ENVIRONMENTAL ISSUES REGARDING AI

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ABSTRACT

Artificial intelligence (AI) creates major environmental pressures through heavy energy demands, water depletion, raw material extraction, and electronic waste. [1, 2]

High Energy Consumption and Carbon Emissions

- Massive Power Demand: Data centers powering AI models consume vast amounts of electricity. According to the Grantham Research Institute on Climate Change and the Environment, data centers used about 1.5% of global electricity in 2024, a share projected to double by 2030. [1, 2]
- Fossil Fuel Reliance: Many data centers draw power from local electrical grids still heavily dependent on coal and natural gas, increasing greenhouse gas emissions. [1, 2]
- Corporate Targets: Tech companies like Microsoft have reported that the rapid expansion of AI has made it harder to hit their internal net-zero and carbon-reduction goals. [1]

KEYWORDS-AI, environment, energy, power, carbon, climate

INTRODUCTION

Water Depletion and Stress

- Cooling Requirements: Massive server clusters generate intense heat and require millions of gallons of water to cool hardware and maintain safe operating temperatures. [1, 2]
- Local Strain: More than half of data centers built recently are located in regions where freshwater supplies are already strained or over-allocated, putting local drinking water and ecosystems at risk. [1]

Critical Mineral Mining and Resource Extraction

- Hardware Demand: Building specialized AI chips and graphics processing units (GPUs) requires large amounts of copper, silicon, gold, aluminum, and rare earth metals. [1, 2]
- Ecosystem Destruction: Mining and refining these materials leads to habitat destruction, deforestation, and water pollution in extraction regions. [1, 2]

Electronic Waste (E-Waste)

- Short Hardware Lifespans: Heavy computational workloads force high-performance chips to run under intense stress, causing them to degrade and require replacement every three to four years instead of five or six. [1]
- Toxic Accumulation: Projections warn that AI infrastructure could generate up to 2.5 million tons of electronic waste annually by 2030, much of which contains toxic substances like lead and mercury and ends up in countries with limited safe recycling capacity. [1, 2]

Mitigation and Solutions

- Standardized Reporting: Organizations like the UN Environment Programme recommend mandatory environmental tracking and public disclosures for AI carbon and water footprints.
- Clean Energy Transitions: Transitioning data centers entirely to wind, solar, or other renewable energy sources helps lower operational emissions.
- Algorithm Efficiency: Designing leaner, more efficient machine learning models reduces the per-query computational load. [1, 2]

There are high hopes that artificial intelligence (AI) can help tackle some of the world's biggest environmental emergencies. Among other things, the technology is already being used to map the destructive dredging of sand and chart emissions of methane, a potent greenhouse gas.

But when it comes to the environment, there is a negative side to the explosion of AI and its associated infrastructure, according to a growing body of research. The proliferating data centres that house AI servers produce electronic waste. They are large consumers of water, which is becoming scarce in many places. They rely on critical minerals and rare elements, which are often mined unsustainably. And they use massive amounts of electricity, spurring the emission of planet-warming greenhouse gases. [3,4,5]

"There is still much we don't know about the environmental impact of AI, but some of the data we do have is concerning," said Golestan (Sally) Radwan, the Chief Digital Officer of the United Nations Environment Programme (UNEP). "We need to make sure the net effect of AI on the planet is positive before we deploy the technology at scale."

This week, UNEP released an issue note that explores AI's environmental footprint and considers how the technology can be rolled out sustainably. It follows a major UNEP report, Navigating New Horizons, which also examined AI's promise and perils. Here's what those publications found.

First of all, what is AI?

AI is a catch-all term for a group of technologies that can process information and, at least superficially, mimic human thinking. Rudimentary forms of AI have been around since the 1950s. But the technology has evolved at a breakneck pace in recent years, in part because of advances in computing power and the explosion of data, which is crucial for training AI models.

Why are people excited about the potential of AI when it comes to the environment?

