Artificial Intelligence & Environment

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Editorial

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Artificial Intelligence & Environment – Harnessing AI to Tackle Eco-Environmental Crises for a Sustainable Future

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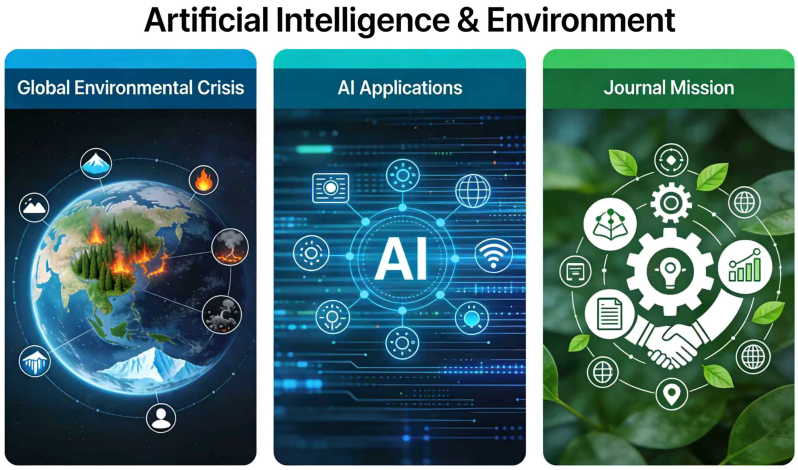
This Editorial marks the inaugural issue of ***Artificial Intelligence & Environment*** (**AI Environ**), an international, multidisciplinary platform for communicating advances in both fundamental and applied research at the nexus of Earth, ecological and environmental sciences and artificial intelligence.

Keywords: Artificial Intelligence, Environmental Science, Climate Change, Sustainability, Machine Learning, Pollution, Policy

Graphical abstract



Humanity confronts an escalating suite of interconnected environmental crises—from climate disruption and biodiversity collapse to pervasive pollution and resource scarcity. These challenges transcend national borders and geopolitical divisions, threatening ecosystem stability, human health, and socioeconomic equity worldwide. The consequences extend far beyond economic or political spheres; they challenge the very foundations of sustainable life on our planet. Addressing these complex and systemic challenges demands robust scientific methodologies capable of disentangling causality and informing effective interventions. Emerging technologies and tools powered by artificial intelligence (AI) will be leveraged for progress in solving complex climate and environmental threats. Leadership will require developing policies grounded in a foundation of sound science and a steadfast commitment to fairness, ensuring our solutions bridge divides in race, economic power, and geography to secure a sustainable and inclusive future for all.

Artificial Intelligence & Environment **(AI Environ)** is launched to serve as a catalytic platform, fostering the integration of advanced AI technologies into environmental science and empowering a global community of researchers, practitioners, and policymakers to tackle pressing sustainability challenges through data-driven innovation.

The Scale and Urgency of Environmental Challenges

Environmental degradation and climate disruption are increasingly influencing global patterns of human security, population migration,

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and public health. However, our existing international frameworks and policies were largely designed for a different era. They are often inadequate to address the new realities of climate-induced displacement and the disproportionate environmental burdens borne by vulnerable nations. Unfortunately, climate and environment are a global problem where some regions are more impacted than others; particularly, developing countries are significantly more impacted due to limited financial, technological, and institutional adaptive capacity.

The Pervasive Crisis of Environmental Pollution

Environmental pollution, in its multiple and interconnected forms, constitutes a direct and escalating crisis. According to the World Health Organization, 99% of the global population breathes air that exceeds safe pollution limits, leading to an estimated 7 million premature deaths annually. Our water bodies are increasingly contaminated by industrial discharge, agricultural runoff, and plastic waste, threatening aquatic ecosystems and human water security.[1] Furthermore, chemical pollution—from heavy metals to emerging pollutants[2] —has permeated global ecosystems, accumulating in the food chain and posing long-term risks to biodiversity and public health. This pollution crisis is both a driver and a consequence of the other challenges outlined below, creating a vicious cycle of degradation.

Food Security and Biodiversity Loss in a Changing Climate

Climate change poses a dire threat to global food systems and biodiversity. A 2021 study in Nature Climate Change revealed a 21% decline in global agricultural productivity since 1961 due to climate change—equivalent to losing seven years of productivity growth.[3] The negative effects are more pronounced in the global south, where extreme weather events exacerbate crop failure and soil degradation. Concurrently, biodiversity is being eroded at an unprecedented rate due to habitat loss, overexploitation, and climate shifts. This loss of species and ecosystems undermines natural pest control, pollination, and soil fertility—services indispensable to food security and human well-being. The intertwined crises of food insecurity and biodiversity loss demand integrated solutions that enhance ecological resilience while ensuring sustainable livelihoods.

Energy Poverty and its Environmental Toll

The energy sector sits at the nexus of human development and environmental impact. Over 2.3 billion people rely on polluting fuels such as wood, charcoal, coal, or animal dung for daily cooking. This practice is a major contributor to indoor air pollution responsible for over 3 million premature deaths. This reliance on traditional biomass also drives deforestation and habitat loss. The UN's Sustainable Development Goal 7 reports that over 60 countries have significant populations without reliable electricity access. Renewable energy sources would not only bring energy sources to regional localities around the world that are struggling to improve standards of living but also improve global climate change.

