

Steering open-source AI to accelerate the sustainable development goals

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While the artificial intelligence (AI) revolution is advancing rapidly, the open-source paradigm offers key pathways and potential risks for accelerating progress towards the Sustainable Development Goals and beyond. This comment introduces four governance actions that consider how sustainability, evaluation, safety, and cooperation can be integrated into the transformation of open-source AI, thereby reducing uncertainties and challenges posed by open-source AI for sustainable global prosperity.

The Artificial Intelligence (AI) Action Summit, held on February 10, 2025, in Paris, highlighted the rising international commitment to harness AI for the Sustainable Development Goals (SDGs) proposed and endorsed by the United Nations^{1,2}, aligned with calls to govern AI in the context of planetary health, across environmental, social, and safety domains³. Between 2018 and 2024, the use of AI to support the SDGs grew by 300%⁴, with contributions in agriculture monitoring (SDG2), ecosystem governance (SDG15)⁵, and climate change mitigation (SDG13)⁶. The rise of open-source paradigms underpins this transition toward a ubiquitous and efficient AI ecosystem. By making the source code, weights, and training data open, releasing them under an open-source license⁷, and allowing the community to study, use, modify, and distribute them, open-source AI was initially envisioned to inherently and efficiently accelerate global progress toward sustainable development.

However, as the open-source AI models have expanded, their impact on the SDGs has revealed an increasingly complex and dualistic nature for SDG progress^{7,8}. The accessibility of open-source models within unregulated environments has introduced critical inhibiting effects that were previously overlooked. Specifically, the lack of structured governance often leads to excessive resource consumption and ethical vulnerabilities, which have not yet been well discussed. The emerging reality suggests that without a deliberate transformation in how these open-source AI models are managed, the openness intended to empower global SDGs could instead undermine it.

While many previous studies and frameworks have advanced the understanding of open-source AI and sustainability, they remain fragmented and separated. On the one hand, most studies emphasize single-stage impacts (e.g., training or deployment) rather than

addressing interdependencies across the full lifecycle of open-source AI models^{9,10}. On the other hand, existing open-source AI governance frameworks, ranging from the United States' innovation-oriented framework to the European Union's risk-based regulatory framework¹¹, primarily operate within national or institutional silos, lacking mechanisms for cross-border coordination and enforcement.

To address the challenges of open-source AI models and governance frameworks, we propose four actions tailored to them, which would advance previous studies and frameworks in two ways. First, they could contribute to shifting the focus from passive implementations to proactive interventions, embedding sustainability, accountability, and transparency throughout the development, deployment, and reuse of open-source AI models. Second, the transformative actions could introduce a multi-stakeholder and cross-scalar perspective, aligning developers, regulators, and users within a coordinated framework that connects local implementation with global cooperation. We conceptualize open-source AI governance as a dynamic interaction among sustainability (sustainable lifecycle management), evaluation (quantitative impact assessment), safety (regulation and scrutiny), and coordination (sharing and cooperation) (Fig. 1), thereby aligning the open-source AI paradigm with sustainable, ethical, and equitable principles.

Why open-source matters in AI models

Leveraging the opportunities offered by AI for SDGs is both desirable and feasible. Recent innovations signal a transition toward an open-source paradigm⁸, aligning with the more accessible and adaptable solutions of the SDGs. Furthermore, they enable localized modeling of the SDGs and foster global collaboration in SDG modeling and policy-making.

The transition toward the open-source paradigm promotes the dissemination of knowledge and the iterative refinement of SDG modeling, which involves mathematical, statistical, and/or computational approaches for analyzing and projecting SDGs (e.g., SDG interaction analysis and scenario simulation)¹². Through open access to algorithms and collaborative development environments, this paradigm enables rapid model iteration in response to emerging SDG challenges, such as epidemics, natural disasters, or conflicts, thereby generating faster and more reliable insights into future SDG trends. The ability to host open-weight AI models on highly optimized, dedicated infrastructure enables speeds of over 179 tokens per second (versus 138 for a proprietary AI model)¹³, which is an advantage for latency-sensitive applications addressing SDG challenges in specific regions. In the environmental dimension of SDGs, open-source natural language processing models like ChatClimate are being developed to

