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Artificial Intelligence, Climate Change and Innovative Democratic Governance

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Abstract

This policy-oriented article explores the sustainability dimension of digitalisation and artificial intelligence (AI). While AI can contribute to halting climate change via targeted applications in specific domains, AI technology in general could also have detrimental effects for climate policy goals. Moreover, digitalisation and AI can have an indirect effect on climate policy via their impact on political processes. It will be argued that, if certain conditions are fulfilled, AI-facilitated digital tools could help with setting up frameworks for bottom-up citizen participation that could generate the legitimacy and popular buy-in required for speedy transformations needed to reach net zero such as radically revamping the energy infrastructure among other crucial elements of the green transition. This could help with ameliorating a potential dilemma of voice versus speed regarding the green transition. The article will further address the nexus between digital applications such as AI and climate justice. Finally, the article will consider whether innovative governance methods could instil new dynamism into the multi-level global climate regime, such as by facilitating interlinkages and integration between different levels. Before implementing innovative governance arrangements, it is crucial to assess whether they do not exacerbate old or even generate new inequalities of access and participation.

Keywords: Artificial intelligence; climate change; climate justice; climate policy; collective decision-making; democratic participation; direct democracy; e-governance; machine learning; open-source governance platforms; quadratic voting; sustainability

I. Introduction

Two major shifts are warranting the attention of observers and analysts in the twenty-first century: first, the reality of a strong digitalisation of many facets of the modern economy and society – further intensified with the rise of artificial intelligence (AI) – and, second, the push for a green transition aimed at decarbonising our economies in order to achieve climate goals. Given the relevance of these two trends, it is important to better understand in what ways they are interlinked and whether they can be mutually reinforcing or to what extent they stand in conflict with one another. This is also important in connection to the ambitious timeline necessary for the green transition to be successful at halting dangerous levels of climate change.

One further point of connection between the digital and green transitions can be found in the potential effects of digitalisation on political dynamics, which can in turn shape climate policy effectiveness. Prior literature paid attention to how digitalisation and online discourse within social media platforms could have a polarising effect on public opinion and reduce the prospects of reasoned debate on climate policy. Another issue relates to the democratic legitimacy of climate policy, where a concern could be that higher legitimacy achieved via greater citizen participation could potentially slow down climate policy. This could be thought of as a dilemma of voice versus speed regarding the green transition. New models of digitally enabled citizen participation with design features preventing polarising tendencies, some of which are already piloted in Taiwan at a large scale, could point towards ways to escape from or ameliorate this potential dilemma of voice versus speed regarding the green transition. Overall, this paper addresses important linkages between the digital and the green transitions while also paying attention to how these effects are intermediated via the political channel. The paper also targets a policy-oriented audience as it presents and discusses novel ways of making democratic governance sufficiently agile to facilitate a green transition that is both swift and deemed legitimate.

This policy-oriented article addresses the following research question: how might the accelerating digitalisation of modern societies shape the envisaged green transition, both directly and indirectly via its effect on politics? This is complemented by the relevant policy question on how digitally enhanced and creatively designed tools for political participation could aid both the political legitimacy and the swiftness of the green transition. Methodologically, the article relies on analysis of the relevant scientific literature on the sustainability impacts of digital technology, while also drawing on sources discussing the role of AI in particular. In addition, the article refers to evidence from Taiwan as an illustrative case where digital tools for bottom-up citizen participation are being piloted and utilised.

Digitalisation and AI could have impacts on climate outcomes in several ways, both in more immediate manners but also indirectly. Starting with the more immediate links, AI can be used to help achieve climate targets via deployment in various specific domains, such as in research on the development of more efficient batteries.[1] There are many more examples of case studies and application domains where the deployment of AI contributes to the green transition and net zero goals.[2]

