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Anticipating the Challenges of AI in Climate Governance: An Urgent Dilemma for Democracies

Ruth Machen[1] | Warren Pearce[2]

[1]School of Architecture, Planning, and Landscape, Newcastle University, Newcastle Upon Tyne, UK | [2]iHuman, Department of Sociological Studies, University of Sheffield, Sheffield, UK

Correspondence: Ruth Machen (ruth.machen@newcastle.ac.uk)

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ABSTRACT

There is increasing interest in AI as a means of accelerating climate policy interventions. While undoubtedly promising, AI's recent history in other fields demonstrates the risk of significant unintended consequences that widen social inequalities or reduce democratic engagement. In this perspective, we review recent developments in climate governance and in AI governance and anticipate several potential problems when the two are combined. In particular, we highlight potential democratic challenges for the application of AI in climate governance through narrowing the range of policy options, narrowing the range of experts and publics that can contribute to climate governance, and how the implementation of AI may run counter to norms of democratic accountability. These challenges represent an urgent dilemma for climate governance as ignoring these issues will erode democratic oversight, lead to unpopular unintended consequences, and could reverse recent positive trends in diversity and participation within climate science and policy. In contrast, engaging with them could strengthen democracy and increase the successful social uptake of the technologies. By way of mitigating these risks, we introduce four principles for a bounded application of climate AI technologies that recognizes and enhances understanding of the political and contested nature of environmental decision-making. First, situating AI within expert and lay public debates. Second, valuing non-quantifiable knowledge. Third, expanding deliberation within AI decision-making. Fourth, developing domain-specific AI applications.

1 | Introducing AI Into Climate Governance

Artificial intelligence (AI), by which we refer to data-driven forms of machine learning and robotics,[1] is attracting increasing interest for its proposed role in climate change governance, via new possibilities for sensing, simulation, automated feature recognition and data-mining (Rolnick et al. 2019, Bhatia 2017; Konya and Nematzadeh 2024). From precision agriculture or forestry management, to prediction of societal conflict around resources and bio/geo surveillance for regulatory enforcement of deforestation and poaching, AI promises to optimize existing decision-making through increased efficiency and efficacy; to yield unforeseen solutions from big data that also surpass subjectivity in decision making; and to produce mitigation or adaptation measures that are spatially mobile regardless of local context.

Expectations are considerable, with a recent survey reporting that 87% of public- and private-sector leaders responsible for climate or AI topics believe that AI is "a useful tool in the fight against climate change" (Maher et al. 2022). Yet, whilst offering exciting possibilities, the recent history of AI in other fields demonstrates how AI's technological promise brings with it potential perils for the *democratic* governance of climate change. In this article, we connect recent developments in climate governance with established AI critiques from

non-environmental domains, to anticipate important potential problems.

As AI has been introduced across a range of policy governance areas, scholarship has shown how the technology is not only built upon economic and social exploitation (Schütze 2024), but that the foundational biases within models and training data sets exacerbate social problems. For example, low- quality data sources have biased large language and computer vision models toward the English language and against marginalized communities (Bender et al. 2021), exacerbating and compounding racial and gender biases (Buolamwini and Gebru 2018, Noble 2018). The opacity of decision points within AI constrains capacity for public debate or recourse when governance systems relying on AI bring about injustices (Amoore 2011). As a result, concerns have been expressed about the democratic accountability of new technologies (Nemitz 2018) and the valuing of processes of governing, beyond efficient means, as ends in their own right (c.f. Bevir 2006).[2] Most recently, Kreps and Kriner (2023) outline "immediate and severe" risks to three pillars of democracy: representation, accountability, and trust—concerns that are particularly pertinent and contested within the domain of climate governance. The speed with which AI models have increased in size, scope, and impact, without regulatory oversight, has compounded these problems with a focus on "move fast and break things" (Taplin 2017) rather than anticipating the deeper social impacts of new technologies (Stahl 2021). This characteristic of AI is relevant to climate governance, where the "need for speed" in the face of increasing emissions and temperatures have prompted governments to declare 'climate emergencies', risking possible drift toward authoritarian political responses (Mittiga 2022). Following these observations, there are good reasons to question whether climate governance's requirements for representation, equitable participation, accountability, and trust are compatible with AI's proliferation.

