ISSN: 2249-7862 (Print) : 2455-877X (Online)
www.aureoleonline.in

Artificial Intelligence and Climate Change: Solution or Part of the Problem

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Abstract

The rapid expansion of artificial intelligence (AI) has positioned it as both a powerful tool for addressing climate change and a growing contributor to the problem. On the one hand, AI enhances climate modeling, optimizes energy systems, improves resource efficiency, and supports sustainable decision-making across sectors. On the other hand, the environmental footprint of AI infrastructure raises serious concerns about its long-term sustainability.

Recent evidence highlights the scale of AI's resource intensity. According to UNEP's Issue Note on the AI Life Cycle (2024), AI servers may consume between 4.2 and 6.6 billion cubic metres of water annually by 2027, mainly for data-centre cooling. This poses significant risks, especially in water-stressed regions. Carbon emissions associated with AI are equally concerning. UNEP-cited studies suggest that training a single large language model (LLM) can emit nearly 300,000 kg of carbon dioxide, comparable to the lifetime emissions of several automobiles. Earlier research in natural language processing estimates emissions of more than 629,000 pounds of CO_2. Energy consumption during AI usage further intensifies the challenge. Studies referenced by UNEP (2024) indicate that a single ChatGPT query can consume up to ten times more energy than a standard Google search, raising concerns about the cumulative environmental impact of widespread AI adoption. As AI becomes embedded in daily life, its indirect contribution to global energy demand continues to rise. Thus, AI represents a paradox in the climate change discourse. While it offers significant mitigation and adaptation potential, unchecked growth risks undermining climate goals. Whether AI becomes a solution or part of the problem ultimately depends on sustainable frameworks guiding its development and deployment.

Keywords: Climate Change, Carbon Emissions, Artificial Intelligence, Energy Consumption

Introduction

There is hardly any aspect of human life that artificial intelligence (AI) has not changed or may not change in the near future. The pervasive impact of AI over the last decade has been powered by machine learning (ML) technologies in general, and deep neural networks (DNN) in particular. Learning AI systems are having an increasing role

to play in commerce, industry, finance, the management of public and private services, communication and entertainment, security, and defense. (Tamburrini, 2022)

Artificial intelligence (AI) is a form of information and communication technology (ICT) that imitates or reproduces aspects of human intelligence. It can exist as online software, such as search engines, image recognition systems, or chatbots, as well as being integrated into cars, robots, and the "internet of things." A major area of AI is machine learning, where programs independently identify patterns or rules from large statistical datasets without explicit instructions from developers. AI is used across many sectors, including industry, transportation, agriculture, healthcare, education, finance, entertainment, and social media. It can improve the efficiency of current processes while also creating entirely new possibilities. Overall, AI has the potential to greatly influence society in both the present and the future. (Coeckelbergh, 2020)

As in many other aspects of life, AI is also effectively used in mitigating climate change. AI improves the accuracy of climate forecasts and extreme weather predictions, optimizes energy usage in homes, offices, and factories, monitors deforestation, and supports sustainable agriculture. However, while aiding climate mitigation, the environmental cost of using AI cannot be ignored. AI itself contributes to environmental degradation through high energy consumption for training large AI models, high water usage for cooling 24/7-running servers, the production of e-waste, and intensive mining of critical and rare-earth minerals such as cobalt, lithium, and copper. Thereby, AI becomes a double-edged sword in climate mitigation.

Objectives

- To examine the role of artificial intelligence as a tool for climate change mitigation and adaptation.
- To assess the environmental footprint of artificial intelligence technologies.
- To suggest effective methods to reduce the net impact of AI on climate change.

Significance

- Addresses a critical research gap: by providing a balanced analysis of AI as both a climate solution and a contributor to environmental degradation, helping move beyond purely techno-optimistic narratives.
- Informs policymakers and regulators by highlighting the need for sustainable AI governance frameworks, including standards for energy efficiency, carbon accounting, and responsible resource use.
- Supports evidence-based decision making by clarifying the trade-offs between AI's mitigation benefits and its ecological footprint, helping stakeholders design strategies that maximize climate benefits while minimizing harm.

