SILVA, Allan Leon Casemiro da; PALMISANO, Angelo. Análise das Políticas de Adaptação Climática no Rio Grande do Sul. **Periódico Eletrônico Fórum Ambiental da Alta Paulista**, *[S. l.]*, v. 20, n. 3, 2024.
DOI: 10.17271/1980082720520245550. Disponível
em: https://publicacoes.amigosdanatureza.org.br/index.php/forum_ambiental/article/view/5550. Acesso em: 15 jan. 2025.

HILTY, Lorenz M.; AEBISCHER, Bernard. ICT for sustainability: an emerging research field. In: HILTY, Lorenz M.; AEBISCHER, Bernard (org.). **ICT innovations for sustainability.** Cham: Springer, 2014. p. 3–36. DOI: https://doi.org/10.1007/978-3-319-09228-7_1 .

JEVONS, William Stanley. **The coal question: an inquiry concerning the progress of the nation, and the probable exhaustion of our coal-mines**. London: Macmillan, 1865.

KAUFMAN, Dora. IA como aliada ou inimiga da natureza. **Valor Econômico,** São Paulo, 10 mar. 2025a. Disponível em: https://valor.globo.com/opiniao/coluna/ia-como-aliada-ou-inimiga-da-natureza.ghtml . Acesso em: 18 out. 2024.

KAUFMAN, Dora. Infraestrutura de IA sustentável. **Valor Econômico**, São Paulo, 18 out. 2024. Disponível em: < https://valor.globo.com/opiniao/coluna/infraestrutura-de-ia-sustentavel.ghtml >. Acesso em: 18 out. 2024.

KAUFMAN, Dora. Regulação da IA no Brasil: soberania, transparência e direitos. **Valor Econômico,** São Paulo, 6 out. 2025b. Disponível em: https://valor.globo.com/opiniao/coluna/regulacao-da-ia-no-brasil-soberania-transparencia-e-direitos.ghtml . Acesso em: 18 out. 2024.

LIU, Yanan; WEI, Xiaoxia; XIAO, Jinyu; LIU, Zhijie; XU, Yang; TIAN, Yun. Energy consumption and emission mitigation prediction based on data center traffic and PUE for global data centers. **Global Energy Interconnection**, v. 3, n. 3, p. 272–282, jun. 2020. DOI: https://doi.org/10.1016/j.gloei.2020.07.008 .

MARTÍNEZ-VARGAS, Ivan. Brasil já colhe benefícios do boom dos data centers. **Valor Econômico,** São Paulo, 6 nov. 2024. Disponível em: https://valor.globo.com/publicacoes/especiais/investimento-estrangeiro/noticia/2024/11/06/brasil-ja-colhe-beneficios-do-boom-dos-data-centers.ghtml. Acesso em: 16 nov. 2025.

NUSDEO, Ana Maria de Oliveira et al. O Brasil como polo de data centers de IA no Sul Global: limites regulatórios e riscos socioambientais. **Revista Jurídica Direito & Realidade**, v. 16, p. 56–86, 2025. Disponível em: https://revistas.fucamp.edu.br/index.php/direito-realidade/article/view/4036 . Acesso em: 16 nov. 2025.

SANTOS, Anicely et al. **IA, data centers e os impactos ambientais**. Policy Brief. Rio de Janeiro: Instituto de Pesquisa e Tecnologia, 2024. Disponível em: https://ip.rec.br/wp-content/uploads/2025/05/Policy-Paper-Data-Centers.pdf . Acesso em: 16 nov. 2025.

SCHUCK, Sofia. Data centers vão dobrar consumo de energia no Brasil e superar iluminação pública, revela MIT. **Exame**, São Paulo, 2025. Disponível em: https://exame.com/esg/data-centers-vao-dobrar-consumo-de-energia-no-brasil-e-superar-iluminacao-publica-revela-mit/. Acesso em: 16 nov. 2025.

SOARES, Ricardo. Inteligência artificial generativa: entre energias renováveis e o uso crescente da energia nuclear. **Jornal da USP**, São Paulo, 16 jan. 2025. Disponível em: https://jornal.usp.br/artigos/inteligencia-artificial-generativa-entre-energias-renovaveis-e-o-uso-crescente-da-energia-nuclear/. Acesso em: 16 nov. 2025.

STACCIARINI, João Henrique Santana; GONÇALVES, Ricardo Junior de Assis Fernandes. Data Centers, Minerais Críticos, Energia e Geopolítica: as bases da Inteligência Artificial. **Sociedade & Natureza**, *[S. l.]*, v. 37, n. 1, 2025. DOI: 10.14393/SN-v37-2025-77215. Disponível em: https://seer.ufu.br/index.php/sociedadenatureza/article/view/77215. Acesso em: 16 nov. 2025.

WIND Task 25. Wind and Solar Energy Curtailment. **IEA Wind, 2025**. Disponível em: https://iea-wind.org/wp-content/uploads/2025/02/Task25-FactS-Curtailment-February2025.pdf. Acesso em: 16 nov. 2025.

DECLARATIONS

AUTHOR CONTRIBUTIONS

- **Study Conception and Design:** Ricardo Miranda dos Santos; Sandra Medina Benini.
- **Data Curation:** Ricardo Miranda dos Santos.
- **Formal Analysis:** Ricardo Miranda dos Santos; Allan Leon Casemiro da Silva.
- **Funding Acquisition:** None.
- **Investigation:** Ricardo Miranda dos Santos.
- **Methodology:** Ricardo Miranda dos Santos; Sandra Medina Benini.
- **Writing – Original Draft:** Ricardo Miranda dos Santos.
- **Writing – Critical Review:** Sandra Medina Benini; Allan Leon Casemiro da Silva.
- **Review and Final Editing:** Ricardo Miranda dos Santos; Sandra Medina Benini.
- **Supervision:** Sandra Medina Benini.

DECLARATION OF CONFLICTS OF INTEREST

We, **Ricardo Miranda dos Santos, Sandra Medina Benini, and Allan Leon Casemiro da Silva**, declare that the manuscript entitled **"Artificial intelligence and its hidden costs: ecological limits and digital coloniality in Brazil"** meets the following criteria:

1. **Financial Relationships:** No funding institution or entity was involved in the development of this study.
2. **Professional Relationships:** The authors hold academic affiliations; however, these affiliations did not influence the analysis, interpretation, or presentation of the results. No professional relationships relevant to the content of this manuscript were established.
3. **Personal Conflicts:** No personal conflicts of interest related to the content of this manuscript were identified.