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Between Power and Nature: An Eco-Political Economy of AI

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Abstract

Greta Thunberg's *The Climate Book* offers an opportunity to reflect on a critical yet persistently marginalized issue in contemporary communication and media scholarship: the environmental impact of digital communication systems and artificial intelligence (AI). Digital systems rely on complex assemblages of natural and synthetic materials, generate significant emissions, demand vast amounts of energy and water, and intensify pollution and electronic waste across global supply chains. Despite growing empirical evidence documenting these impacts, environmental concerns remain underdeveloped in dominant policy, industry, and academic narratives surrounding AI. Recent acknowledgements by major technology corporations and international institutions have begun to reveal the scale of these costs, including unprecedented demand for rare minerals, escalating energy consumption, and intensifying pressure on water resources. Yet, there is still no shared conceptual framework capable of systematically accounting for AI's ecological footprint. This absence is exacerbated by disciplinary fragmentation and by the widespread perception of AI as inherently beneficial or environmentally neutral. In response, this article further develops an "eco–political economy of AI" as a comprehensive analytical framework for understanding and addressing the environmental harms of AI systems. This approach foregrounds three interconnected segments of AI's global production/supply chain: resource extraction, energy consumption, carbon emissions, and digital waste. It further advocates for interdisciplinary integration across media and communication studies, geography, computing, and engineering, alongside indigenous knowledge systems and environmental justice perspectives.

The crucial importance of Greta Thunberg's book, highlighted in multiple contributions to this issue, is its focal point for discussions within media and communications scholarship. In particular, the book challenges the idea that scientific knowledge is too complex for the public and emphasizes the role of accessible scientific literature in expanding our understanding and engagement with environmental issues. Thus, it paves the way for a clear engagement with environmental communication beyond disciplinary boundaries to connect with policymakers, activists and practitioners.

This book is vital as it underscores yet another urgent issue: the ongoing lack of discussion in mainstream debates regarding the environmental impact of digital communication systems and artificial intelligence (AI). It is notable that this is the only crucial topic the book fails to address, and it's one that communication scholarship should approach with even more commitment than before. These systems, comprising both natural and synthetic materials, consume energy, emit emissions during production and operation, and exacerbate pollution and waste problems upon disposal. Since this topic is overlooked in the book, communication scholars should refocus their research agenda towards understanding and mitigating these environmental concerns.Despite growing attention to the environmental harms of ICT systems (Ferreboeuf, 2019), AI gets principally heralded as the key technology to solve contemporary challenges, including the climate crisis, which is one of the goals of sustainable development (Sætra, 2023). This AI hype frequently overlooks the significant environmental impacts stemming from the increasing demand for AI tools (Brevini, 2020a; Dobbe, 2022). Amid the media frenzy promoting the popularity of AI models, "Digital Lords" (Brevini, 2020b) such as Microsoft, OpenAI, and Google as well as various international institutions (OECD, 2022; European Commission, 2022) have finally acknowledged the substantial environmental costs associated with meeting the increasing demand for AI tools. These costs include unparalleled demand for rare metals (European Commission, 2022), massive energy expenditure (Brodie, 2023) and an unprecedented impact on water consumption (Shaji George et al., 2023). Microsoft's most recent environmental report for 2022 after the launch of Open AI generative AI services reveals a significant 34% increase in its worldwide water consumption from 2021 to 2022, reaching nearly 1.7 billion gallons (Microsoft, 2022).

Surprisingly, despite a wealth of evidence (Brevini, 2021), there is no universally agreed-upon conceptual framework or standardized guidelines for understanding the intricate ecological impacts of AI. The widespread adoption and perceived benefits of AI, along with the distinct separation between research fields, contribute to a fragmented academic landscape.

In various interventions, I have called for the development of an "eco-political economy of AI" (Brevini, 2021, 2022, 2024) to understand the complex elements involved in the assessment of AI environmental harms. This approach involves examining three crucial segments of AI's global production/supply chain to account for its environmental costs: a) mining and resource extraction, b) consumption, energy use and carbon footprints, and c) digital waste. Moreover, it involves the integration of theories from various disciplines such as media and communication, geography, computing, and engineering, while also integrating indigenous concepts and environmental justice paradigms.

Why political economy of communication (PEC)?