On the other hand, AI in general can also be part of the problem, such as when developing and deploying large AI systems that consume large amounts of energy that then cannot be used for other purposes.[3] Equally problematic is the large infrastructure, including data centres, that is relied upon.[4] Besides the consumption of energy, the infrastructure and hardware upon which the usage of AI systems rests also contains embodied carbon that would have to be accounted for. On top of this comes the enormous amount of edge devices such as smartphones that will increasingly be drawing on algorithms and AI-powered applications.[5] The production of the hardware associated with the whole infrastructure for developing and deploying AI is built from minerals and materials frequently sourced in peripheral countries via methods that can infringe acceptable labour standards, produce negative externalities for communities close to the extraction sites and pollute or disrupt local ecosystems.[6] If one considers the interactions of algorithms and behavioural patterns in the aggregate, it is possible that AI-based

[1] Y Liu et al, "Machine Learning Assisted Materials Design and Discovery for Rechargeable Batteries" (2020) 31 Energy Storage Materials 434.

[2] D Rolnick et al, "Tackling Climate Change with Machine Learning" (2022) 55 ACM Computing Surveys 42.

[3] E Strubell, A Ganesh and A McCallum, "Energy and Policy Considerations for Deep Learning in NLP" (arXiv, 5 June 2019) <http://arxiv.org/abs/1906.02243> (last accessed 14 February 2023).

[4] S Robbins and A van Wynsberghe, "Our New Artificial Intelligence Infrastructure: Becoming Locked into an Unsustainable Future" (2022) 14 Sustainability 4829.

[5] LH Kaack et al, "Aligning Artificial Intelligence with Climate Change Mitigation" (2022) 12 Nature Climate Change 518; C-J Wu et al, "Machine Learning at Facebook: Understanding Inference at the Edge", *2019 IEEE International Symposium on High Performance Computer Architecture (HPCA)* (2019).

[6] K Crawford, *The Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence* (New Haven, CT, Yale University Press 2021).

targeted marketing could fuel less sustainable consumption habits.[7] Sometimes, efficiency gains driven by AI (eg autonomous vehicles, which might be more efficient per unit of distance) can turn out to be less sustainable at the societal level (eg because individualised travel is more often chosen instead of public transit options).[8]

Next, there are channels in which AI can affect sustainability outcomes via its effect on the political process. If AI uptake increases economic inequality within societies,[9] this can contribute to political polarisation and render the political process more dysfunctional, thereby also making effective climate policy less likely.[10] A recent contribution by legal scholars provided a systematic overview and a conceptual framework to understand the role of algorithms in the context of law and regulatory regimes.[11] This article also refers to the important issue of algorithmic filters utilised by for-profit digital platforms and how these can result in the emergence of echo chambers among people with similar views.[12] This raises the challenge as to whether open-source civic-minded platforms can be designed following different principles in such a way that incentivises healthier conversation across opinion camps, as is the objective being pursued in the Taiwan context.

A more optimistic position would be that AI can be useful for creating workable tools for citizen participation. According to this view, citizen participation and associated legitimacy benefits could make more ambitious climate policy possible at the speed required for decarbonising the economy in time before perilous climate tipping points are reached. It is argued that citizen participation can be enhanced via technology-based solutions that enable widespread participation as an added layer that complements traditional representative democracy.[13] Frequently, this process involves relying on civic tech, which is basically digital civic engagement often with the participation of voluntary programmers and coders, allowing for the setting up of open-source systems and tools for citizen deliberation, community organising and mobilisation, helping with the articulation of citizen demands regarding policy. Another concept referred to in this context is crowdsourcing or citizen sourcing, which amounts to finding ways to collect insights dispersed or distributed across large groups that can generate valuable information attuned to circumstances on the ground as guidance for policymaking or any collective choice.[14] Given the sheer quantity of data that emerges from a crowdsourcing exercise,

[7] P Dauvergne, *AI in the Wild: Sustainability in the Age of Artificial Intelligence* (Cambridge, MA, MIT Press 2020).

[8] F Creutzig et al, "Leveraging Digitalization for Sustainability in Urban Transport" (2019) 2 Global Sustainability e14; Z Wadud, D MacKenzie and P Leiby, "Help or Hindrance? The Travel, Energy and Carbon Impacts of Highly Automated Vehicles" (2016) 86 Transportation Research Part A: Policy and Practice 1.

