npj | climate action

Perspective

https://doi.org/10.1038/s44168-025-00304-8

Embedding the frontiers in climate action: navigating the evolving earth-human ecosystem

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Artificial intelligence (AI) offers transformative potential in addressing climate change by capturing the nuanced dynamics of the Earth-human ecosystem. However, AI-driven solutions risk cognitive offloading and epistemic stagnation, which can limit our capacity to reimagine symbiotic coexistence as climate crises evolve. We propose shifting from narrow, solution-oriented narratives to proactive, inclusive visions that endogenize AI through transdisciplinary approaches—ensuring resilience redesign benefits marginalized communities and fosters reciprocal learning for regenerative futures.

In the Anthropocene, achieving rapid global decarbonization hinges on accelerating the convergence between socio-economic systems and frontier technologies. Artificial intelligence (AI)—often framed as the core of leap-frogging technological transitions—serving as both a catalyst and a complicating force. While enhancing climate modeling[1], renewable energy optimization[2,3], and clean-tech innovation, AI's environmental footprint poses significant countervailing risks. The development and deployment contribute to surging carbon emissions, water consumption, land degradation, and energy demand through resource-intensive infrastructure and computational processes. Data center electricity consumption is projected to double by 2030, potentially representing 3–4% of global power demand[4]. Training GPT-4 has been estimated at 21,660 tons of CO_2-equivalent, roughly 12 times more than GPT-3.5[5]. Cooling requirements exacerbate water stress, with typical 1-megawatt (MW) facilities using up to 25.5 million liters annually[6]. These paradoxes underscore the urgency of reconciling AI's transformative potential with planetary boundaries and profound capital and ecological costs.

Despite these challenges, AI demonstrates significant potential for climate action through three primary pathways: (1) enhancing scientific understanding of climate systems (e.g., *Early Warning System For All*[7], *ecological intelligence*[8]); (2) optimizing existing infrastructure (e.g., *energy efficiency*[9], *carbon sequestration, storage*[10], *and smart grid management*[11]); (3) accelerating scientific breakthroughs for new functionality (e.g., *fusion energy*[12]). Yet these apparent gains can obscure a critical paradox: AI's overarching operational footprint may undermine sustainability goals and perpetuate deeper, systemic harms. Beyond measurable environmental damage, the unsustainable deployment of AI can normalize extractive relationships with living systems and erode human agency—particularly among marginalized and indigenous communities whose resilience rests on millennial reciprocal ties to ecosystems. Algorithms designed to predict droughts or manage renewable grids often rely on centralized compute and water-intensive cooling, potentially straining local supplies and amplifying carbon footprints in regions already vulnerable to climate impacts. This duality and frequent invisibility of communities necessitate a recalibrated approach that prioritizes systemic efficiency and equity rather than reinforce cycles of disempowerment.

A further barrier—beyond quantifiable socio-economic and environmental side effects—lies in the communication and governance gaps. Conventional climate strategies often treat ecosystems as mere resource pools, externalizing Earth's interconnected life-support systems while sidelining place-based knowledge. Evidence[13] shows that mere information exchange rarely ensures behavior change or shared visions. For instance, even technically robust AI-driven flood-prediction tools depend on how risk data is contextualized for subsistence farmers who may lack digital literacy[14]. Without participatory design, even well-intentioned communication can reinforce power imbalances, as seen in top-down adaptation projects in developing economies[15]. Such gaps impede efficiency and perpetuate epistemic hierarchies by privileging technocratic knowledge over place-based wisdom. Thus, the question of whose vision governs AI becomes inseparable from whose voices are silenced in climate innovation.

This prompts a pivotal clarifying question about authorship and authority in climate futures: *Whose vision governs AI's role in climate strategies?* The prevailing "collective vision" often reflects technocratic agendas dominated by the Global North institutions, sidelining Indigenous knowledge and local priorities. For example, the Intergovernmental Panel on Climate Change's Sixth Assessment Report emphasizes AI for climate modeling while giving limited attention to Indigenous data-sovereignty risks[16]. Without rectifying such exclusions, AI risks hindering—rather than facilitating—inclusive climate futures[17].

