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Compliance and enforcement in a brave new (green) world: best practices and technologies for green governance

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Abstract

International and transnational cooperation is needed to strengthen environmental governance initiatives with advanced technologies. In January 2023, Ontario Tech University hosted a symposium entitled *Tech With a Green Governance Conscience: Exploring the Technology–Environmental Policy Nexus.* Attendees spanned diverse disciplines, sectors, and countries, bringing unique and diverse perspectives to the technology–environmental policy nexus. Emergent themes arising from the symposium include the role of artificial intelligence in environmental governance, while eliminating the detrimental social impacts associated with these advanced technologies via algorithmic bias, misunderstanding, and unaccountability. The symposium explored the tech–society–ecology interface, such as the authoritarian intensification of digitalized environmental governance, "technocracy", and the ethical implications of sacrificing democratic legitimacy in the face of imminent environmental destruction. Select participants (i.e., co-authors) at the symposium provided input on a preliminary framework, which led to this perspective article focused on the politics surrounding *green* governance in the 21st century. We conclude that while emerging technologies are being deployed to address grand environmental challenges such as climate change, biodiversity loss, and resource depletion, the use of these various technologies for progressive environmental policy development and enforcement requires co-productivist approaches to constructive technology assessments and embracing the concept of technologies of humility. This necessitates a space for dialogue, reflection, and deliberation on leading adaptive environmental governance in the face of power and politics, as we interrogate the putative neutrality of advanced technology and techno-solutionism.

Introduction

Science and technology studies (STSs) remind us that technology is not deterministic, and that there is still agency and contingency as we embark on new and unprecedented technological possibilities. The STS scholarship also acknowledges that emerging technology does not unidirectionally shape our values and norms; rather, our understanding of governance and social organization informs the co-production of technology and what we make of nature, society, and the "real world" (Jasanoff 2012). The increasing use of digital information and communication technologies (ICTs) and artificial intelligence (AI) in environmental monitoring, regulation, and governance must be carefully considered as we try to tackle climate change, nature and biodiversity loss, pollution, and waste. This is because such technological measures may paradoxically result in increased damage through rebound effects. Adopting a co-productivist and constructive technology assessment (CTA) approach (Rip et al. 1995) to environmental governance, this paper argues that the social problems surrounding the use of these new technologies—for example, the global expansion of AI surveillance, the infringement of civil liberties, extractivism, and the commodification of nature via digitalization—must be addressed with humility and the inclusion of a large diversity of stakeholders in technological design and implementation processes (Kemp et al. 2001).

While knowledge of the intersection between advanced technology and the drivers (and impacts) of planetary threats holds tremendous promise in helping policymakers anticipate future risks to develop scenarios to test the possible ef-

fects of different policies and decisions (Foray and Grübler 1996; Jaffe et al. 2002), CTA must include sociotechnical critique in the design, development, and implementation phase so that policy informs the dynamics between emerging and advanced technologies and governance structures (Jaffe et al. 2003). Relying on Canadian examples of *green governance*, we examine the social and political shaping of a range of technologies and take into account the coproduction of these technologies and its effects on society.

The distribution of new technologies in society is uneven at best: it is often beyond the reach of nonexperts and pertinent rights-holders in many jurisdictions, including compliance and enforcement bodies. This is especially so with regard to the transfer and adaptation of environmentally sound technologies (ESTs). As the 1992 Rio Declaration reminds us, nation-states should cooperate "… by enhancing the development, adaptation, diffusion, and transfer of technologies, including new and innovative technologies" (Rio Declaration on Environment and Development 1992: 366). International and transnational CTA is needed to strengthen various environmental governance efforts. While this is desirable, it may also be implausible, forcing sectors to seek alternative forms of regulation and governance, which, in turn, raises ethical considerations. How do we ensure environmentally sound governance of advanced technologies (what we conceptualize as "*green* governance" of new and emerging tech), so that we may achieve the 2030 Sustainable Development Goals? Such analysis is, in turn, the topic of this perspective article as we draw upon examples of the Canadian technology–environmental policy nexus.