[9] A Korinek and JE Stiglitz, "Artificial Intelligence and Its Implications for Income Distribution and Unemployment" (*National Bureau of Economic Research*, December 2017) <https://www.nber.org/papers/w24174> (last accessed 14 February 2023).

[10] A Gallego and T Kurer, "Automation, Digitalization, and Artificial Intelligence in the Workplace: Implications for Political Behavior" (2022) 25 Annual Review of Political Science 463; M Anelli, I Colantone and P Stanig, "Individual Vulnerability to Industrial Robot Adoption Increases Support for the Radical Right" (2021) 118 Proceedings of the National Academy of Sciences of the United States of America e2111611118; C Boix, "AI and the Economic and Informational Foundations of Democracy" in JB Bullock et al (eds), *The Oxford Handbook of AI Governance* (Oxford, Oxford University Press) <https://doi.org/10.1093/oxfordhb/9780197579329.013.64> (last accessed 14 February 2023).

[11] PRB Fortes, PM Baquero and DR Amariles, "Artificial Intelligence Risks and Algorithmic Regulation" (2022) 13 European Journal of Risk Regulation 357.

[12] ibid.

[13] J Pitt, J Dryzek and J Ober, "Algorithmic Reflexive Governance for Socio-Techno-Ecological Systems" (2020) 39 IEEE Technology and Society Magazine 52.

[14] T Aitamurto and K Chen, "The Value of Crowdsourcing in Public Policymaking: Epistemic, Democratic and Economic Value" (2017) 5 The Theory and Practice of Legislation 55; T Aitamurto and H Landemore, "Crowdsourced Deliberation: The Case of the Law on Off-Road Traffic in Finland" (2016) 8 Policy & Internet 174.

there are efforts to use natural language processing methods and machine learning for analysing civic data.[15] From a different perspective, a recent contribution explored the relationship between AI and democratic processes and democratic legitimacy.[16] That article recognised the risks posed by AI, but also presented arguments according to which AI could at least in principle and under certain carefully assessed conditions even be deployed to counter populist tendencies in politics while advancing democratic legitimacy, especially when considering both its input and output dimensions.[17]

Some authors highlight the potential direct benefits of AI for sustainability, such as boosting scientific advances in green technology. For instance, Nicholas Stern and Mattia Romani point to a potential new growth phase driven by green technology innovation enabled and boosted by AI.[18] They expect tipping points for key relevant technologies to be met in the next five years. They mention advances with regard to green fertiliser, battery systems and crop analysis and in improving climate disaster alert systems. They also see AI helping with breakthrough technologies, such as fusion and solar energy, quantum chemistry or alternative protein design, bringing these technologies closer to large-scale deployment.[19] It is worth noting that if scientific advances facilitated by machine learning succeed in making production processes in the steel, cement and chemicals industries less carbon intensive, this would constitute major progress towards decarbonisation.[20]

There are other contributors to the debate that caution against an overly optimistic view of the solutions that digitalisation can offer for sustainability, emphasising potential governance challenges, for example. According to this view, technology-based sustainability solutions could solidify power imbalances and promote exclusionary tendencies to the detriment of communities and institutional actors in the Global South.[21]

This article is structured as follows: first, the benefits and risks of digitalisation for sustainability policies and outcomes will be explored, including discussions about experiments with innovative participatory methods in Taiwan and about sustainability aspects of foundational models. Next, connections between digitalisation and climate justice will be considered. Lastly, before a brief conclusion, the paper will put forward ideas on how multi-layered governance arrangements for international climate policy could draw on innovative participatory methods.

II. Democratic governance, digitalisation and environmental sustainability

As a starting point, we will briefly discuss some of the potential opportunities and risks of digitalisation for the political process and what this means for the promotion of

[15] T Aitamurto et al, "Civic CrowdAnalytics: Making Sense of Crowdsourced Civic Input with Big Data Tools", *Proceedings of the 20th International Academic Mindtrek Conference* (Association for Computing Machinery, 2016) <https://doi.org/10.1145/2994310.2994366> (last accessed 14 February 2023).