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We therefore advocate epistemic justice: embedding AI within pluralistic resilience frameworks. This requires institutionalized participation and strategic dialogue to redress inequities, as demonstrated by the Local Communities and Indigenous Peoples Platform[10] under the UNFCCC[9]. Such strategic governance and communication choices prevent AI from supplanting human agency while fostering a shared vision for future climate strategies.

Framing AI as a "temporary fix" reflects a broader pattern of techno-solutionism. Corporate carbon "offsets" for AI often prioritize public relations over systemic change[18], while nearly 72% of industry stakeholders reportedly view AI primarily as a cost-cutting tool rather than a catalyst for long-term sustainability (EU AI Act consultation[19]). This reactive mindset perpetuates dependency, as seen in AI-driven carbon trading that commodifies emissions without addressing root causes[20], mirroring colonial patterns of resource extraction. Such approaches treat symptoms, not systems—disregarding ecosystems as relational life systems demanding intrinsic respect—revealing why incremental reforms cannot resolve AI's foundational misalignment with planetary well-being. Transitioning AI from a temporary fix to an enduring ally for climate well-being requires endogenization: integrating it into the fabric of human experience and co-evolving with our understanding of Earth-human system. Lessons from adaptive governance models, such as the polycentric systems advocated by Ostrom[24], demonstrate how decentralized decision-making can align AI with localized climate priorities while avoiding universalist prescriptions.

The subsequent sections reframe the visions necessary for proactive climate action, examining how AI can contribute to, rather than disrupt, the vision development of climate strategies. A key focus is to identify a comprehensive process for the endogenization of AI in climate action. Insights are drawn from leading practices and from communities at the climate frontlines, showing how transdisciplinary approaches can inclusively incorporate AI to facilitate learning alongside proactive climate action, ultimately fostering a far-reaching impact on the Earth-human ecosystem. To realize the transdisciplinary approaches requires a critical reframing of AI's fundamental role from a reactive tool to a proactive partner in climate strategy.

Framing the vision: AI in advancing proactive climate action

AI's shifting role from predictive (reactive) to proactive climate resilience

Integrating AI into climate strategies requires a fundamental shift from reactive to proactive paradigms. The critical distinction lies in both technical capacities and governance choices. Reactive AI—primarily predictive systems rooted in machine learning, which relies on historical data to classify patterns and forecast outcomes (e.g., extreme weather prediction using Earth-system model ensembles like the World Climate Research Program's Coupled Model Intercomparison Project[21]). These approaches face inherent technical constraints: dependence on existing datasets restricts responses to known scenarios, leaving them ill-suited to unprecedented or nonlinear climate events. By contrast, proactive frameworks leverage AI's emergent capacities and generative architectures to co-create forward-looking scenarios (e.g., Agentic AI)[22], enabling anticipatory strategies rather than reactive fixes. This represents not only a technical advancement but a deliberate deployment choice—where human stakeholders steer AI toward resilience planning through participatory design, such as community-involved urban-heat simulations[23] and adaptation-pathway modeling.

Despite substantial advances in AI for Earth-system modeling and climate analysis, current applications remain constrained by a solution-oriented mindset that retrofits existing tools to emerging crises rather than reimagining Earth-human relationships. This limitation stems from predictive AI's unavoidable reactivity, which needs to be transcended to address sustainability challenges. Critically, climate disruption demands continuous adaptation rather than finite "solutions", as human activity has impaired the self-organizing capacities of many Earth's subsystems (e.g., coral reefs that once buffered ocean heat can now amplify warming). Addressing this reality requires recognizing living systems as dynamic, relational entities that merit intrinsic respect. AI must therefore integrate ecological intelligence alongside optimization, fostering deeper understanding of how we 1) build epistemic trust across knowledge systems; 2) co-adapt with changing planetary conditions; and 3) cultivate cognitive transcendence for navigating climate uncertainty.

To deepen climate resilience, we need a radical shift from prediction to prospective stewardship, collectively shaping AI's trajectory rather than passively awaiting market-driven outcomes. The question should not be where AI will take us, but how to actively co-steering its development through principled partnerships that center climate resilience. Transformative applications should empower societies to envision new ways of coexisting with future climate crises. AI's role should be to expand our capacity to improvise new thoughts beyond our current thinking, evolving alongside our perspectives to reimagine the future of climate resilience. The goal is not a "final solution," but continuous co-adaptation as planetary conditions change. This shift from a predictive to a proactive paradigm is operationalized through what we term the "endogenization" of AI—a process of deeply and equitably embedding technological evolution within socio-ecological systems.