As AI, soil, water, and air sensors, satellites, and drones equipped with sensors and cameras (Kloppenburg et al. 2022) support green governance and help achieve sustainability goals, it is important to find ways of proactively limiting or eliminating the detrimental social impacts associated with these advanced technologies that occur through algorithmic bias, misunderstanding, unaccountability and, of course, the expansion of surveillance and infringement of civil liberties. It is quite clear that the global governance of climate change will involve the use of advanced technologies as a way of mitigating the consequences of the planetary crisis unfolding before us. However, at the present time, countries are in no way united about the best path forward. During the negotiations leading up to the 2015 Paris Agreement, disagreement between industrialized and developing countries over policy direction and options occurred, raising purposeful questions about the power imbalances in the EST trades, as well as problems surrounding their privatization.

It is our contention that the absence of a genuinely global or transnational CTA framework for green governance will inhibit the efficient adaptation of ESTs and hinder the prospect of bringing forth sociotechnological changes that could help us effectively respond to biodiversity loss, climate change, pollution, ecosystem health, and resource depletion. While we recognize that ESTs are in themselves not a panacea for all of the world's environmental problems, we believe that ESTs, when developed, designed, and used appropriately, can do some good. Advanced technologies are contradictory: they can harm, help, and hinder and advance the pursuit and achievement of environmental sustainability. If not for the historical development and diffusion of techno-social systems powered by energy sources whose use drove up carbon emissions, we would not have the Anthropocene. However, at the present time, advanced technologies through a CTA lens can support green governance measures to identify and assess the Anthropocentric consequences, and help us imagine new practices for adapting to or mitigating these impacts.

If used well, advanced technologies for green governance can improve public safety by safeguarding resources, aiding in the gathering and analysis of evidence about those responsible for environmental harm, and enhancing enforcement and management strategies. However, environmental law enforcement agencies may be slow to adopt and implement said technologies, as they lack guidance via appropriate policy responses. Like many public entities, they grapple with a wide range of political prerogatives, fiscal constraints, and institutional inertia when determining which technologies may be most appropriate and cost-effective for their compliance and enforcement practices (Nakashima 2014). Technology is additional to existing systems and can replace the current system (often with conflict), and can be added into the current works, which can result in less effective solutions. Law enforcement with regard to the efficient and effective adoption and use of new technologies is by no means a new issue (Timberg 2014). Near the close of the 20th century, concerns were raised that the diffusion of new internet and ICTs would hamper law enforcement's ability to investigate crime (Swire and Ahmad 2011). This ignited the "going dark" debate, which entailed questions about law enforcement's ability to intercept and monitor real-time online communications and was concerned with how officers could operate within electronic surveillance laws and conduct court-mandated surveillance of digital communications (Finklea 2015). How might such questions be addressed in the global green governance context, where law enforcement struggles to define and adapt best practices for investigating the proliferation of cyber poaching or using drones to facilitate the illegal wildlife trade?

The Faculty of Social Science and Humanities and the Digital Life Institute's Sustainability, Equity, and Digital Culture research cluster (both at Ontario Tech University) hosted a Social Sciences and Humanities Research Council-funded symposium to explore such questions. Entitled *Tech With a Green Governance Conscience: Exploring the Technology–Environmental Policy Nexus*, the symposium addressed broad issues such as emerging technologies and the illegal and legal wildlife trade, invasive species, climate change, smart cities, smart homes, tech-inspired economic expansion, and Indigenous environmental knowledge. Attendees spanned diverse disciplines, sectors, and countries, bringing unique and intersectional perspectives to the technology–environmental policy nexus. The first day focused on the role of technologies in global environmental governance through wildlife forensics; web scrapers and the governance of online illicit markets in endangered species; technoscience, biosecurity, and biological conservation; and even the role of the metaverse in the fight against climate change. On the second day, various themes of the tech–society–ecology interface were explored:

the authoritarian intensification of digitalized environmental governance, "technocracy", and the ethical implications of sacrificing democratic legitimacy in the face of imminent environmental destruction—to name a few. All participants (i.e., co-authors) provided additional input on a preliminary framework, which led to this perspective article. In what follows, we comment on the politics surrounding *green* governance in the 21st century. This is followed by an exploration of constructive technology assessments of advanced technologies and environmental governance. We then turn our attention to data privacy and sovereignty, and also the role of humility in citizen/community science, as a way of achieving a balance with traditional forms of governance. Finally, we provide some concluding thoughts on governance frameworks as we enter a brave new (green) world.

Politics as usual?