Literature Review

Artificial intelligence (AI) has increasingly been recognized as a transformative technology in climate change mitigation and adaptation. Early work by Nick Bostrom and subsequent technological assessments highlighted the broad societal implications of intelligent systems, but more recent scholarship focuses specifically on environmental outcomes. Studies such as Strubell et al. (2019) brought attention to the substantial carbon emissions associated with training large natural language processing models, estimating that model development can produce emissions comparable to multiple automobiles over their lifetimes. This work catalyzed a growing body of research examining the environmental costs of AI infrastructure, including energy consumption, data-centre cooling requirements, and lifecycle impacts. At the same time, a parallel stream of literature emphasizes AI's potential as an enabler of climate action. According to the IEA (2017), AI applications in energy systems can improve demand forecasting, enhance grid efficiency, and accelerate the integration of renewable energy sources. Similarly, Rolnick et al. (2019) argue that machine learning can significantly contribute to emissions reduction across sectors such as transportation, agriculture, and urban planning. These findings position AI as a key technological lever for achieving climate targets, particularly when integrated with policy support. More recent analyses adopt a balanced perspective, framing AI as a "double-edged sword." UNEP (2024) highlights the growing water and energy demands of AI data centres, warning that unchecked expansion may offset some climate gains. Tamburrini (2022) and Coeckelbergh (2020) further stress the ethical and governance dimensions, arguing that sustainable outcomes depend on regulatory frameworks, transparency, and responsible innovation. Overall, the literature suggests that the net climate impact of AI is contingent on how technological progress is aligned with environmental policy and sustainability principles.

Methodology

Research Design

This study adopts a qualitative and analytical research design. It is primarily conceptual in nature, aiming to critically examine the dual role of artificial intelligence in climate change — both as a mitigation tool and as a contributor to environmental degradation. The design is suitable because the study seeks to synthesize existing knowledge rather than test a specific causal hypothesis.

Nature and scope of data

The study is based entirely on secondary data. Information is collected from:

- Peer-reviewed journal articles on AI and climate change
- Reports from international organizations such as UNEP, IEA, and IPCC
- Policy documents and industry sustainability reports
- Books and academic publications on AI ethics and environmental economics

These sources provide data on AI's environmental footprint (energy use, carbon emissions, water consumption) as well as its applications in climate mitigation (energy optimization, forecasting, agriculture, and transport).

Method of Analysis

The study uses a thematic and comparative analytical approach:

- Thematic analysis is used to categorize literature into two major themes:
  -AI as a climate solution
  -AI as an environmental challenge
- Comparative assessment is then conducted to evaluate the trade-offs between benefits and environmental costs.
- Evidence is synthesized to identify the conditions under which AI's net impact becomes positive, particularly the role of green AI practices, renewable energy use, and governance frameworks.

Analysis

The relationship between artificial intelligence (AI) and climate change is characterized by a structural paradox: AI simultaneously enables climate mitigation while contributing to environmental pressures. Evidence from the literature indicates that AI technologies enhance forecasting of extreme weather events, support forest monitoring, and improve energy efficiency across sectors (Rolnick et al., 2019). These applications demonstrate AI's capacity to optimize resource allocation and strengthen climate resilience by improving the accuracy and timeliness of environmental information.

At the same time, the environmental footprint of AI infrastructure is substantial. Global carbon emissions have reached historically high levels, underscoring the scale of the climate challenge within which digital technologies operate (IEA, 2023). AI's rapid expansion adds to this pressure through energy-intensive data centres and computational processes. Estimates cited in the literature suggest that training large AI models can emit more than 629,000 pounds of CO_2, while a single AI query may consume up to ten times more energy than a typical search engine query (Strubell et al., 2019). The environmental impact of artificial intelligence is closely linked to the composition of energy sources powering digital infrastructure. Current estimates indicate that approximately 60% of the energy used to support AI systems is derived from fossil fuels, while renewable sources account for about 27%, with the remaining 13% representing other sources. This distribution highlights that a majority of AI-related electricity demand is still carbon-intensive. As a result, the climate benefits generated by AI applications may be partially offset by emissions associated with fossil-fuel-based power generation. The data therefore underscore that decarbonizing the electricity mix is a critical prerequisite for ensuring that the expansion of AI aligns with global climate mitigation goals. A transition toward renewable energy would significantly lower the lifecycle emissions of AI systems and enhance their net positive contribution to sustainability.

Water use is another critical dimension. AI data-centre cooling requirements are projected to consume 4.2–6.6 billion cubic metres of water annually by 2027 (United Nations Environment Programme [UNEP], 2024). These figures highlight that AI's environmental impacts extend beyond carbon emissions to include resource depletion and ecosystem stress.