Endogenizing frontier technological evolution for equitable climate resilience

AI's rapid advance in climate action holds great promise but also risks widening existing digital divides, particularly where technological access and infrastructure are limited. Uneven adoption may deepen inequities, especially in adaptation efforts addressing unavoidable climate impacts such as extreme weather or agricultural disruption. Critically, vulnerability stems not only from socio-economic disparities but also from disrupted relationships with living systems that sustain resilience. To counter this, AI integration necessitates prioritizing equitable access to climate services. For instance, AI-enhanced forecasting systems—often critiqued for reactive and centralized designs—require redesign to address structural vulnerabilities (e.g., resource inequality) and ecosystem fragility. Initiatives like the Coordinated Regional Climate Downscaling Experiment (CORDEX) under the World Climate Research Program demonstrate this balance: downscaling meteorological data while integrating Indigenous ecological knowledge of landscape-level relationships[24]. Similar approaches help ensure AI tools prioritize community agency over passive risk prediction, restore reciprocity with living systems that buffer climate shocks, and address the underlying drivers of climate vulnerability—including resource distribution inequalities and information-access gaps.

Building on the imperative for equitable access to AI in climate adaptation, it is equally important to rigorously address the environmental and social costs associated with AI's energy and material demands. This requires participatory frameworks in which AI deployment is shaped by and for local communities, particularly Indigenous groups whose stewardship practices have sustained ecosystems for millennia. Interventions should be needs-based, aligned with local priorities, and supportive of resource stewardship and circularity. Rather than perpetuating top-down solutions and business-as-usual consumption, AI initiatives should be informed by diverse, context-specific insights that prioritize authentic human needs, enrich the environment, and balance supply and demand. This calls for moving beyond vague appeals to "wisdom" or "genuine needs"—terms often weaponized to justify technocratic agendas—toward explicit recognition of whose knowledge defines sustainability. For example, the Amazon Conservation Team's use of AI to map ancestral territories in collaboration with Indigenous communities help ensure that "balance" between supply and demand is rooted in biocultural sovereignty, not merely market metrics.

A systematic transition framework is needed to examine how AI applications can evolve alongside climate change. Building on Frank W. Geels' multi-level perspective on socio-technical transitions, AI can foster transnational and trans-local networks that empower local communities to address climate challenges independently, strengthening a self-sufficient earth-human ecosystem. However, these models often presume technological

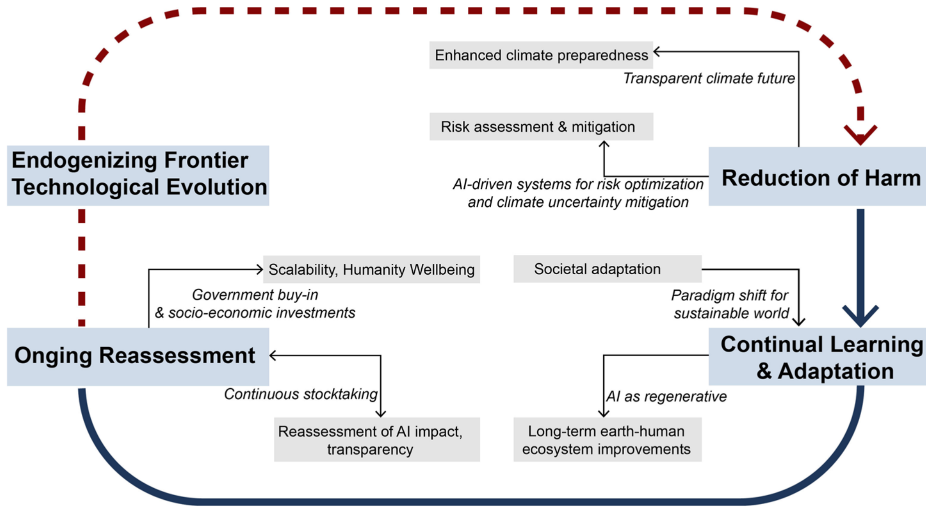

Fig. 1 | Endogenization process of AI's integration in climate actions.