There has always been a persistent and troubling gap between the inherent value of new and emerging technology and the ability to put it to work effectively. Key challenges that organizations face include legitimate resistance to change or even the choice (and manner) of implementation of new technology (Leonard-Barton and Kraus 1985). The literature in innovation studies, science and technology studies, political science, the sociology of infrastructure, history of technology, and governance also reveals that political contestation also contributes to high barriers to behavior change when societies switch from older familiar systems to newer, potentially more effective ones (Geels et al. 2017). As such, emerging technology is truly a Janus-faced creature (Jones 2012) insofar as it can support strategic cross-sector environmental enforcement efforts and also open doors for potential exploitation by a range of malicious actors. While the diffusion of emerging technologies offers opportunities and challenges, so does its security (Finklea 2015). Cutting-edge technologies that exist but cannot be employed or deployed (for various reasons ranging from uneven diffusion and access, to legal, policy, and regulatory regimes, to ethical concerns to high cost) is where the friction with green governance will be significant. Remote sensors could be set up in industrial facilities to report directly on emissions to regulatory authorities, provided that regulations are amended to allow remote monitoring (Macauley and Brennan 1998). Imagery from satellites or remotely operated platforms could be used to survey distant habitats in almost real time—if it were affordable (Manfreda et al. 2018; Shirk et al. 2022). Wildlife can be tracked with electronic tags feeding data back to wildlife managers to be able to make near real-time management decisions for the benefit of wildlife populations and people—if data integration and management systems could be refined (Cooke et al. 2022). However, caution must be exercised because such innovations do not always lead to equitable outcomes for Indigenous and global Southern communities; for example, concerns about electronic tagging and habitat surveillance via digitalisation and the commodification of nature lead to new forms of what Upchurch (2020) refers to as "extractive capitalism"—that is, a new dimension of colonial extractivism under the ideology of neoliberalism. Clearly, the practical application of technologies to environmental governance is fraught with problems, some of which limit collaboration and increase inequity and unaccountability while maintaining the status quo.

Jasanoff (2007) echoes this point by arguing that in the case of climate change, science cannot tell us how to allocate technological resources between prevention and mitigation, or whom to hold responsible for protecting those most vulnerable to the effects of rising temperatures. In fact, she advocates for *technologies of humility*—in other words, recognizing the limits of scientific knowledge and about when to stop turning to technology to solve problems. Technologies of humility encourage us to reframe environmental problems so that their ethical dimensions are brought to the forefront, directing us to address people's vulnerability to emerging technology and their risks and benefits (Jasanoff 2007). A reflexive approach to technological policy-making and practice, technologies of humility are contrasted against the traditional *technologies of hubris* that view technology as a tool for controlling nature and the world with greater certainty. A potent example of this lack of humility comes in the form of the Jevons Paradox. Succinctly put, technological advances that allow resources to be used more efficiently do not tend to conserve those resources in the long run. Jevon first noted this in the late 19th century regarding coal-saving technologies and the paradox has repeated itself with things like energy-saving appliances and efficient automobiles (Alcott 2005). More efficient and lower cost LED light bulbs have now created a situation where light pollution is emergent with significant deleterious impacts (Pawson and Bader 2014). Recently, green technologies in the cruise ship industry have similarly corresponded with increased, instead of decreased, adverse environmental impacts as they have increased efficiencies, reducing per passenger costs and prices, and therefore increasing the overall demand for cruises, ratcheting up CO_2 emissions (MacNeill 2023). We can consider Tesla's innovation in the electric vehicle (EV) space as another example. Although EVs have a lower cradle-to-grave environmental impact than internal combustion (ICE) vehicles, they remain too expensive compared with others to effectively replace ICE vehicles in mass markets. Tesla's solution is to find efficiencies in production as they redesign auto manufacturing around EVs. Specifically, the innovation of the gigapress in EV manufacturing will introduce a new economic mode that exhibits high fixed, but low variable costs, creating long-term price drops in auto production. This, if the Jevons paradox continues to hold, will result in increased production and consumption of cars—EV or otherwise—possibly erasing and surpassing any per unit environmental gains via the saturation of global markets with more cheap cars (and more lithium mines). A similar perverse effect might be seen when monitoring technologies, designed to reduce environmental harm by detecting illegal wildlife trade activities, are used by illegal hunters to more efficiently find and trap endangered animals, thereby increasing environmental harms.