Political economy traditionally delves into the production, distribution, exchange, and consumption of wealth, income, and opportunities, analysing their implications for individual and societal welfare (Schier & Vig, 1985). With the advent of late capitalism, this field expanded its focus to incorporate Marx's historical materialism and class analysis. This expansion marked a pivotal moment when political economy evolved into a radical critique of the burgeoning capitalist system, emphasizing its unfair and unequal characteristics. In doing so, political economy distinguished itself from mere economics, positioning itself as a critical lens through which to examine the complexities of socio-economic structures. As Vincent Mosco (1996) pointed out, political economy explores "the wider totality of capitalist social relations" (p. 263). Further, as Jonathan Hardy has noted, such an approach encompasses "studies that consider political and economic aspects of communications and which are critical in regard to their concerns with the manner in which power relations are sustained and challenged" (Hardy, 2014, p. 4).

Earlier, Golding and Murdock (2005) declared that political economy aimed to go behind "technical issues to engage in basic moral question of justice, equality and public good" (p. 18). More notably, the strength of political economy lies in the central role it gives to questions of power in societies. So, to apply a political economy approach to artificial intelligence, as I have explained in several interventions (Brevini, 2021, 2023, 2024), needs to be concerned with at least four main areas.

- Who owns and controls the essential infrastructures that power AI? Who are the main players? What are the consequences of power concentration in this context?
- Relationship between the AI industry and states: How governmental policies and actions impact its values and development.
- Organization of AI industry production: Labour processes, managerial controls, and workers.
- Interplay between AI and the broader societal framework: How is AI development mirroring dominant social structure in capitalist societies? How is symbolic power used to legitimize power asymmetries within a capitalist system?

As Verdegem elucidates "power is all about who can influence what society looks like and who controls the means for doing so. In the context of AI, power decides who can and will benefit from new technologies and applications" (2021, p. 305).

Political economy of communication and the ecological crisis

There is a fifth, more neglected question that political economists of communication have started to ask, although with much less consistency and frequency. As Brevini and Murdock point out,

> Up until comparatively recently the implications of the very obvious fact that media systems and equipment are assembled from a range of natural and synthetic materials, consume energy and produce emissions in their production and use, and contribute to problems of pollution and waste in their disposal, has attracted surprisingly little comment or analysis. (2017, p. 5).

They further note that, "In communication and media scholarship, the overwhelming focus has been on texts, the industry that produces them, and the viewers that consume them; the materiality of devices and networks has been consistently overlooked" (Gillespie et al., 2014, p. 1). Notable exceptions are Richard Maxwell and Toby Miller's (2012) pioneering work *Greening the Media*, which underlined the need to study media as material structures and artefacts, thus illustrating how information technologies contribute to the global ecological crisis, in their life cycles until disposal.

Similarly, Vincent Mosco (2017) pointed out how the expansion of cloud computing is generating greater calls on energy and scarce resources. The transfer of user data from flash drives and other portable storage devices to the massive server farms that constitute the cloud significantly increases demand for both power to operate the facilities and water to cool them. The first book that explicitly placed the climate crisis at the centre of communication systems from a political-economic perspective was *Carbon Capitalism and Communication* (Brevini & Murdock, 2017). Here, the authors explicitly called for a research agenda that considered the way in which "the new digital complexes place escalating demands on energy, water and resources in their production, transportation and use" and "add to the accumulating amounts of waste and pollution already generated by accelerating rates of digital obsolescence and disposal" (2017, p. 217).

Beyond political economy: Communication studies, the digital and the environment

In the current academic landscape, scholars from diverse disciplines are progressively engaging with the intricate relationship between technology and its role in mitigating the global ecological and climate crisis (Sætra, 2023). Examples here include AI-powered tools for environmental monitoring, smart agriculture and digital alternatives to curb carbon emissions. These are often celebrated without a corresponding acknowledgment of technologies' inherent environmental harms (Brevini, 2020a, 2021). Crucial systematic evidence reviews of literature on environmental sustainability and digital communication conducted by Kuntsman and Rattle (2019) revealed that scholars engaging with sustainability and digital technologies promoted a "paradigmatic myopia", where various environmental blind spots persisted despite acknowledging some environmental concerns—such as e-waste and energy consumption—and proposing mitigating efforts.