evolution as an exogenous process driven by markets and external forces. Echoing with Joseph Schumpeter's concept of creative destruction, frontier technologies like AI can disrupt existing socio-technological systems. However, we aim to challenge the idea that technological evolution is entirely external. It has an endogenous component—once we establish a clear vision, supported by policies, communities of knowledge, and the will to advance to a different future, we can introduce that to endogenize some of the factors that would otherwise have been exogenous in technological evolution. This means technology isn't simply an external force imposed upon us; we can shape its trajectory through strategic investments, policies, and incentives to guide its role in addressing climate challenges. In the context of climate action, we highlight three critical phases of endogenizing AI in proactive strategies (as shown in Fig [1]), forming a circular loop that enables continuous tracking and planning for a better climate future. The following three phases can be applied to wider scenarios of frontier technology's integration into sustainability issues.

- Reduction of Hazard (Risk Optimization and Preparedness): This phase emphasizes AI-enhanced risk assessment and mitigation (e.g., early warning systems, deforestation monitoring), while reassessing existing strategies for addressing climate change, even without frontier technologies. Stakeholders must reconcile climate-resilience expectations with data-driven realities, leveraging current capacities while evolving strategies for emerging threats.
- Continual Learning and Adaptation (Paradigm Shift Towards Regeneration): Here, AI transcends harm reduction to enable regenerative and resilient future. It fosters societal adaptation, reimagining human-Earth coexistence through scientifically guided, ethically grounded innovation.
- Ongoing Reassessment (Continuous Evolution and Scalability): Continuous evaluation of AI and other frontier technologies is essential as deployments scale across various climate scenarios. Post-implementation reflection ensures socio-economic equity, requiring technical expertise alongside evolving needs, government investments, public-private partnerships, and accessible infrastructure.

To fully and equitably integrate AI into proactive climate frameworks requires harmonizing technology with local knowledge systems and ensuring that technological advances address diverse needs. Strategically guiding technological evolution—rather than deferring to market forces—can embed AI within a human-well-being agenda, helping frontier tools serve resilience and sustainability rather than perpetuating inequality. The following section translates this theoretical framework into practice. By examining leading applications of AI in sustainability, we can evaluate how these initiatives either align with or deviate from the principles of proactive, endogenized technological evolution.

Leading practices: navigating AI's dualities in planetary resources (food, natural resources, water, and health)

While AI drives breakthroughs in sustainability and promises transformative planetary resources management, its deployment reveals a core tension: technological advancement versus resource justice. Progress requires not only technological innovation but also a critical navigation of trade-offs between AI's own resource footprint and exclusionary access patterns. AI-driven eco-based solutions can create regenerative neighborhoods, seamlessly integrating natural and built environments to enhance human well-being. By applying AI to permaculture principles, we can boost agroecological health, restore biodiversity, and ensure food security. The following practices illustrate how AI can drive proactive climate adaptation and resource sustainability.

AI in regenerative agriculture: promise vs. practical constraints

Adaptive diversification with resource audits. AI-driven systems can support crop and livelihood diversification by synthesizing data on soils, microclimates, and markets to inform adaptive crop and livelihood strategies. This reduces the risks associated with monocultures and help farmers shift towards more resilient, diversified agricultural practices. For example, FarmSense provides crop-diversification strategies based on real-time soil and weather analysis, while India's Krishi Vigyan Kendra (KVK) uses AI-based advisory services to suggest climate-resilient crops, reducing vulnerability to market and climate shocks.

Seasonal climate forecasting. By combining historical and real-time weather data inputs, AI models can predict extreme climate events with greater accuracy, enabling farmers and communities to make proactive decisions regarding planting and harvesting seasons. IBM's Watson Decision Platform for Agriculture uses AI to provide farmers with highly localized, actionable forecasts that help farmers better plan crop cycles and resource allocation.