The big benefit of AI is that it can detect patterns in data, such as anomalies and similarities, and use historic knowledge to accurately predict future outcomes. That could make AI invaluable for monitoring the environment, and helping governments, businesses and individuals make more planet-friendly choices. It can also enhance efficiencies. UNEP, for example, uses AI to detect when oil and gas installations vent methane, a greenhouse gas that drives climate change.

Advances like those are fostering hope that AI could help the world tackle at least some aspects of the triple planetary crisis of climate change, nature and biodiversity loss, and pollution and waste.

So how is AI problematic for the environment? [6,7,8]

Most large-scale AI deployments are housed in data centres, including those operated by cloud service providers. These data centres can take a heavy toll on the planet. The electronics they house rely on a staggering amount of grist: making a 2 kg computer requires 800 kg of raw materials. As well, the microchips that power AI need rare earth elements, which are often mined in environmentally destructive ways, noted Navigating New Horizons.

The second problem is that data centres produce electronic waste, which often contains hazardous substances, like mercury and lead.

Third, data centres use water during construction and, once operational, to cool electrical components. Globally, AI-related infrastructure may soon consume six times more water than Denmark, a country of 6 million, according to one estimate. That is a problem when a quarter of humanity already lacks access to clean water and sanitation.

Finally, to power their complex electronics, data centres that host AI technology need a lot of energy, which in most places still comes from the burning of fossil fuels, producing planet-warming greenhouse gases. A request made through ChatGPT, an AI-based virtual assistant, consumes 10 times the electricity of a Google Search, reported the International Energy Agency. While global data is sparse, the agency estimates that in the tech hub of Ireland, the rise of AI could see data centres account for nearly 35 per cent of the country's energy use by 2026.

Driven in part by the explosion of AI, the number of data centres has surged to 8 million from 500,000 in 2012, and experts expect the technology's demands on the planet to keep growing.

Some have said that when it comes to the environment, AI is a wildcard. Why is that?

We have a decent handle on what the environmental impacts of data centres could be. But it's impossible to predict how AI-based applications themselves will affect the planet. Some experts worry they may have unintended consequences. For example, the development of AI-powered self-driving cars could cause more people to drive instead of cycling or taking public transit, pushing up greenhouse gas emissions. Then there are what experts call higher-order effects. AI, for example, could be used to generate misinformation about climate change, downplaying the threat in the eyes of the public. [9,10,11]

Is anybody doing anything about the environmental impacts of AI?

More than 190 countries have adopted a series of non-binding recommendations on the ethical use of AI, which covers the environment. As well, both the European Union and the United States of America have introduced legislation to temper the environmental impact of AI. But policies like those are few and far between, says Radwan.

"Governments are racing to develop national AI strategies but rarely do they take the environment and sustainability into account. The lack of environmental guardrails is no less dangerous than the lack of other AI-related safeguards."

How can the world rein in the environmental fallout from AI?

In the new issue note, UNEP recommends five main things. Firstly, countries can establish standardized procedures for measuring the environmental impact of AI; right now, there's a dearth of reliable information on the subject. Secondly, with support from UNEP, governments can develop regulations that require companies to disclose the direct environmental consequences of AI-based products and services. Thirdly, tech companies can make AI algorithms more efficient, reducing their demand for energy, while recycling water and reusing components where feasible. Fourthly, countries can encourage companies to green their data centres, including by using renewable energy and offsetting their carbon emissions. Finally, countries can weave their AI-related policies into their broader environmental regulations.