The challenge of achieving such humility in environmental governance is rooted in entrenched governmental structures and unresponsive politics, and the presence of multinational companies intentionally developing new technologies to de-

feat compliance monitoring technologies, or assuming they are too powerful to be compelled to comply with global, regional, and national emissions standards when utilizing their technologies to bypass regulations (i.e., Volkswagen's egregious role in "Emissionsgate"). Companies also look to reduce the data quality by claiming that aggregated data in the form of high-level harmonized system codes on shipment declarations are necessary to enable the speed of trade, while this aggregation of data impinges upon understanding the full biodiversity of the wildlife trade (Tlusty et al. 2023). Simply put, in the future, how do we keep firms and other actors from using computers to erode planetary data accuracy and abet environmental crime?

Geo-engineering is another new technology laws on the books did not anticipate, and still do not. In 2012, a First Nations salmon restoration group in Haida Gwaii garnered worldwide attention after dumping more than 100 metric tonnes of iron into the Pacific Ocean in a process known as ocean fertilization. This act of geo-engineering was supposed to create a phytoplankton bloom that would spur salmon returns and capture carbon for profit (Omand 2016). It was reported and authorities investigated the case but in the end, no one was prosecuted. It was too complex and there were too many layers of potential jurisdiction—international, federal, and Indigenous. Yet geo-engineering to counter climate change potentially has a bright future, given the lack of serious progress in implementing global green agreements across economies.

Air, land, and sea: the nexus between advanced technology and environmental governance?

Transboundary resources such as air, water, and all types of migratory species are nonstationarity (Wolkovich et al. 2014). After all, the Anthropocene is planetary, and though its consequences cross borders, humans and governments still try to govern transboundary resources through the construction of bordered spaces (whether national, subnational, or protected zone regulations), resulting in continual negotiation, contestation, and compromise (Miller et al. 2022). Nevertheless, there are many avenues of convergence between environmental governance and high-tech applications to monitor air pollution, fisheries, forestry, and other burning issues. Are we misplaced in focusing our resources and hopes in the development and adaptation of new technologies as key to environmental law compliance and enforcement? What of the human dimension—agency, creativity, and resilience? After all, regulation and enforcement are de minimis rules that represent the final safety net of a long process designed to ensure people respect the environment. What about culture and peer pressure, education, awareness, and compliance promotion directed at users that aim to encourage behavioral change at the individual and collective levels of modern society? The activities to ensure seafood are produced more sustainably rely on programs that encourage innovation that troubles business-as-usual scenarios and status quo national rule making (Tlusty 2012). Only when operation above the de minimis level fails does enforcement and the justice system step in. Kloppenburg et al. (2022) suggest that the convergence of technologies and environmental governance draws upon three pillars of *seeing and knowing, participation and engagement, and interventions and actions.* Again, we must be wary of this convergence, as it often treats technology naively as objective and separate, rather than a co-productive system-actor, leveraged for vested interests. However, the aforementioned pillars reconfigure what we *see and know*, which, in turn, informs levels of *participation and engagement.* There is little consideration of humility in such reconfigurations and as Jasanoff (2007, p. 2) states, "policy-makers need to focus on when it is best to look beyond science for ethical solutions. And science advisers need to admit that other sorts of analyses must also inform political decisions".

We all are told that we can think globally and act locally. However, can we *act* globally as well? How could we use our technologies to achieve such a feat? For example, illegal deforestation is responsible for between 12% and 20% of global greenhouse gas emissions, depending on the source, in addition to reducing biodiversity and chopping down carbon storage sinks (Grantham Research Institute on Climate Change and the Environment 2023). This is clearly a global issue with local consequences. What can Canadian scientists and policymakers do to help address this global issue that impacts us? It is not just in our long-term biological survival interest to look at this, it is also in our short-term, selfish economic interest as well. It is estimated that 10%–12% of wood products imported into Canada, mainly furniture and paper, come from timber at high risk of having been illegally harvested or transported (Ramage et al. 2017). This is worth some CA$1.5 billion or, as a government economist estimated, impacts 13 000 direct and indirect Canadian jobs in our *regulated* forestry sector. And it goes both ways. For example, Canadian logging companies have also been implicated in sending "biofuel" wood pellets abroad in violation of strict green energy rules. Canada has come a long way in the last 50 years with respect to environmental governance, but it still has a very long way to go to improve its sustainability track record, especially as provincial governments sometimes seek to weaken and remove environmental protections. What green governance lessons remain to be learned, considering the presence of multisectoral, multiscalar, and cross-border approaches to constructive technology assessments and polycentric governance (Heikkila et al. 2018)?