Waste and Sanitation Crisis

Inadequate and ineffective waste management is another challenge to sustainable development, particularly for rapidly developing countries. This desire for rapid growth to achieve higher living standards comes at a sacrifice to the environment. Over 2.7 billion people lack access to basic waste collection, forcing them to live in a contaminated environment. Leachate from dump sites contaminates groundwater and soils. Poor waste management is a leading contributor to water pollution. Uncollected waste also provides breeding grounds for diseases and the World Health Organization estimated that over 20% of global deaths are linked to environmental risks, including those from poor sanitation and waste management.

AI as a Transformative Tool for Environmental Science

AI is revolutionizing how we understand and respond to environmental issues. Machine learning, deep learning and other AI approaches provide the capacity to decipher complex patterns from massive, multi-source environmental datasets, distinguish between natural variability and anthropogenic signals, and generate actionable insights at unprecedented scale. Thus, AI empowers scientists to better distinguish between speculation and factually supported hypotheses in several climate and environmental issues.

Enhancing Predictive Modeling and System Optimization

Moving beyond traditional statistical analysis, AI enables the simulation of highly complex, non-linear environmental processes. This enhances our ability to forecast climate impacts, model pollutant transport and fate, and predict ecosystem dynamics with greater accuracy. Key application areas include:

- **Environmental Monitoring and Data Analysis**: AI algorithms can process multi-source data from remote sensing, IoT sensor, and historical data to track pollution, assess ecosystem health and monitor biodiversity.
- **Climate and Ecosystem Modeling**: AI improves the resolution of climate models and simulates complex ecological interactions, supporting impact assessment and natural resource management.
- **Pollution Control and Waste Management**: AI can optimize pollution monitoring networks, enhance waste sorting and recycling systems, and improve the efficiency of water and air treatment processes.
- **Sustainable Agriculture and Food Security**: AI aids in crop yield prediction, soil health monitoring, and precision farming to enhance agricultural resilience and productivity.
- **Sustainable Human Settlements and Global Resource Management:** AI enables the transition towards sustainable human settlements worldwide. It supports integrated planning to reduce the environmental footprint of urbanization while improving resilience and livability.

Accelerating Discovery and Innovation

Recent research demonstrates the power of AI to unlock new scientific insights.[4] For example, machine learning is emerging as a pivotal tool for extracting meaningful patterns from complex, high-dimensional data. It is revolutionizing the analysis of remote sensing imagery, enabling real-time pollution monitoring and source identification; it is enhancing the predictive accuracy of water quality models and optimizing the operation of water treatment processes; and it is accelerating the discovery and design of novel materials for environmental remediation and renewable energy applications.[5] Machine learning has also been used to predict regulatory inspection outcomes with high accuracy, enabling resource allocation that can increase violation detection rates by over 600%.[6]

Moreover, AI is facilitating the integration of sustainability across disciplines. A recent analysis of 792 studies at the AI-SDG nexus highlights the growing role of deep learning and supervised machine learning in forecasting, system optimization, and remote sensing applications—from health and education to clean energy and ecosystem management.[7]

Bridging Science, Policy, and Public Engagement

However, the power of AI-derived insights can only be realized if they effectively inform policy and public action. Yet, history is replete with instances where policy has refused to follow scientific evidence. For instance, during the 20th century overwhelming scientific evidence indicated the adverse effects of lead in gasoline and paint will result in neurotoxic effects causing measurable and irreversible cognitive damage in children. Consistently, when scientific reviews recommended stricter limits on pollutants, policy decisions to weaken or delay these standards lead to directly attributable increases in asthma, heart disease, and premature deaths. Unfortunately, there is a lot of noise leading to ill-informed policies and conclusions based on expedient political gain rather than improving quality of life standards.

AI can help bridge this gap by generating transparent, high-fidelity models that quantify trade-offs and project outcomes under various intervention scenarios. These tools empower policymakers to evaluate regulatory effectiveness, anticipate unintended consequences, and design adaptive, resilient strategies grounded in robust evidence rather than short-term political considerations.

Furthermore, the adoption of best practices in machine learning—such as those outlined in the chemistry community[8]—ensures that AI applications are reliable, reproducible, and ethically sound. By adhering to FAIR data principles and robust validation frameworks, we can build trust in AI-driven environmental solutions and foster broader public engagement.

Disseminate your impact to the community

We launch ***Artificial Intelligence & Environment*** to bring together a multi-disciplinary community to solve many pressing complex problems that plague humanity related to environmental sciences, climate change, pollution, waste management as well as a host of other related issues. As humanity potentially enters the gilded age of AI, then let us leverage these methodologies and resources to design practical solutions. We welcome the global community to contribute to the mission of this journal.

As researchers, practitioners, and policymakers, let us lead the charge to steward this transformative era. ***Artificial Intelligence & Environment*** calls upon the global community to harness knowledge, insight, and action to secure a sustainable future for humanity and the planet we share. We particularly encourage contributions that: Develop and validate AI models for predicting environmental behavior and toxicology of emerging pollutants; Apply machine learning to optimize resource use, reduce waste, and enhance circular economy systems; Explore the role of AI in advancing environmental justice, equity, and inclusive sustainability; Bridge technical AI advancements with deep sustainability science expertise.

As we stand at the frontier of a new scientific and societal paradigm, let us collectively harness the power of AI not merely as a technological advance, but as a foundational force for planetary stewardship. Together, we can translate data into wisdom, and insight into actionable strategies that secure a more resilient and sustainable future for all.

Declarations

Competing interests

The authors declare that they have no conflict of interests.

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