Overall, the analysis suggests that AI's climate implications depend heavily on energy sources, technological design, and governance frameworks. While AI can accelerate decarbonization, its unchecked growth risks offsetting some environmental gains.

Findings

- **AI significantly enhances climate mitigation capabilities**
  AI applications improve prediction of floods, droughts, and heatwaves, enable methane detection, optimize transport routes, and support precision agriculture, which can reduce fertilizer use by around 20%, indicating measurable efficiency gains.
- **The environmental footprint of AI is rapidly expanding**
  High energy consumption, water usage, and material requirements indicate that AI contributes to environmental degradation if powered by carbon-intensive energy systems.
- **Digital infrastructure intensifies resource pressures**
  The growth of data centres increases electricity demand and local water stress, particularly in regions already facing resource scarcity.
- **Corporate sustainability claims lack full transparency**
  Although major technology firms report carbon neutrality or negative targets, limited disclosure makes it difficult to assess actual lifecycle emissions.
- **AI's net impact on climate is conditional**
  The balance between benefits and costs depends on renewable energy adoption, efficiency improvements, and policy oversight.

Suggestions

- **Adopt Green AI standards and disclosure norms**
  Mandatory reporting of energy use, carbon emissions, and water consumption can improve accountability and enable better policy design.
- **Accelerate renewable energy integration in data centres**
  Transitioning AI infrastructure toward clean energy sources can significantly reduce its carbon footprint and align digital growth with climate targets.
- **Encourage low-carbon innovation in AI design**
  Investment in efficient algorithms and reduced-compute models can lower the environmental intensity of AI development.

- **Promote lifecycle sustainability approaches**
  Policies should address mineral extraction, hardware recycling, and e-waste management to reduce the broader ecological impact of AI.
- **Strategically deploy AI where climate benefits are highest**
  Priority sectors include energy systems, climate risk modelling, agriculture, and environmental monitoring.

Limitations

Despite offering a comprehensive assessment of the relationship between artificial intelligence and climate change, the study is subject to several limitations.

- First, the analysis is based entirely on secondary data, as primary data on the environmental footprint of AI systems were not available. The absence of primary empirical measurements limits the ability to conduct direct estimation or econometric testing of AI's environmental impacts.
- Second, the study relies on existing estimates and reported statistics, which vary across sources due to differences in methodologies, system boundaries, and assumptions. Consequently, the magnitude of emissions, energy consumption, and water usage associated with AI should be interpreted as indicative rather than precise.
- Third, limited transparency in industry reporting constrains accurate assessment. Many technology firms disclose sustainability targets but provide insufficient granular data on lifecycle emissions, making comprehensive evaluation difficult.
- Fourth, the rapid pace of technological change means that the environmental footprint of AI is evolving quickly. Improvements in hardware efficiency, algorithm design, and energy sourcing may alter the conclusions over time.
- Finally, the study adopts a conceptual and analytical approach, focusing on synthesis rather than empirical causal identification. As a result, while it highlights relationships and trade-offs, it does not quantify the exact net climate impact of AI.

References

Coeckelbergh, M. (2020). AI ethics. MIT Press.

International Energy Agency. (2017). Digitalisation and energy. IEA.

International Energy Agency. (2023). World energy outlook 2023. IEA.

Rolnick, D., Donti, P. L., Kaack, L. H., Kochanski, K., Lacoste, A., Sankaran, K., Ross, A. S., Milojevic-Dupont, N., Jacques, N., Waldman-Brown, A., Luccioni, A. S., Maharaj, T., Sherwin, E. D., Mukkavilli, S. K., Kording, K. P., Gomes, C. P., Ng, A. Y., Hassabis, D., Platt, J. C., Creutzig, F., Chayes, J., & Bengio, Y. (2019). Tackling climate change with machine learning. arXiv. https://arxiv.org/abs/1906.05433

Strubell, E., Ganesh, A., & McCallum, A. (2019). Energy and policy considerations for deep learning in NLP. Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics, 3645–3650.

Tamburrini, G. (2022). The AI carbon footprint and responsibilities of AI scientists. Philosophies, 7(1), 4. https://doi.org/10.3390/philosophies7010004

United Nations Environment Programme. (2024). Artificial intelligence (AI) end-to-end: The environmental impact of the full AI lifecycle needs to be comprehensively assessed. UNEP.