"Smart earth technologies" are changing the processes, forms, and temporalities of environmental governance (Bakker and Ritts 2018). The introduction of AI represents the latest in a series of "black boxes" inserted into climate governance, challenging democratic norms by reducing the complexities of democratic decision-making to simple input–output models that downplay the role of human judgment in policy implementation (Biesbroek et al. 2015; Burrell 2016). Applying insights from the critical social science literatures on democracy and AI to current trends in climate governance, we anticipate three challenges with the potential to reverse positive developments for increased transparency and participation in climate governance. First, the closing down of available policy options as AI interventions are narrowly oriented to solving a particular task. Second, narrowing the range of experts and publics who can meaningfully contribute to climate governance. Third, the ways in which AI may run counter to democratic accountability by rendering decision-making less visible and fragmenting responsibility. While these characteristics may offer appealing gains in efficiency, they also risk eroding democratic norms which in turn increase the likelihood of subsequent public resistance and antagonism (Mouffe 2005).[3] Technological challenges to democracy are not new but gain renewed vigor via AI's application to politicized domains, such as climate governance. Attention is required on how to make AI technologies work toward, rather than against democratic ends.

2 | Closing Down Policy Options

As AI becomes increasingly publicly available, large language models (LLMs) like ChatGPT are being deployed by policymakers in cities such as Tokyo for policy preparation tasks such as classifying and analyzing information (voter concerns or scientific evidence) and creating draft text;[4] and in Singapore, to optimize urban design plans.[5] In the face of multiple policy goals, AI promises an efficient workaround, by calculating pareto-optimal climate policy solutions based on "objective functions" (Rolnick et al. 2019, 54). Using reinforcement or adversarial learning, AI seeks 'solutions' to complex problems that perform better against multiple objectives. However, ambiguity, uncertainty, and diverse values stakes mean that there is often no single optimal solution but rather a vast political terrain of options in which value contestation is unavoidable and the fate of winners or losers rests upon imperfect processes of political decision-making. Such contestation increasingly extends to the very structures of politics and power which have driven climate change (Shaw 2023). Thus, whilst AI may promise an optimal solution, it removes the possibility of what Chantal Mouffe (2005) calls "agonism", a struggle between adversaries over legitimate policy alternatives as well as the meanings and implications of climate change itself—the diversity of which is incompatible with the liberal idea of solving climate change through rational consensus (Machin 2013). As many scholars have highlighted before us, when the stakes are contested, there is no single solution (Nightingale et al. 2020), rather, the legitimacy of democratic decision-making rests on considering a range of proposals which appeal to different publics. In such political conditions, the use of AI in climate governance risks annulling "the possibility of actual decision" (Amoore 2011, 38).

We anticipate three ways these theoretical concerns over policy narrowing might play out in practice. First, AI depends on quantified machine-readable data sets, meaning *less-quantifiable knowledges are often displaced*. For example, in precision agriculture, optimization for carbon mitigation and increased yields may displace inherited land knowledge practices that serve wider ecosystem objectives—factors that are technically difficult to quantify and politically easy to dismiss. Second, the *weightings* used within ML models to prioritise certain considerations are profoundly political (Amoore 2019) yet their opacity excludes public deliberation. Providing access for public intervention at certain moments is crucial if climate governance is to remain grounded in specific locales, rather than adopting a "view from nowhere" (Borie et al. 2021). Third, AI could further *amplify injustices*, as "ground truths" (Jaton 2017) are inherited via data packages that perpetuate problematic assumptions and structural biases. For example, within climate adaptation, Integrated Assessment Models (IAMs) already help shape decisions about where to adapt and where to abandon and will likely form the foundations for future applications of AI (Rolnick et al. 2019). Such IAMs have been heavily criticized for biases (Nost 2019) including unevenly addressing the hazard of flooding "across existing lines of vulnerability and race" (Molloy et al. 2023, 1). Reinforcement learning algorithms—fundamentally different from probability-based IAMs that learn from mathematical theorems (Chapman et al. (2023, 9)) may further exacerbate these data trends as they attempt to learn from existing data patterns. The combined effect is the concealed shaping of policy options before they reach the political table, signaling the role of material infrastructures in shaping climate imaginaries

(Machen et al. 2023) and raising questions over who gets to decide which policy options are assessed, how these are weighted, and the fate of unquantifiable aspects of climate policy—such as values, future aspirations, and the place of non-humans—within AI-driven decision-making processes.