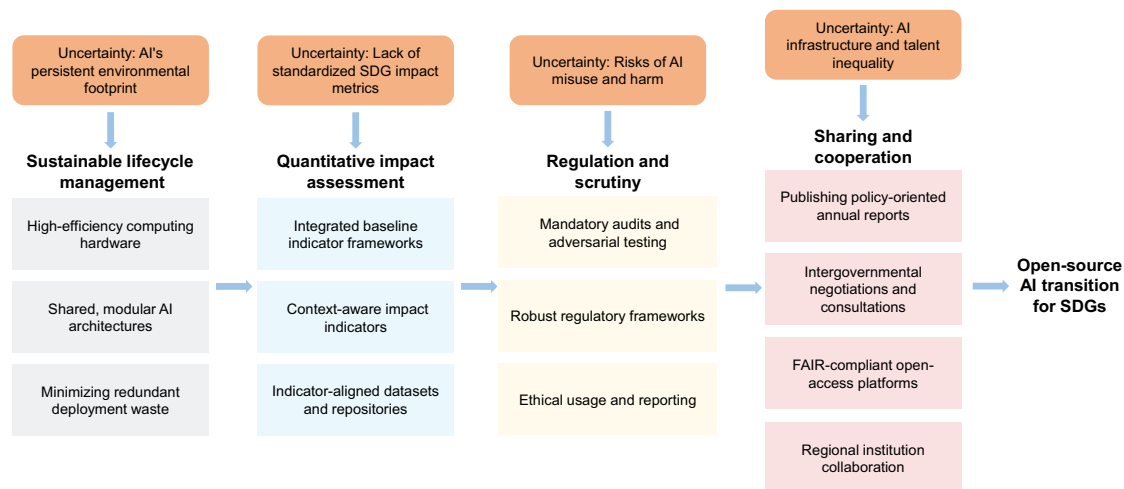


Fig. 1 | Uncertainties and solutions for the open-source Artificial Intelligence (AI) transition. Key uncertainties of open-source AI persist regarding environmental impacts, assessment methodologies, potential misuse, and infrastructure inequalities. Our proposed solutions address these through integrated governance

mechanisms: sustainable lifecycle management; quantitative impact assessment; regulation and scrutiny; and sharing and cooperation. These coordinated actions are essential to harness open-source AI's potential for Sustainable Development Goal (SDG) progress.

respond exclusively with validated scientific knowledge, which contributes to mitigating the risk of climate misinformation¹⁴. In the social dimension of the SDGs, open-source language models like Llama have been explored as potential tools to help address global shortages of therapists, particularly in meeting specific community health needs¹⁵. In the economic dimension of the SDGs, open architecture enables small and medium-sized enterprises to adopt and customize cutting-edge AI to optimize production by providing open access to foundational models¹⁶.

The open-source paradigm shift significantly lowers the costs of utilizing AI models, fostering broader participation in achieving the SDGs. For instance, while delivering comparable performance, open-source AI models cost 5 to 29 times less than proprietary models¹⁷. This extends the scope of AI applications beyond specialist domains to a broader spectrum of users and organizations¹⁸, effectively democratizing access to AI while facilitating knowledge co-creation for the SDGs¹⁹. Environmentally, low-cost computer vision models enable decentralized, affordable monitoring of ecosystems, for example, in polar and high-mountain regions²⁰. Socially, universities and global citizen science platforms, such as Zooniverse, leverage these low-cost, accessible open-source AI tools to deliver curricula and facilitate knowledge co-creation at a massive scale²¹. Economically, global studies indicate that organizations using open-source AI are 24% more likely to report positive cost savings and a higher return on investment than those relying solely on proprietary solutions²². This paradigm improves the balance and equality of SDG progress globally and reduces gaps in regions' ability to analyze the SDGs.

Challenges of open-source AI without governance for sustainable development goals

In recent years, open-source AI has experienced unprecedented growth. However, in the absence of governance frameworks, open-source AI poses significant challenges and risks for its application in advancing the SDGs.