Community-based disaster risk reduction. AI-powered analytics can help governments and communities predict, monitor, and respond to hazards such as floods, droughts, and storms. In the Philippines, Project NOAH utilizes AI to generate real-time flood warnings, offering communities an alert to evacuate or prepare, minimizing loss of life and property. Similarly, Google AI's Flood Forecasting Initiative integrates satellite data with AI to predict riverine floods and deliver early alerts in regions of southern India. However, these advances carry environmental trade-offs: for instance, data centers supporting such technologies, including IBM's facilities in India, consume significant water for cooling and can contribute to adverse local climate outcomes. Balancing these benefits against operational impacts is crucial to ensure AI deployment truly supports sustainable and resilient communities.

Packaging frontier technology for systemic resilience. Frontier AI integration in agriculture must fuse technologies, policies, and cultural practices to address interconnected challenges of resource efficiency, equity, and climate resilience. The Small Robot Company (UK) deploys AI-guided robots to plant seeds and monitor soil health with minimal soil disturbance, a practice central to regenerative farming. However, scaling such innovations requires ancillary policies, such as secure land tenure for farmers and training programs to build digital literacy, ensuring technologies align with local socio-ecological contexts. In the US, Iron Ox employs AI-controlled robotic arms in greenhouses to optimize water use, reportedly achieving substantial reductions in irrigation compared with traditional methods. This application demonstrates AI's role in reducing agriculture's water footprint—a critical step toward land-use reallocation for carbon sequestration. These gains should be paired with cross-sector policies such as payments for ecosystem services and safety nets for transitioning workers.

Beyond efficiency, AI's value includes: Biocultural intelligence: Training models on Indigenous soil knowledge and regional eco-dynamics enables context-specific solutions; Ethical traceability: Blockchain-integrated AI verifies sustainable practices (e.g., water stewardship) for premium consumer markets—mirroring the World Economic Forum's co-design hubs that balance productivity, equity, and regeneration.

By embedding AI within socio-technical bundles—rather than isolated techno-fixes—nations can safeguard food and water security while advancing a just transition. This demands governance frameworks that prioritize marginalized communities' access to AI tools, ensuring innovations like precision agriculture serve as bridges to resilience, not accelerants of inequality.

AI for water management

The same dualities reappear in water systems, where precision gains can be offset by data-driven resource burdens. As the hydrosphere redistributes heat[12] worldwide, global warming manifests most acutely through changes in the spatiotemporal distribution of freshwater. While traditional software has long enabled basic irrigation scheduling, AI introduces adaptive precision—leveraging sensor networks, machine learning, and predictive analytics to optimize water use at scales. However, scaling AI-driven water management demands confronting its own resource paradox: the same systems designed to conserve water often rely on energy-intensive data centers that strain local water supplies for cooling. For example, training a single AI model for irrigation optimization can consume significant amount of water (cooling plus operational energy), comparable to the annual needs of a small farm in arid regions.

AI's Differentiation in Water Management

- Hyper-Localized Adaptation:
  Successful localization hinges on translating data into timely action, a capability exemplified by AI systems like Netafim's Precision Irrigation. By leveraging I Internet of things (IoT) and satellite data to dynamically adjust water use in real time, such systems achieve a 20–30% reduction in waste compared to static and predictive software.
- Predictive-Responsive Hybrid Systems:
  AI bridges the gap between forecasting and action. For instance, pairing AI with hydrological models (e.g., FAO's AQUASTAT project) can c predict shortages months ahead, enabling pre-emptive measures such as supplementary irrigation or drought-resistant crop shifts—capabilities absent from static systems.
- Scalability with Equity Risks:
  While AI can optimize basin-wide water distribution (e.g., California's Central Valley), its scalability often prioritizes high-tech agribusiness over smallholders. Open-source AI platforms, like the Water Data Alliance, are emerging to democratize access, allowing farmers to customize tools using local data without proprietary constraints.
  Addressing AI's Water Footprint
  To avoid hypocrisy, AI deployments should adopt water-positive design principles:
- Green AI: Deploy low-energy algorithms (e.g., Tiny ML) and renewable-powered data centers. Microsoft's Project Natick underwater data centers, cooled by seawater, exemplify this shift.
- Circular Water Stewardship: Pair precision irrigation with wastewater recycling and reuse, as demonstrated in high-reuse regions that approach ~90% recycling rates.