Take Cognizant, a multinational information technology company, who promotes the role of generative AI in (a) *problem framing* (understanding user issues), (b) *prioritizing* (understanding urgency), (c) *data collection* (data capture), (d) *analysis* (extracting relevant information and drawing attention to interesting input features), (e) *meaning creation* (interpret expert conclusions), and (f) *making recommendations* (suggest recommended outcomes, trigger appropriate downstream, and follow-up activities):

In each of these six operative stages (identified by our italics, from their words in Figure 1), AI risks creating a mirror chamber of our present failures—in knowledge, in framing, in assumptions, and in values that has no regard for the future/ends (planetary survival) nor the casualties from its decisions. It has been shown that generative AI in particular is based on historical data sets that favor the status quo, and so do not encourage radical change (Sætra 2023). Through its discreet prioritization, AI optimizes outputs in ways that are biased toward dominant economic interests whilst framing solutions as technical rather than social or political (Amoore 2019). The residual effect is that AI narrows the options available for policy debate before deliberation between alternative strategies takes place and reduces scope for procedural deliberation.

3 | Disempowering Experts and Publics

In recent years, geographic and epistemic diversity within both climate science and policy have been expanding (Pearce et al. 2018; Standring 2022). We anticipate AI threatens to reverse these important developments. Whilst recognizing the limits of participation, especially the way that it is mobilized within system governance approaches to democracy (Bevir 2006), we nevertheless emphasize