Openness introduces a set of uncertainties. While open-source AI reduces the energy and water footprints of downstream processes

such as inference, fine-tuning, and model repurposing, these efficiencies do not extend to upstream hardware and infrastructure tiers, where resource intensity remains high. Its hardware lifecycle, spanning chips, GPUs, data center infrastructure, and consumer AI devices, has been identified as a potential contributor to global material and toxic waste streams. In addition, the decentralized nature of open-source AI development has led to a fragmented landscape in which numerous smaller institutions repeatedly deploy functionally redundant models on inefficient local infrastructure or legacy data centers, thereby exacerbating systemic energy and computational waste. This phenomenon of redundant computing significantly amplifies the overall carbon footprint of the open-source AI industry, a problem further compounded by the lack of a standardized quantitative framework for measuring AI's environmental impact.

The proliferation of open-source AI models has significantly reduced the cost of producing deepfakes and targeted disinformation. Compared with commercial systems, open-source AI typically lacks consistent maintenance, dedicated technical support, and rigorous security auditing, relying instead on community-based efforts that can be uneven in quality and stability. For example, nearly 60% of AI models labeled "open" have no license as of late 2025²³. Owing to the absence of pre-release auditing, the release of training weights and parameters alongside the proliferation of unregulated open-weight AI models also makes it easier for malicious actors to identify weaknesses, develop phishing tools, or propagate bias, hate speech, and harmful misinformation.

Open-source AI models have exacerbated the phenomenon of "AI colonialism", whereby powerful countries, corporations, and institutions in the Global North exert disproportionate control over training data and digital infrastructures, often at the expense of autonomy and equitable participation in the Global South²⁴. Datasets and digital infrastructures rooted in Global North countries risk being misapplied to geographical contexts of the Global South. Such misapplications often result in higher error rates and lower relevance of geopolitical governance in SDG solutions. Countries in the Global South will face further marginalization in the future of

open-source AI due to a lack of robust digital infrastructure and structured data²⁴.

In the meantime, the few attempts at international coordination and agreement on the development of open-source AI have been largely unsuccessful, as evidenced by the 2025 AI Action Summit, where no agreement was reached².

Actions for harnessing open-source AI potential for sustainability

The 2025 AI Action Summit revealed that there are even more challenges in this area than initially anticipated in the absence of dedicated governance actions. Hence, we propose a set of actions that encompasses lifecycle management, impact assessment, regulatory policy, and shared mechanisms to ensure that open-source AI solutions tangibly advance progress toward the SDGs.

Integrate sustainability into open-source AI lifecycle management.

Integrating sustainability across the AI lifecycle requires a multi-pronged strategy that addresses computing hardware, model development, and application deployment²⁵, which could shift from fragmented reinvention to governed commons. The computing hardware phase requires a fundamental shift toward high-efficiency computing, built on the principles of energy-efficient architectures, liquid cooling, and renewable energy, which have demonstrated significant environmental benefits such as reducing data center energy demand by up to 20% and water consumption by up to 52%²⁶. In the model development phase, creating shared, modular AI architectures can eliminate the immense waste from redundant development efforts. For example, using model distillation and pruning techniques can result in an overall Large Language Model compression of around 70%²⁷. In the deployment and application phase, it is essential to mitigate waste from the redundant deployment of numerous similar models by transitioning towards a deployment-centric framework that prioritizes the use of multimodal foundation models as reusable infrastructure²⁸. In addition, many technical efficiency metrics are vital for sustainability in the AI lifecycle, such as Power Usage Effectiveness and carbon emissions per training or inference. Beyond these metrics, effective governance requires a broader “Return on Environment” indicator²⁹. This evaluates the net contribution of open-source AI to the SDGs by balancing its direct environmental costs against the benefits it generates.

Establish a framework for quantitative AI impact indicators. Currently, there is a lack of standardized quantitative indicators to analyze the complex impacts of open-source AI on the SDGs across different spatial and temporal scales. The India-AI Impact Summit 2026 shifts from dialogue to demonstrable impact, highlighting that governance requires quantitative impact frameworks as a prerequisite, especially for countries in the Global South³⁰. The critical action is to incorporate the impacts on the SDGs by establishing composite frameworks that collect, integrate, and associate multiple baseline indicators, accurately measuring the facilitating and inhibiting impacts of multiple dimensions generated by different AI models. A typical example is the 13 Sustainability Criteria for AI Systems, which cover over 40 indicators and measure the social, environmental, and economic sustainability of AI clearly³¹. In addition, the establishment of local AI impact indicators adjusts local social, economic, and environmental characteristics under a quantitative impact framework, which is essential for countries to systematically collect and develop

corresponding datasets and model repositories aligned with these indicators. This enables normative indicators to be transformed into analytically robust evaluation outcomes, ultimately operationalized as actionable policy practices.