In the field of media and communication there are noteworthy contributions that fit the umbrella term of "ecomedia." In the conceptualizations outlined by Rust et al. (2015), ecomedia encompasses media both *pertaining to* and *originating from* the environment. Ecomedia can also be seen as dynamic, material exchanges that shape, encompass and generate environments, milieus, objects (including texts, gadgets, platforms) and infrastructures (Starosielski & Walker, 2016; Ivakhiv & López, 2024). Specific engagements with the environmental costs of digital communication include Sean Cubitt's 2016 concept of "finite media," which brings attention to the finite nature of material resources required for, and subsequently depleted by, digital media. Other notable works are Marks and Przedpełski's (2022) research on the carbon footprint of streaming technologies, Parikka's (2015) exploration of the disastrous environmental consequences resulting from technological developments and Gabrys's (2016) study of environmental sensors and examination of the environmental impacts of digital information and electronic waste in her *Digital Rubbish* (2013). Prominent among recent research endeavours are those data center studies focusing on extensive carbon and extractive footprints of data infrastructures (Hogan, 2021, Brodie, 2023). These studies, although certainly relevant in engaging with environmental considerations in the realm of digital communication, fail to engage with the broader global ecosystem and global supply chains associated with digital technology. Consequently, the overall complexity of its environmental harms is not addressed.

AI studies and limits to engagement with the environmental question

As AI continues its advancement and integration into diverse societal contexts, it has prompted a broader interdisciplinary engagement to comprehend not only the technical capabilities of these technologies but also their wider social and political implications (Dignum, 2020). This evolving field is now specifically defined as "Critical AI studies" (Lindgren, 2023; Verdegem, 2021). A significant focus within critical AI studies revolves around the concern for bias, encompassing issues of race and gender discrimination, exclusion and oppression within AI systems (Eubanks, 2018; Noble, 2018; Broussard, 2023). Instances of discriminatory outcomes have been documented, particularly when AI models are trained on data reflecting societal power imbalances. Facial recognition systems, for instance, exhibit higher error rates for individuals with darker skin tones and demonstrate better accuracy in identifying male or binary genders (Broussard, 2023; Noble, 2018; Benjamin, 2019). Another crucial topic investigated in Critical AI is the impact on privacy and surveillance (Pasquale, 2015). With AI systems acquiring enhanced processing capabilities for vast datasets, there is a growing risk of heightened surveillance and privacy infringements (Dencik et al., 2022). Furthermore, concerns arise regarding the use of AI in decision-making processes, especially in critical domains such as criminal justice and healthcare, raising significant issues related to human rights and civil liberties (Smuha, 2021; van Wynsberghe, 2020). Working from a decolonialist perspective, Ricaurte (2019, 2022) employs a multidimensional approach, fostering an intersectional and feminist analysis to deconstruct algorithmic violence and empower resistance, particularly in the context of addressing data colonialism (Mohamed et al., 2021; Couldry & Mejias, 2019; Hao, 2022).

AI environmental damage: Beyond carbon footprints?

Engineering studies played a pivotal role in advancing the field of AI by providing the technical foundation and methodologies for the development and implementation of AI systems. They have also been delivering the most promising research concerning the environmental toll of AI and its energy consumption. The most pioneering study in the field that connected AI with its environmental costs was published in June 2019 by Strubell et al. (2019) at the College of Information and Computer Sciences at the University of Massachusetts Amherst. For the first time, research sought to quantify the energy consumed by running AI programs. Additionally, recent studies focusing on ChatGPT have highlighted the urgency of recognizing the massive water footprint caused by AI models (George et al, 2023; Heikka, 2023; Microsoft, 2022; Dryer, 2020).

However, existing research predominantly fixates on isolated environmental footprints. Overall, studies are limited in number, highlighting the need for more comprehensive research to ascertain the reliability and validity of such findings (van Wynsberghe, 2021). Expanding upon the groundwork laid by Henderson et al. (2020), Anthony et al. (2020) introduced “carbontracker” as a novel tool designed for monitoring and predicting the energy consumption and carbon emissions associated with training deep learning models (ibid). Notably, the carbontracker not only enables the generation of carbon impact statements but also provides a unique feature allowing users to halt model training at the user’s discretion if the predicted environmental cost is exceeded. In more recent times, tools such as the machine learning emissions calculator (Lacoste et al., 2019) have become increasingly accessible (Luccioni et al., 2023). However, these studies never engage with the complexity of AI global ecosystems and the overall ecological impact of AI. This conclusion aligns with the findings of a systematic review of engineering studies specifically addressing AI and ecological concerns conducted by Verdecchia et al (2023). The review underscores a significant increase in engineering publications exploring topics such as green software, green applications, and green data centers, with a substantial 76% of the papers emerging since 2020. However, it is noteworthy that the prevailing themes within these publications primarily revolve around monitoring, hyperparameter tuning, deployment and model benchmarking (Verdecchia, 2023).

These matters are of great relevance, but they don't delve into the intricate ecosystems of technologies and the comprehensive ecological repercussions of AI.