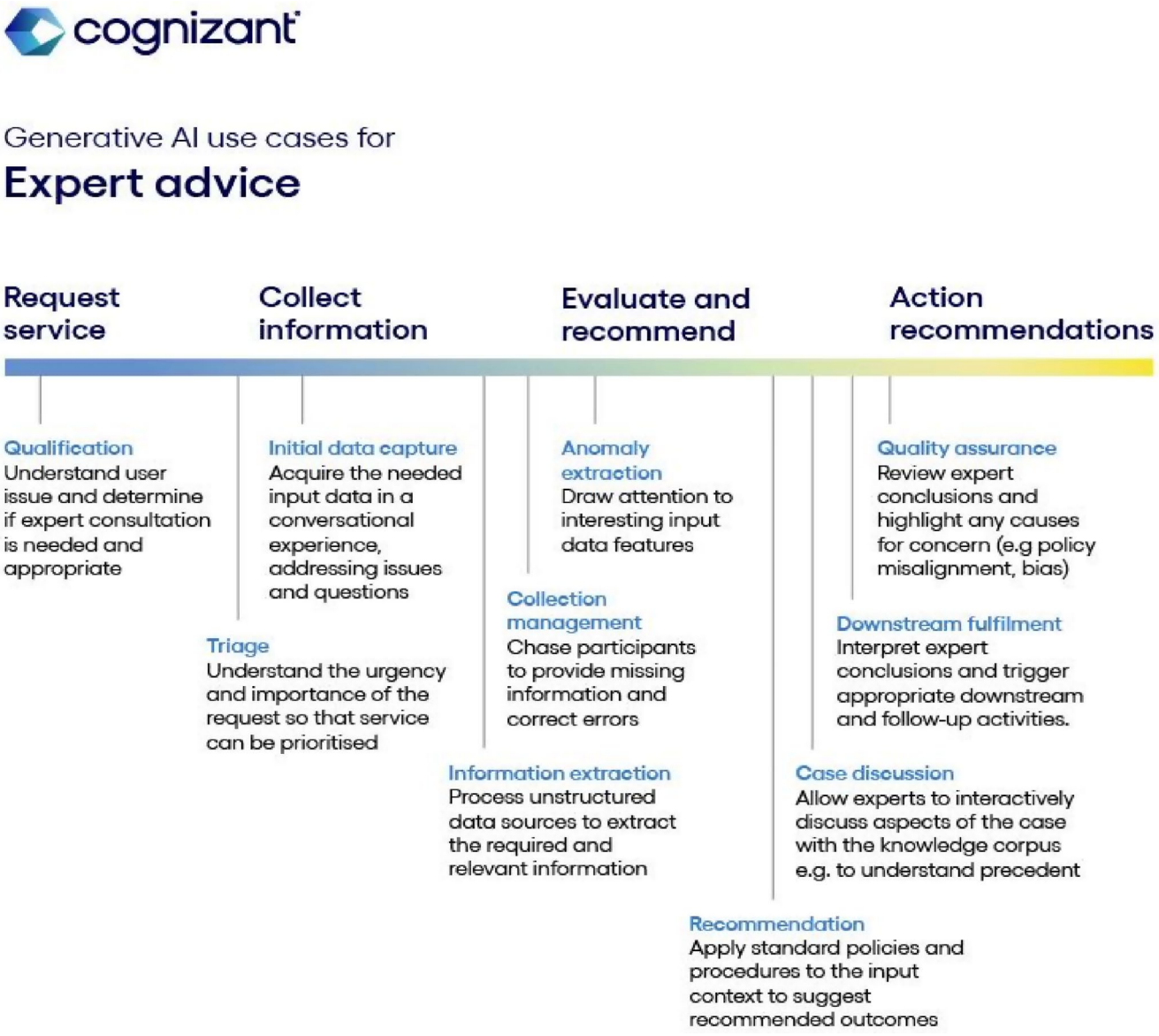

FIGURE 1 | Cognizant's generative AI services for working with 'Expert Advice'. *Source*: https://www.coGnizant.com/content/dam/cognizant-dot-com/insights/gen-ai-usecase-chart-expert-advice.jpg.

the importance of expanding the diversity of perspectives that partake in decision-making—both as an end in itself, and pragmatically for insights, efficacy, and democratic legitimacy.

First, the forms of scientific expertise that are called into complex decision-making will undoubtedly change, creating new knowledge-power dynamics. On the one hand, as LLMs increasingly interface with climate science directly, this may reduce calls for scientific experts per se in policy-making processes, as, for example, IPCC reports can be queried via tools such as ChatClimate (Vaghefi et al. 2023)—here the effect on knowledge diversity is uncertain. On the other, we have observed firsthand how the introduction of IAM models into policy increasingly privileges the expertise of modelers and statisticians. Where once the knowledge of the atmospheric physicist or the empirical ecologist was prized, this is changing to privilege the software engineer or the biometric statistician. Greater use of AI is likely to accentuate this trend further, concentrating power both in technical computer modeling epistemic communities which, with a few notable exceptions, have been dominated by white, western, male perspectives that continues to be resistant to diversification and in the United States and China where the expertise and resources of private AI corporations reside.

Second, AI may threaten the engagement of publics. Redistributing power is an active ambition of influential AI leaders such as Sam Altman, whose "grand idea" is to "capture much of the world's wealth through the creation of artificial general intelligence and then redistribute this wealth to the people" (Metz 2023). However, opening up lay querying of climate science through LLMs does not equate to public participation, either in science, or decision-making. Instead, the potential for AI to exacerbate inequalities in power concentrations is acknowledged both in theory and practice (Gebru et al. 2023). For instance, Dauvergne (2020) has highlighted how AI concentrates power in the hands of transnational agri-tech companies, excluding small-scale farmers from markets. These power shifts necessitate active attention to democratic engagement within climate governance to ensure that decision making prioritizes the greater good over the financial gain of privately owned technology companies (Lahsen 2020). We anticipate that the disempowerment of publics may occur particularly through AI's rendering opaque the processes of decision making—and its points of intervention, and through the erasure of unquantifiable 'inputs' to climate policies such as public values, which are the subject of sustained debate within climate, biodiversity, and ecosystem governance.

Such public values have previously surfaced in public participatory processes like the UK Climate Assemblies and the "My 2050" program, which have shown both the power of democratic climate engagement, and also that democratic legitimacy is threatened if the range of policy options presented by experts to publics are too constrained (Cherry et al. 2021; Mohr et al. 2013). AI-shaped policy decisions pose a threat to democratic legitimacy if they preclude public debate around values. Loss of democratic expression is likely to result in more intense public resistance; civil society is increasingly demanding not only more action on climate change but also more democracy (Gayle 2022). Attempts to use AI to tame political complexity could reverse recent advances in epistemic and geographic diversity, constituting a type of 'data colonialism' that replicates the patterns of imperial exploitation that have made climate change such an acute problem (Ghosh 2021).