AI's value lies not in replacing legacy systems but in context-aware adaptation—balancing precision gains with accountability for its resource tolls. To align with the paper's vision, AI must advance water justice: conserve freshwater while redistributing power over its use. The dualities observed in these practical applications underscore that technological innovation alone is insufficient. Navigating these trade-offs effectively demands robust and adaptive governance structures that ensure equity and accountability.

Broader implications: culture, governance, and norms

The integration of AI into climate action has far-reaching implications for societal structures, governance systems, and cultural norms. It demands governance frameworks that transcend reactive regulation, instead fostering adaptive, justice-centered systems capable of addressing both technological and socio-ecological complexities. Below, we outline actionable pathways to operationalize this vision.

Adaptive governance frameworks

Mechanism: Establish transnational AI-climate tribunals under the UNFCCC to audit compliance with equity and sustainability standards. These bodies would mandate:

- Equity Impact Assessments (EIAs): Required for all AI-climate projects, evaluating effects on marginalized communities (e.g., water access, labor displacement). Modeled after the EU's AI Act, EIAs would involve local stakeholders in co-designing metrics.
- Dynamic Policy Sandboxes: Test AI innovations in real-world contexts while enforcing safeguards. For example, drone-assisted irrigation pilots in Kenya can iterate policy design in partnership with pastoralist communities.

Transparency and inclusivity

Mechanism: Institutionalize participatory oversight boards to democratize AI deployment:

- Community Data Trusts: Enable marginalized groups to govern environmental data collection and use (e.g., practices inspired by Māori data sovereignty principles).
- Open-Source Climate AI Platforms: Mandate public funding for tools like 'ClimateBERT', ensuring transparency in model training and accessibility for grassroots organizations.

Ethical and environmental accountability

Polycentric governance systems need to be designed to leverage untapped capacities for resilience within existing environmental legal structures[25]. This approach embeds binding mechanisms across three tiers:

- Tiered Resource Caps: Mandate regionally calibrated thresholds via reinterpretation of water/waste rights statutes. Fast-track certifications as innovation incentives for solutions like Microsoft's ocean-cooled Project Natick that exceed standards.
- Equity-Centered Procurement: Apply adaptive procurement clauses under public contracting laws. Empower communities to impose penalty fees for non-compliance, reinvest in community-led audits.
- Adaptive Legal Triggers: Following the model of "legal triggers for reevaluation": Community-led review panels (e.g., Indigenous water protectors assessing watershed impacts) to validate compliance.

Governance is not a bureaucratic hurdle but a tool for redistributing agency. By anchoring AI-climate strategies in enforceable rights-based frameworks—rather than voluntary pledges—we can ensure technologies serve systemic equity, not just efficiency. This aligns with the paper's thesis: AI's endogenization hinges on governance that prioritizes who decides over what is decided.

Endogenizing technological evolution

The preceding governance frameworks find nascent expression in national strategies, marking initial progress toward AI's endogenization. Establishing these AI ecosystems therefore necessitates a recalibration of development and deployment paradigms to ensure the technology serves as an equitable resource, particularly for marginalized communities.

To endogenize technological evolution for equitable climate solutions, the huge momentum should be diverted from collective commitments from governments, businesses, and financial institutions. Countries like the UK and European Union have implemented data-sharing policies that facilitate the availability of climate-relevant data. The UK's Energy Data Task Force and the EU's INSPIRE Directive on environmental data have been spearheading the direction of endogenizing frontier technology into climate action. Germany has launched initiatives to integrate AI into environmental protection efforts with leading initiatives like the five-point program 'Artificial Intelligence for Environment and Climate'. These initiatives focus on using AI to analyze environmental data for better climate monitoring and to optimize renewable energy usage.

Beyond these policy-driven initiatives, the full endogenization of AI necessitates a paradigm shift from reactive to proactive engagement with climate challenges. In climate action, the proactive approach is to leverage AI for generative foresight that is inspired by different perspectives and collective wisdom. AI enables proactive data analysis and scenario modeling, allowing us to predict and address climate risks before they fully materialize. Scaling up this proactive approach globally will require a cultural shift towards cross-sectoral and cross-national collaboration and open engagement. Climate action benefits from environments that encourage experimentation and collective problem-solving—with AI as a central enabler.