Assure trustworthy open-source AI through regulation and scrutiny.

The greater the misuse of AI, the more difficult it becomes for humans to distinguish authentic content from harmful synthetic media. Establishing robust governance for these high-stakes SDG applications requires a clear accountability chain involving developers, users, and governments³². For developers, especially at major tech companies, it is crucial to use security-audited training datasets to mitigate bias and to adopt explainable AI technologies appropriate to different model types. Improving transparency in the use, modification, and distribution of AI models relies on licensing agreements like the Open Source AI Definition³³. Governance of open-source AI security calls for mandatory third-party audits and the implementation of simulated adversarial attacks to mitigate specific vulnerabilities. Furthermore, governments worldwide hold developers accountable and prevent users from spreading malicious content by establishing regulatory policies, such as the EU AI Act and the U.S. Transparency in Frontier AI Act. Finally, users are accountable for applying AI ethically and helping to identify and report misuse, such as strictly adhering to the “Prohibited AI Practices” defined under the EU AI Act.

Build global knowledge-sharing mechanisms and regional cooperation.

Although the transition to open-source AI has improved democratizing access globally, inequality persists in other areas, such as computing infrastructure, talent distribution, and data sovereignty. From a global perspective, building open-access platforms that adhere to the Findability, Accessibility, Interoperability, and Reusability principles is crucial to ensure equitable access to computation, data, and foundational AI models. The United Nations would play a critical role in governing these AI infrastructures, helping reduce governance inequalities across Global South countries. For example, an institution named Global Dialog on AI Governance could strengthen global cooperation mechanisms by publishing policy-oriented annual reports on AI infrastructure performance and by conducting intergovernmental negotiations alongside broad consultations with diverse stakeholders³³. In addition, a Global Fund for AI would help ensure that all countries secure a minimum irreducible AI capacity across skills, compute, data, and models³⁴. From a regional or national perspective, valuable datasets remain confined within local government institutions and private corporations due to data sovereignty regulations that prevent global sharing³⁵. Hence, cooperation between global platforms and regional research centers is essential to leverage shared foundational models while integrating proprietary, localized datasets. To navigate complex data-privacy regulations such as the General Data Protection Regulation, partnerships can adopt data-sharing models that provide controlled interfaces to sensitive data or rely on metadata, representative samples, and synthetic datasets through Retrieval-augmented generation and Parameter-Efficient Fine-Tuning. These regional research institutions, such as The Australian Artificial Intelligence Institute and The National Institute for AI Evaluation and Security in France, serve as critical intermediaries that enable the localization and deployment of foundational models by synergizing global resources with regional data to develop context-specific solutions.

Towards open-source AI for sustainability

Under current trends, open-source AI models could be a core force in accelerating the SDGs and reshaping the post-2030 Agenda as a follow-up to the SDGs. On the one hand, these models could more rapidly and efficiently address context-specific prioritization of the SDGs. They could also enable the identification of enablers, barriers, and pathways for sustainable transformation, even in the face of scale and complexity. On the other hand, open-source AI, combined with appropriate governance actions, could shift the paradigm from top-down decision-making to more inclusive strategies for the post-2030 agenda, bringing lessons learnt by global citizens from the SDGs. Also, the collective intelligence of global citizens would be directly translated into actionable policy pathways for sustainable development, ensuring the post-2030 agenda is more inclusive and evidence-based.

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Author contributions

M.C. conceived the study. K.W., P.M., and M.C. wrote the first draft of the commentary. M.C., K.W., P.P., C.A., S.N., K.H., A.V., F.C., T.F., N.B., M.M., P.M., F.B., H.J.S, J.L., M.P., M.B., H.G., M.C., P.H., and G.L. edited and reviewed the commentary.

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Competing interests

John Ludden declares that he is co-Chair of the GeoGPT Governance Committee (Co-chair, GeoGPT Zhejiang Lab <https://geogpt.zero2x.org/>), while other authors declare no competing interests.

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