4 | Accountability

AI challenges democratic demands for accountability in decision-making in multiple ways (Schippers 2020). Within climate governance, AI provides the potential to increase visibility of unwelcome activities; for example, using remote sensing to identify illicit deforestation or polluting activities that are escaping regulatory attention. However, the relationship between visibility and accountability is complex, and increasing visibility can bring double-edged outcomes. For example, while digital surveillance technologies can empower indigenous communities by making their multifarious relationships with territories more visible, they also enable new forms of surveillance and securitization that automates violence against indigenous communities (Cifuentes 2023; Parris-Piper et al. 2023). Who acts on this new information, and who is held to account evokes inequalities in whose information counts, the context in which it is interpreted, and on which actors (with which capabilities) are involved (Mason 2020). Increased visibility only improves accountability where there is strong governance (Kramarz and Park 2016) and the degree to which governance responds in support of marginalized communities depends on the *deliberative openness* regarding how those governance processes are chosen (Bäckstrand 2008).

The ability of machine learning to inductively identify hitherto untold data correlations and leverage points promises to offer foresight into the pre-emption of conflict from water resource shortages (Water Peace Security Partnership, 2025) or to reveal geographically sensitive urban planning solutions (Milojevic-Dupont and Creutzig 2021). In the case of water conflict, ML is being used to forecast water conflict 12 months in advance. However, the lure of temporal foresight involves rendering certain locations as problematic hotspots (see Figure 1). Who is determined to be responsible for these conflicts, and who determines responsibility, could serve to extend the colonial ways of seeing and knowing that form the roots of anthropogenic climate change (Cifuentes 2023; Parris-Piper et al. 2023). As Chandler (2018) has observed, these forms of data-based identification focus attention on the governance of effects while bypassing questions of cause and responsibility. In climate governance, this has the potential to significantly alter core principles, such as 'polluter pays'.

Figure 1: The WPS Global Early Warning Tool. source: https://waterpeacesecurity.org

Meanwhile, the question of which parts of governance processes are rendered visible or opaque remains highly political. Designers and programmers struggle to account for the decisions made by AI (Bathae 2018) and the ability of AI to give only a 'partial account' (Amoore 2019) of itself has led some scholars to question whether transparency can ever address AI's inbuilt biases (Ananny and Crawford 2018).

This raises legal accountability concerns when something goes wrong, notably regarding accidents caused by self-driving cars (Stilgoe 2018). In AI, accountability is fragmented across multiple human and non-human actors such that even where individual developers can be identified, there are challenges in holding AI developers to account and giving democratic control to those impacted (Cremer and Whittlestone 2021). In climate policy, the increasing adoption of the language of 'climate emergency' has led many scholars to highlight wider concerns about governance processes under 'states of exception' bypassing democratic norms (Hulme 2019). However, there are other ways of governing emergencies that do not involve increased sovereign or legislative power (Adey et al. 2015). We suggest that AI is one such emerging mode of governing emergencies—not through the exception—but through the ordinary that has a more pernicious relationship with democracy. Unlike the state of exception where a lead (often sovereign) body gains increased powers—meaning that accountability is easily located (if not necessarily enforceable)—AI has no such focused accountability, and, unlike the state of exception, AI governance has no such temporal limitation. In this context of fragmented and decentralized accountability, the discourse of climate emergency may serve to confer legitimacy for AI interventions that bypasses democratic governance processes and establish everyday forms of emergency governance—that consolidate faster, slicker delivery of the status quo, rather than opening up to questioning or deliberating over alternative approaches—without the caveats that the 'state of exception' formally held. This lack of accountability has the potential to undermine trust in environmental governance systems (Chapman et al. 2023).

5 | The AI Dilemma

The potential for AI to increase efficiency in climate governance may appeal to decision-makers. However, we argue that this rise of AI presents an urgent dilemma for democratic climate governance. If we see the present moment as a critical juncture (Coeckelbergh and Sætra 2023) in which human society is able to exert some influence over its future, then it is urgent to avoid situations in which climate change policy is governed too narrowly through AI, for this risks narrowing the range of policy options under consideration, reducing diversity of expert and public participation in decision-making and weakening the accountability of decisions. Whilst concerns over transparency, participation, and accountability plague both climate and AI governance debates independently, we argue that overzealous use of AI worsens, rather than relieves, these challenges. Instead, we argue for a bounded application of climate AI technologies that acknowledges the partiality of its knowledge contribution, the contested nature of political decision-making and prioritizes democratic participation as the key to climate policy that is both effective and equitable (Pickering et al. 2022). Conflict and partiality are unavoidable. What is at stake is dealing with these agonistically; that is, recognizing the legitimacy of alternatives and the political nature of decision-making (Mouffe 2005) rather than succumbing to the post-political promise of AI.