In a related vein, satellites can track fishing vessels, sometimes even when their automatic identification system beacons are turned off. These vessels are a haven for illegal, unreported, and unregulated fishing, but also for modern slavery and exploitation. Right now, nongovernmental organizations are identifying and tracking these vessels—on the high seas and on the edges of national exclusive economic zones, where governments cannot or will not intervene—but all they have the power to do is track. Still, the costs are high and their ability to influence recalcitrant states and companies to submit to compliance controls is limited. Assuming that we all depend on healthy oceans for our survival, are there ways Canada can—from a policy perspective—put pressure on this industry through the management of emerging

technologies across borders, scales, and sectors? Can the government use new technologies to ensure the legal and sustainable sourcing of imported fish, like the European Union is doing? From an enforcement perspective, Canadian authorities can only act in Canada and on laws that exist. However, if laws are being broken elsewhere while the impacts are felt here, how do we react? We contend that the solution here lies in this notion of humility, cross-border participation, and collaboration in constructive technology assessments. Undoubtedly, Canada has the technologies and the means to be more proactive in environmental governance outside of its borders on issues that impact the country, such as illegal emissions, forestry, and fisheries, both through active surveillance and enforcement in international spaces, as well as through other mechanisms such as targeted foreign aid and security spending and capacity building on the issue, but that is a policy choice, and one that current governments may not be keen to make.

Quis custodiet ipsos custodes?

If we consider the practical application of technologies in everyday environmental policing, for example, we recognize that computers and databases are ubiquitous and they play a very important role in enabling officers to identify, target, intercept, investigate, and prosecute violators. The gathering and the use of personal and commercial information are key to enabling the risk-management regimes that seek to target threats while hopefully simplifying procedures for low-risk regulatees; however, who is being regulated? It may be an importer, an industrial facility, a taxidermist, a traveller, or even an unsuspecting family on a picnic in a protected area; in other words, everyone is subject to green governance at some point. The reality is that for all the information collected by governments—in Canada and elsewhere—it is actually not that widely shared within governments. In Canada, there are privacy protection laws that allow the gathering of information for a stated purpose only. For example, a pollution investigation officer cannot see your customs declaration, unless you were found at the border with a regulated substance such as an ozone-depleting substance like a canister of freon. Similarly, the provincial officer checking your moose hunting license will not see the conviction you had for illegal hunting in another province, or the elephant ivory bracelet you ordered on an ecommerce website. While technologies exist to collect, store, and share information, policy limits that. However, that may not be unreasonable when we consider the ethical issues surrounding advanced technologies.

At what point does the government's use of technologies to protect the environment become an intrusion on your life and privacy? The Cambridge Analytica scandal involving Facebook users' personal data being collected and used for political advertising in the 2010s revealed the fragile relationship between democracy and social media platforms developed by large multinational corporations. To what extent can we extrapolate broad definitions of governance to the more specific, yet context-contingent, realm of environmental governance? How might the internet, smartphones, and social media platforms and services allow or disallow us to engage with and participate in democratic environmental governance? More importantly, can local communities be more engaged in the process of technological governance—or are we slipping further into an authoritarian technocracy that renders local voices powerless? One need only look to China for examples of authoritarian environmentalism and the tensions between environmental protection, human rights, and social justice (Lo 2021). From a procedural perspective, the misguided faith in eco-elites imposing top-down environmental decisions weakens democratic legitimacy (Kloppenburg et al. 2022). There is, also, the rise of techno-solutionism (Morozov 2013) and its potential to curtail inclusive, participatory, fair, and just processes. The misuse of advanced technology can negatively impact knowledge systems, values, cultures, and rights of diverse stakeholders, including the views of groups that are often already marginalized (e.g., the working poor, women, indigenous peoples, or racialized or religious minority groups) (Lockwood et al. 2010).