[16] P Cavaliere and G Romeo, "From Poisons to Antidotes: Algorithms as Democracy Boosters" (2022) 13 European Journal of Risk Regulation 421.

[17] ibid.

[18] N Stern and M Romani, "The Global Growth Story of the 21st Century: Driven by Investment and Innovation in Green Technologies and Artificial Intelligence" (*Grantham Research Institute on Climate Change and the Environment*, 2023) <https://www.lse.ac.uk/granthaminstitute/publication/the-global-growth-story-of-the-21st-century/> (last accessed 20 February 2023).

[19] ibid.

[20] Cement and steel production combined are responsible for over 10% of all global greenhouse gas emissions. See: M Fischedick et al, "Industry" in *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, Cambridge University Press 2015) PNNL-SA-103522.

[21] N Bernards et al, "Interrogating Technology-Led Experiments in Sustainability Governance" (2020) 11 Global Policy 523.

sustainability and the green transition. Beginning with the benefits, an enhanced information and communications technology (ICT) infrastructure in combination with improved accessibility could potentially help improve some aspects of the political process and bring about sustainability dividends. Recent social science research explores whether political participation is statistically linked to climate policy or climate outcomes. The contribution by Schaffer and colleagues, analysing six Organisation for Economic Co-operation and Development (OECD) countries, reports empirical evidence that climate policy is responsive to public demand.[22] A recent quantitative study by Escher and Walter-Rogg relying on data from a large cross-section of countries for the period from 1990 until 2020 reports that civil society participation leads to lower carbon dioxide (CO_2) emissions in democracies, but only in the long run.[23]

It is possible to conceive of ways through which technology can facilitate and enhance the quality of political participation. Moreover, digitalisation, employed in new and creative ways, holds the potential of facilitating citizen participation. This could in theory happen in various ways.

First, digital tools could be employed in a manner that promotes deliberation among citizens. These tools could reduce the costs of horizontal communication among citizens. Further, they could reduce the costs of arranging (collective) meetings and establishing other types of interactions among citizens. This increased ease of citizen interactions could be relevant for improving the quality of the political process, as the mutual exchange of views and information among the vote-casting citizenry could improve the collective decisions reached via the aggregation of votes. It has been argued, for instance, that group deliberation could increase the probability that single-peaked preferences materialise, which helps avoid cyclical majorities, a perennial problem affecting democratic preference aggregation. A possible mechanism could consist of group deliberation being helpful for making participants focus on a shared ideological or cognitive dimension, in essence inducing the attainment of a meta-consensus or meta-agreement.[24] Experiments relying on deliberative opinion polls, where preferences of participants are gauged before and after deliberative meetings, produced initial evidence that is in line with this meta-consensus hypothesis.[25] There is also critique of this hypothesis, as well as further assessments relying on computational simulations.[26] Given such insights, and for the purposes of this article, technology-supported citizen deliberation could prove particularly relevant for reaching effective collective decisions that can set the right frame for society to adjust towards meeting the United Nations (UN) Sustainable Development Goals (SDGs).

Second, digital technology could facilitate citizen engagement via experiments involving remote voting. The core of the idea is that technological tools could greatly reduce the costs of political participation and thus encourage more active engagement by the average citizen. Ideally, citizen engagement allows for feedback loops and fine-tuning

[22] LM Schaffer, B Oehl and T Bernauer, "Are Policymakers Responsive to Public Demand in Climate Politics?" (2022) 42 Journal of Public Policy 136.

[23] R Escher and M Walter-Rogg, "The Effects of Democratic and Nondemocratic Institutions on CO_2 Emissions" [2023] Politische Vierteljahresschrift <https://doi.org/10.1007/s11615-023-00458-2> (last accessed 12 May 2023).

[24] D Miller, "Deliberative Democracy and Social Choice" (1992) 40 Political Studies 54; J Knight and J Johnson, "Aggregation and Deliberation: On the Possibility of Democratic Legitimacy" (1994) 22 Political Theory 277; JS Dryzek and C List, "Social Choice Theory and Deliberative Democracy: A Reconciliation" (2003) 33 British Journal of Political Science 1.