UNEP is focused on helping the world better navigate the environmental challenges of tomorrow. To do that, we have ramped up our work on strategic foresight, scanning the horizon for emerging threats to the planet. This process culminated in the development of Navigating New Horizons – A Global Foresight Report on Planetary Health and Human Wellbeing, which was published earlier this year. Produced in collaboration with the International Science Council, it examined eight global shifts accelerating the triple planetary crisis of climate change, nature and biodiversity loss, and pollution and waste. [12,13,14]

DISCUSSION

The environmental impact of the design, training, deployment and use of artificial intelligence includes the greenhouse gas emissions from generating electricity for data centres and computing hardware, operational and upstream water use, and material impacts from hardware manufacturing, mining and electronic waste.[1][2][3][4]

Estimating AI's environmental effects can be difficult because results depend on how impacts are measured, including whether accounting includes only model computation or also data-centre overhead, idle capacity, hardware manufacture, and local electricity supply.[5]

As these issues have received greater attention, governments and regulators have increasingly considered data-centre reporting requirements, energy-efficiency standards, and broader transparency measures for AI-related resource use.[6][7]

Carbon footprint and energy use [15,16,17]

AI-related energy use arises at multiple stages, including model training, fine-tuning, inference, storage, networking, and supporting infrastructure such as cooling and power conversion.[2] Existing research primarily focuses on the cost of model training and deployment, rather than other aspects of the AI life cycle, such as dataset creation and decommissioning.[8]

RESULTS

AI systems depend on specialised computing hardware, and rapid turnover in servers and accelerators may contribute to rising e-waste.[4] The World Health Organization identified e-waste as a growing environmental and public-health issue.[33] The primary contributor to e-waste from AI is the high performance hardware used in data centers, which can contain hazardous materials like lead, mercury, and chromium.[4] AI data center components are also swapped frequently, with companies expected to completely replace their hardware every three years to remain competitive.[34] Recycling AI hardware can also be more difficult than typical consumer electronics due to the possibility of storing sensitive data.[35]

A 2024 study in Nature Computational Science estimated that generative AI could add between 1.2 and 5 million tonnes of e-waste by 2030 under the scenarios examined by the authors.[4] In the study's higher-end scenarios, this would represent up to 12% of projected global e-waste by 2030.[4] The authors also reported that circular economy strategies along the generative AI value chain could reduce AI-related e-waste generation by 16–86%.[4] A study from 2026 instead estimated that by 2030, AI servers would generate 131.0 to 224.8 thousand tonnes of e-waste per year [18,19]

CONCLUSIONS

The environmental effects of AI-related infrastructure are not distributed evenly. Research on data centres in the United States has found that their environmental footprints vary by region and may intersect with local electricity systems, water availability and existing environmental burdens.[30] In that study, one-fifth of servers' direct water footprint came from moderately to highly water-stressed watersheds, while nearly half of servers were fully or partially powered by plants located in water-stressed regions.[30]

Concerns have also been raised about local air pollution, permitting and grid stress in communities hosting AI-related facilities and associated power infrastructure. In 2025, civil rights and environmental groups challenged permits connected to an xAI facility in the Memphis area, arguing that air pollution burdens could fall disproportionately on historically overburdened neighbourhoods. The dispute has been the subject of regulatory and legal proceedings.[43][44][45]

Climate solutions

Despite concerns about its environmental footprint, AI has been used in environmental and climate-related applications, including weather forecasting, Earth observation, and optimisation in transport and energy systems.[19,20]

In weather forecasting, peer-reviewed studies have reported strong results for some AI-based forecasting systems under specific evaluation frameworks. A 2023 Nature paper on Pangu-Weather reported strong medium-range forecasting performance relative to a leading numerical weather prediction system in the study's evaluation.[46] AI has also been used in research on extreme weather and climate-event modelling.[47]

AI has also been proposed for mitigation-oriented optimisation. Google's Green Light project, for example, uses traffic data and machine learning to recommend traffic-signal timing adjustments intended to reduce stop-and-go traffic and associated emissions at intersections.[48]

Whether AI produces net environmental benefits at large scale remains an open question, because outcomes depend on deployment choices, rebound effects, additional infrastructure demand and the extent to which electricity and cooling systems are decarbonised.[1]

Conflict on the use of AI for environmental research

There is ongoing debate over the balance between the possible environmental benefits of AI applications and the environmental costs of scaling AI systems. This includes discussion of transparency, efficiency, rebound effects, and the extent to which AI-related infrastructure growth may offset environmental gains from specific applications [20]

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