Who will "watch the watchers" and "guard the guards"? Citizen science, also known as participatory or community science, has been identified as a way for the general public to engage in scientific research and knowledge production. From design to implementation, evaluation, and data management, citizen science projects in the field of ecology and environmental sciences contain elements of humility, seeking to redress inequality. The call for humility stems from the need to cultivate perspectives and epistemologies that are marginalized in the technology–environmental policy nexus discourse. Community science is also based on principles of participant engagement and retention; data quality assurance and bias correction; and the ethical considerations pertaining to sharing data (Fraisl et al. 2022). Biodiversity research, land cover assessment, and forest health monitoring are just a few examples of this "participatory paradigm" (Bäckstrand 2003). Consider, for example, biodiversity-related community science projects. These projects have contributed at least 50% of the observations of global biodiversity databases, such as the Global Biodiversity Information Facility. The Great Southern BioBlitz is yet another example of community-driven biological surveying within several designated areas across the Southern Hemisphere. Including more than 270 local and regional initiatives in that half of the globe, and contributing over 190 000 biodiversity observations across the Southern Hemisphere in 2021, GBS increases biodiversity awareness through community science (Groom et al. 2017).

Other examples of similar initiatives include MammalWeb, Spipoll, and the Participatory Guide of the Marine Species in the Barcelona Metropolitan Area (Fraisl et al. 2022). It would, however, be naive to believe that community science can serve as a solution to technocratic environmental governance or even environmental crime. For example, might spatial data and biodiversity research lead to infringements of data privacy and sovereignty or inadvertently aid illegal hunting, respectively (Resnik et al. 2015)? What does the protection of sensitive community data look like in a brave new (green) world? The CARE (collective benefit, authority to control, responsibility, and ethics) principles guiding Indigenous

data governance seem to balance the scales of community science with, say, top-down fortress conservation and environmental governance, but much more work needs to be done in the field of (environmental) data privacy and sovereignty (Carroll et al. 2021).

Concluding thoughts: a brave new (green) world

Advanced technologies open doors to new forms of environmental governance, and we have more information than ever before available to us for building and implementing ambitious green governance frameworks. We have the technologies and knowledge to build a sustainable future, but there is one final challenge: how do we get the best information into the policy makers' hands at the right time, and ensure that this information is actually acted upon and implemented? While technology promises wonderful solutions to the problems of our time, it is not in itself or by itself a fix to challenges of green governance. For example, artificial intelligence may take on the role of data mining, analysis, and ultimately, decision-making to help us prioritize conservation efforts, but the power of this approach is limited by the type of data already available. Where might co-productivist approaches, CTA frameworks, or technologies of humility be situated in Kuhn's paradigm shift cycle when we unpack the technology–environmental policy nexus? Whole phyla of organisms remain undocumented and require local people on the ground and in the water to identify and measure undescribed taxa. We must ensure that the limited resources applied to shiny new technologies are not being used at the expense of older, but necessary, technologies like field taxonomy, securitization, emergency powers, exceptional measures, etc. Who will decide technological governance protocols and practices? Is there a justifiable need for sacrificing democratic legitimacy/participation in cases where environmental destruction has become (or is threatening to become) catastrophic?

Although we are enthusiastic about the many potential benefits that may arise from technologies, we cannot "engineer" or use technologies to solve every environmental problem (Huesemann 2001). Knowing the societal limitations of technology is perhaps more important than knowing its capabilities. Recognizing the societal barriers to bringing about good environmental governance at local, national, and global levels is just as significant as identifying the potential of technologies to surmount them. These understandings invite opportunities for cross-disciplinary and extra-academic thinking on how to use resource-saving technologies in a way that avoids increased environmental damage. Ecologists have for years argued that technological innovations within an economic system that is programmed for perpetual expansion and growth on a planet of finite resources will result in these perverse effects, and thus we cannot look at redesigning technologies without redesigning the economy (Hickel 2020). However, beyond strictly defined "Western" science and social science, ideological and cultural changes toward concepts of sufficiency versus efficiency—often embedded in Indigenous ways of knowing—may prove more important in regulating new monitoring and efficiency-generating technologies (MacNeill 2020). The new paradigm shift before us is one that needs to supplement science with an analysis of the human condition and for policy analysts and policymakers to re-engage with humility and the coproduction of emerging technology in the face of inevitable uncertainty and planetary crises.

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