Geography studies, environmental justice, and indigenous knowledge

Studies in geography and human geography are extremely relevant. They have traditionally focused on understanding climate change with their multi-and inter-disciplinary approaches highlighting its economic, political, ecological and social dimensions (Aspinall, 2010; Hulme, 2011, Little, 2023). For example, they have shown how political decisions on energy transition reactions to climate change may become entangled in economic displacement, unemployment, embodied externalities and human rights violations, especially in the Global South and Indigenous lands. Hernández (2015), for example, demonstrates the significance of "energy sacrifice zones" that impact upon vulnerable communities throughout the lifecycle of renewable energy technologies. While the journey toward decarbonization can yield social net benefits, it also has the potential to amplify vulnerabilities and energy injustice (Newell & Mulvaney, 2013). As stated by Carley et al., "Some individuals and communities are more vulnerable to possible adverse impacts than others" (Carley et al., 2018).The work of Sovacool and Linnér (2016; see also Sovacool, 2021) is of particular relevance, as the authors developed a framework to discuss power relations and vulnerabilities in climate change mitigation and energy transitions. While this framework has not been directly applied to communication technologies or AI, it offers a useful starting point for conceptualizing the environmental damages of AI. It envisions four different processes:

- Enclosure - Capturing Resources or Authority: Involves the transfer of public assets into private hands or expanding private roles in the public sector.
- Exclusion - Political Marginalization: Focuses on limiting stakeholder access to decision-making processes and employing unfair planning or policymaking procedures, leading to political marginalization.
- Encroachment - Ecological Damage: Involves ecological harm such as intrusion into biodiversity areas, interference with ecosystem services, and shifting emissions sources without reduction.
- Entrenchment - Worsening Inequality: Refers to the exacerbation of inequality and the disempowerment of women or minorities. (Sovacool, 2021)

As highlighted by Mishra in this issue, traditional ecological knowledge is knowledge gained through millennia of direct interaction with the environment, encompassing beliefs and practices passed down through generations. This knowledge is vital for Indigenous communities in managing ecosystem processes and it becomes crucial if we want to consider holistically the environmental harms caused by AI.

The need for an eco-political economy of AI

To address the limitations of disciplinary-based investigations, *Is AI Good for the Planet*? (2021) called for a novel approach. And, an eco-political economy approach was posited as a framework for understanding, holistically, the complexity of environmental harms associated with the global production/supply chain of AI (Brevini, 2021, 2024). Embracing the tradition of the critical political economy of communications allows us to view communications systems as assemblages of material devices and infrastructures (Maxwell & Miller, 2012; Brevini & Murdock, 2017; Mosco, 2017).

I previously argued that “we should understand AI as a set of technologies, machines and infrastructures that demand amounts of energy in order to compute, analyze and categorize the use of scarce resources in their production, consumption and disposal, exacerbating the problems of waste and pollution” (Brevini, 2021, p. 41). However, understanding the environmental impacts of AI requires initiating every discussion with an analysis of the global production/supply chain involved (Brevini, 2021, 2023a, 2023b; Dobbe, 2022). This analysis has to foreground the imperative of extraction (Natural Resources Defense Council [NRDC], 2022), which AI currently depends upon for its production, transportation, training, and disposal (Brevini, 2021).

To understand the complexity of these processes, it is crucial to draw on “interdisciplinary bodies of knowledge from geography and communications” (Morgan, 2022, p. 1) to construct an eco-political economy of AI. This framework aims to integrate Indigenous concepts, environmental justice paradigms, and theories spanning media and communication, geography, computing and engineering. It locates three segments of the global production/supply chain, which are outlined next.

Producing the material resources needed for AI involves the extraction of rare metals and mineral resources. This first segment follows the legacies of colonialism (NRDC, 2022). In her work on digital developments with humanitarian structures, Mirca Madianou developed the notion of “technocolonialism” in order to analyse how “the convergence of digital developments with humanitarian structures and market forces reinvigorate and rework colonial legacies” (Madianou, 2019, p. 2). The same colonial genealogies and inequalities characterize AI’s global production/supply chain. The extractive nature of technocolonialism resides in the minerals that need to be mined to make the hardware for AI applications. The contemporary usage of mineral resources is growing exponentially: the European Commission (2022) has stressed that the demand for lithium in the EU, mainly for use in batteries, is projected to rise by 3,500% by 2050.