Conclusion: a call for proactive and endogenized AI development in climate action

This synthesis returns to the central claim: AI advances climate action when it is proactive, endogenized, and governed for equity. AI offers transformative potential for climate adaptation and resilience. This perspective highlights the importance of stimulating further research into the success of frontier technologies across various levels of climate intervention. The "endogenization" of AI—embedding it as a co-evolutionary partner within Earth-human systems- offers an opportunity to reflect on how AI can be responsibly incorporated into climate solutions. Although visions of AI in climate action paint its widespread adoption as both inevitable and desirable, we should remember that every one of us has a say in how things proceed as climate change. We decide when and how AI deserves to be included in our communities of knowledge[15] (*groups of individuals with distributed knowledge and understanding that allow individual community members to benefit from expertise held by others*) for joint sustainability within the earth-human ecosystem. AI should be carefully aligned with the values and needs of those it is meant to serve, particularly in vulnerable regions. For sustainability pioneers, this demands 1) rewiring AI's logic beyond optimization: moving beyond reactive tools toward generative foresight co-developed with marginalized communities; 2) activating latent legal leverage; and 3) investing in sovereignty: prioritizing funding for community-controlled innovation and replacing 'capacity building' with reparative tech transfer.

Legal and policy frameworks lag behind AI advancements, with no specific global or regional policies mandating accountability for AI in climate mitigation. However, this gap does not preclude immediate action. Existing laws harbor "untapped adaptive and transformative capacities[25]" that can be mobilized without awaiting new legislation. Rather than deferring to future frameworks, governance actors can repurpose existing environmental statutes through "open-ended substantive provisions" (e.g., statutes mandating "environmental protection") to embed AI-specific rules like carbon audits for AI-driven infrastructure projects under National Environmental Policy Act compliance. In this interim period, regulators can activate adaptive legal triggers for revaluation, leverage flexible interpretation of statutes to prevent AI deployments from exacerbating ecological fragility, and utilize cooperative federalism to empower subnational actors.

Key Points for AI in Climate Action

1. Proactive and Collaborative AI for Climate Action: AI should be used not just reactively but as a proactive enabler of climate resilience, prioritizing the needs of populations most vulnerable to climate injustice. These groups include indigenous communities, smallholder farmers, low-income coastal populations, urban informal settlers, etc. For these groups, AI's "proactive" potential lies in co-designing solutions that address systemic marginalization: Equitable Technology Transfer; Capacity Building as Reparative Justice; Inclusive Participation. Global collaboration must prioritize the redistribution of subsidies, channeling funds from high-emitting nations to community-led AI hubs—such as Senegal's Open Climate Lab—where young people and older adults prototype agroecological AI tools.
2. Investing in AI for Empowerment and Resilience: Prioritizing investment in AI for climate adaptation and resilience can empower regions most affected by climate impacts, helping them become more self-sufficient. AI should complement human knowledge, supporting local and community-driven solutions to foster co-learning and adaptability.
3. Ethical Governance and International Cooperation: AI's integration into climate action requires strong governance frameworks to ensure transparency, accountability, and fairness. International cooperation, along with equitable transboundary management, is necessary to protect vulnerable populations and ensure the sustainable use of AI technologies across borders.

Data availability

This manuscript does not report data generation or analysis.

Received: 18 April 2025; Accepted: 2 October 2025;
Published online: 30 October 2025

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Acknowledgements

This material is based on work supported by the Computational Social Science Research Award Scheme Project 202501020010, National Natural Science Foundation of China (NSFC) under Grant No. 71974106 and 72242107, the Major Project of the National Social Science Foundation of China under Grant No. 18ZDA110, UrbanLab Galway Project extends to the Horizon Europe IN SITU project, project funded by the Beijing Social Science Foundation (No.23GLC046), and the strategic study project of the Chinese Academy of Engineering (2022-JB-02).

Author contributions

Y.Z. and Y.N. conceptualized the ideas. Y.Z. and Y.J. developed the manuscript and wrote the first draft, along with the subsequent revisions and corrections. Z.Y., Ulf, and Y.N. commented on drafts of the manuscript. All authors wrote, read and approved the final paper.

Competing interests

The authors declare no competing interests.

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