If democracy itself is unquantifiable and unpredictable (Schippers 2020), then the challenges of working with unquantifiable data in algorithmic processes may suggest that there is something fundamentally antithetic about AI and democratic concerns. We are not suggesting that there is only one way to work with AI but whilst alternative engagements with digital technologies, such as hacking and repurposing algorithmic devices, hold potential for becoming vital tools in democratizing both environmental data and decision making (Webb 2020), this depends crucially upon the contexts into which they are designed and enrolled (Crawford 2016; Pronzato 2023). Many of the democratic challenges that we discuss exemplify the conflicting dynamics within climate governance between attaining policy stability and yet remaining open to radical transformation (Paterson et al. 2022). It is not enough to provide more efficient solutions: democratic societies must also ensure that the right questions are being asked. AI algorithms are indifferent to their target of optimization, to the consequences of their thresholds, and to the implication of error. If we are committed to particular democratic values, then these need consideration alongside processual speed or simplicity (the values and aesthetic qualities that underpin mathematical proofs). What we are seeing is not just the importing of particular methods but also of particular logics, aesthetics, and values into processes of environmental governance: a process that necessitates wider democratic debate.

To this end, we urge the opening of a research agenda around the democratic implications of AI in climate governance and environmental governance more broadly. We conclude by proposing some further principles for bringing AI into climate governance in ways which maintain or strengthen democracy that build upon those identified by Cowls et al. (2023):

1. Develop domain-specific applications for AI that are recognized as one knowledge source among many.
2. Situate the findings of AI within strong processes for both expert and lay political debate and include agonistic pluralism in AI ethics alongside transparency, fairness, and accountability.
3. Enhance the scope for both expert and lay deliberation within AI decision-making processes, challenging the ways in which commitments to particular values become 'baked in' to AI approaches.
4. Acknowledge and value knowledge which is not easily quantified and therefore at risk of exclusion from AI-driven data analytic processes.

The potential applications of AI within climate-related decision-making are vast and diverse, we need strong social and political reflexivity about how, when, and with what latitude these technologies are put to work. As Cremer and Whittlestone (2021, 100) remind us "we are not mere bystanders in this AI revolution: the futures we occupy will be those of our own making."

Climate policymakers, researchers and citizens can and should work together to help make socially and democratically robust decisions about how, when, and why to include AI within climate governance.

Author Contributions

Ruth Machen: conceptualization (equal), formal analysis (equal), writing – original draft (equal), writing – review and editing (equal). **Warren Pearce:** conceptualization (equal), formal analysis (equal), writing – original draft (equal), writing – review and editing (equal).

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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Endnotes

[1] For the purposes of this article, we employ a simple working definition that defines the AI field by the techniques used. Following Wang (2019) it is AI's ability to flexibly combine inference rules and processes according to the experience of the system that both differentiates it from mere computation and renders problem solving processes non-replicable.

[2] It is for this reason that we are less concerned with which countries formally have democratic political systems, and how this affects climate governance, than with looking at how AI sits with the ethico-political commitment to valuing and embracing the possibility for difference in the international project of governing of climate change across many different political regimes.

[3] For example, in August 2020, UK students took to the streets to protest against the use of a predictive model to calculate their A-level grades following the emergency cancellation of written examinations due to COVID-19. The resulting grades were widely criticized as unfair, with students' rallying cry of "fuck the algorithm" directing public attention onto the increasing role of unaccountable calculation in determining social policies, and forced a government U-turn (Amoore 2020b; Benjamin 2022; Kolkman 2022).

[4] For the integration of AI in policy preparation see Tokyo's Metropolitan Government use of ChatGPT LLM: https://www.japantimes.co.jp/news/2023/06/14/national/tokyo-metropolitan-government-chat-gpt-use/.

[5] For the integration of AI in urban planning see Singapore's use of Vertex GenAI: https://niveussolutions.com/gen-ai-in-singapore-transforming-technological-landscape/.

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