The second segment, covering the production of AI models, incurs high environmental costs. A staggering increase in energy and water consumption by data centers, fuelled by the rise of generative AI, has pressured Digital Lords to disclose more about their environmental footprint. Since the launch of generative AI services in 2022, both Microsoft and Google have reported notable surges in water consumption. Google’s data centers used 20% more water in 2022 compared to 2021 (Google, 2023), while Microsoft's water consumption rose by 34% during the same period (Microsoft, 2022). Looking ahead, Goldman Sachs (2024) forecasts that data centers will account for 8% of U.S. energy use by 2030, up from just 3% in 2022. In quantifying the energy consumed by running AI programs, Strubell et al.’s 2019 case study found that a common AI linguistics training model can emit more than 284 tonnes of carbon dioxide equivalent. This is comparable to five times the lifetime emissions of the average American car. It is also comparable to roughly 100 return flights from London to New York (Brevini, 2021). Because AI servers process enormous amounts of data, they require cooling systems that are largely water-powered, resulting in a massive water footprint (George et al. 2023; Microsoft 2022). Estimated global data centre electricity consumption in 2022 was 240-340 TWh per year or around 1-1.3% of global final electricity demand. (International Energy Agency [IEA], 2024). Moreover, greenhouse gas emissions from ICT could grow from roughly 1-1.6% in 2007 to exceed 14% worldwide by 2040, accounting for more than half of the current relative contribution of the whole transportation sector.

The third segment of the eco-political economy of AI is disposal. Discarded digital devices transform into electronic waste, leaving local governments responsible. The challenge of proper disposal is so immense that it is often outsourced, with many countries—primarily in the Global

South—becoming dumping grounds for the e-waste of wealthier nations. The UN's *Global E-Waste Monitor* (Unitar, 2024) highlights that global electronic waste production is growing at a rate five times faster than documented recycling efforts. In 2022 alone, the report noted that a record 62 million tons of e-waste represented a staggering 82% increase since 2010. At this pace, global e-waste production is expected to reach 82 million tons by 2030. Alarmingly, only 1% of the demand for rare earth elements is met through recycling. Generative AI exacerbates this crisis by accelerating server upgrades, particularly in chip development. The newest AI chips, such as Nvidia's, are contributing to unprecedented levels of electronic waste (Kidd, 2024).

However, a novel eco-political economy of AI that aims to understand holistically the complexity of AI's environmental harms needs to engage with concepts from environmental justice and Indigenous knowledge (Kukutai & Taylor, 2016; Urzedo et al., 2022). Environmental harms need to be connected with matters of cultural and social recognition. Ulloa Ulloa et al. (2017), for example, illuminate how Indigenous understandings of environmental justice are closely linked to specific knowledge systems and environmental management approaches. Examples include the revitalisation of seeds, the assertion of food sovereignty, territorial control, and independent economic production (Ulloa Ulloa et al., 2017; Hernández, 2015). These actions serve as strategies for cultural resistance and the recovery of traditional practices, with multiple examples coming from Aboriginal countries in Western Australia (Urzedo et al., 2022). From the perspective of Indigenous communities, environmental injustices, including the climate crisis, are inherently linked to and indicative of the ongoing dynamics of colonialism, dispossession and patriarchy (Birhane, 2020; Urzedo et al., 2022; Kukutai & Taylor, 2016). The contributions of Sovacool and Linnér (2018; see also Sovacool, 2021) hold significant relevance as they have devised a framework for examining power dynamics and vulnerabilities within climate mitigation and energy transitions. The rise of "wellbeing economics" (Laurent, 2023) offers valuable ideas for an eco-political economy of AI. Instead of prioritizing growth, wellbeing economics advocates sustained social-ecological wellbeing, which is defined as a balance of planetary health, cooperation and justice that leads to holistic human prosperity. The long-term flourishing of humanity depends on nurturing health and fostering these values (Laurent, 2023).

We need to ask who should own and control the essential infrastructures that power artificial intelligence and, at the same time, place the climate emergency at the centre of debate. At the time of writing, there are several international agreements, position papers and guidelines that are being discussed and initiated in global forums or at national levels, illustrating that progress is being made. For example, UNESCO (2021) recently adopted a recommendation on AI explicitly clarifying that "if there [is a] disproportionate negative impact of AI systems on the environment (...) they should not be used".

Over the past year, stories highlighting the unsustainability of the data centers powering AI have gained traction; the environmental impact of AI is coming under scrutiny for the first time. This shift has undoubtedly been driven by the massive increase in energy and water consumption caused by generative AI, which has forced Digital Lords to acknowledge these urgent environmental concerns. While the accompanying shift in public discourse is a step in the right direction, current reporting offers only a narrow view of the intricate and far-reaching environmental costs of digital technologies and AI. To address these matters, communication and media researchers need to explore and develop further the eco-political economy of AI.

Author Bio

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