[25] C List et al, "Deliberation, Single-Peakedness, and the Possibility of Meaningful Democracy: Evidence from Deliberative Polls" (2013) 75 The Journal of Politics 80.

[26] V Ottonelli and D Porello, "On the Elusive Notion of Meta-Agreement" (2013) 12 Politics, Philosophy & Economics 68; SR Rad and O Roy, "Deliberation, Single-Peakedness, and Coherent Aggregation" (2021) 115 American Political Science Review 629.

of environmental and climate policies, or even for greater citizen input at the policy formulation phase. The idea is to consider the overlap and possible interplay between the (environmental) sustainability domain and what is often termed e-democracy (other related terms are e-government and e-participation).[27]

Regarding remote voting, going forward, distributed ledger technology (DLT) might be used to make reasonably reliable remote voting possible.[28] This would have the advantage of significantly reducing the costs of casting votes, thereby encouraging citizen participation. DLT-enabled remote voting could be tested or piloted at local levels of government, for example. Other contributors point to the serious risks of DLT-based remote voting and question their use.[29] In addition, one should not forget that the potential of remote voting to be democracy-promoting is context-dependent. An important issue in this regard is that if online access is unevenly distributed among the citizenry in question, online participation tools would lead to objectionable inequalities in participation. Discussions on the applicability of remote voting exist, for example, in the context of shareholders of companies voting at annual general shareholder meetings, and those might offer tentative lessons about the risks and opportunities associated with using DLT-supported remote voting, even if they refer to a different, private-sector context.[30]

Assuming that the risks can be sufficiently mitigated, remote voting could vastly reduce the administrative costs of relying on direct democratic methods such as referenda or initiatives as means to increase opportunities for citizen involvement in politics. One can debate whether a high level of direct citizen participation in politics can also have detrimental effects. Examples of such criticisms are that direct democratic elements could possibly magnify populist tendencies, that voters are too uniformed or "rationally ignorant" or that such an approach increases the possibility for dramatic, salient events to induce the electorate to cast votes guided by fleeting emotional reactions, something against which democracy in its representative form is better at safeguarding against. Empirical research on direct democracy cautions against scepticism about allowing more frequent direct citizen involvement and offers evidence that, for instance, the occurrence of referenda and initiatives is associated with significantly higher measured government effectiveness and significantly lower corruption levels.[31] In addition, it could be speculated that direct democracy allows voters to perform an agenda-setting role and motivate the passing of environmental laws and policies that would have been opposed and often successfully "blocked" by influential industry groups or other vested interests that benefit from delaying more ambitious climate policy and have considerable influence in the context of a purely representative system.[32]

[27] M Kneuer, "E-Democracy: A New Challenge for Measuring Democracy" (2016) 37 International Political Science Review 666; M Kneuer and M Datts, "E-Democracy and the Matter of Scale. Revisiting the Democratic Promises of the Internet in Terms of the Spatial Dimension" (2020) 61 Politische Vierteljahresschrift 285.

[28] A Benabdallah et al, "Analysis of Blockchain Solutions for E-Voting: A Systematic Literature Review" (2022) 10 IEEE Access 70746.

[29] S Park et al, "Going from Bad to Worse: From Internet Voting to Blockchain Voting" (2021) 7 Journal of Cybersecurity tyaa025.

[30] D Yermack, "Corporate Governance and Blockchains" (2017) 21 Review of Finance 7; A Lafarre and C Van der Elst, "Shareholder Voice in Complex Intermediated Proxy Systems: Blockchain Technology as a Solution?" (2020) 4 Stanford Journal of Blockchain Law & Policy 29.

[31] L Blume, J Müller and S Voigt, "The Economic Effects of Direct Democracy – A First Global Assessment" (2009) 140 Public Choice 431.

[32] A Vatter, B Rousselot and T Milic, "The Input and Output Effects of Direct Democracy: A New Research Agenda" (2019) 47 Policy & Politics 169.

Third, participatory budgeting is another method of citizen involvement that in some cases relies on online tools. Systems of participatory budgeting have been put in place throughout the world and particularly early on in a few select Brazilian municipalities, in some cases at the neighbourhood or city district level.[33] Citizens are given the opportunity to regularly attend meetings and give input about the allocation of public revenue. Such a model would involve citizens in the hard choices of directing taxpayer money towards sustainability investments that are appropriate to the given local context.[34] Technologically supported communication and virtual preparatory meetings and information sessions could reduce the overall transaction costs associated with participatory budgeting systems. However, relying on online tools could also lead to unequal access and hence unequal participation opportunities, which would undermine democratic principles.[35]

Forth, digitalisation and sensing tools could give citizens new opportunities to hold officeholders more accountable regarding the achievement of sustainability targets. Digitalisation could also increase the public's possibilities for monitoring environmental policies (eg via citizen sensing projects).[36] Decentralised measuring of air quality constitutes an example of this, in which dispersed citizens individually feed their measurements into a common platform, thereby generating precise and timely environmental data that allow the tracking variables of interest.[37] Participation in such projects can be encouraged if the respective platforms are not for profit and run on open-source systems that do not encroach on user privacy or otherwise target users with adverts. Such initiatives would ideally help improve the accountability of political representatives and political officeholders. Monitoring of targets via technology could also render interlinkages between levels of government more effective, enabling more effective polycentric governance. This could help ensure a higher degree of overall coherence of state activity in the sustainability realm. Relatedly, technology could support the effective realisation of the subsidiarity principle, according to which (environmental) policies shall be taken on by the lowest possible level or unit of governance that is closest to voters. The subsidiarity principle envisages room for local governance experimentation, local context-observant policies and citizen feedback. At the same time, benchmarking via sensors could allow local units to be evaluated to make sure that all government units are working towards sustainability targets at the required commonly agreed-upon pace and disincentivise free-riding on the efforts of other units. Comparison of different environmental policy reforms and sustainability strategies and approaches can generate learning.

A few risks regarding digitalisation, sustainability and political processes should be mentioned. The shift towards online political discourse prompted by expanding digitalisation could also create impediments to realising the SDGs. A greater role for ICT and greater social media reliance could further polarise the political discourse and facilitate certain forms of manipulation – especially by vested interest groups with some form of privileged access or resources for launching online campaigns – resulting in potentially detrimental effects for the sustainability agenda. In other words, the reach and

[33] S Gonçalves, "The Effects of Participatory Budgeting on Municipal Expenditures and Infant Mortality in Brazil" (2014) 53 World Development 94; T Peixoto, FM Sjoberg and J Mellon, "A Get-Out-the-Vote Experiment on the World's Largest Participatory Budgeting Vote in Brazil" (2020) 50 British Journal of Political Science 381.

[34] S Gherghina and P Tap, "Ecology Projects and Participatory Budgeting: Enhancing Citizens' Support" (2021) 13 Sustainability 10561.

[35] M Touchton, B Wampler and P Spada, "The Digital Revolution and Governance in Brazil: Evidence from Participatory Budgeting" (2019) 16 Journal of Information Technology & Politics 154.

[36] S Mahajan et al, "From Do-It-Yourself (DIY) to Do-It-Together (DIT): Reflections on Designing a Citizen-Driven Air Quality Monitoring Framework in Taiwan" (2021) 66 Sustainable Cities and Society 102628.

[37] C-C Ho, L-J Chen and J-S Hwang, "Estimating Ground-Level $PM_{2.5}$ Levels in Taiwan Using Data from Air Quality Monitoring Stations and High Coverage of Microsensors" (2020) 264 Environmental Pollution 114810.

influence of concentrated interests could be magnified.[38] Another risk is that if political conversation increasingly shifts to online environments, an amplification of more extreme positions and views could ensue, leading to heightened societal polarisation. Of course, this would also at least to some degree depend on the algorithms and practices of the most widely used (social media) platforms, such as the way in which they utilise AI-powered recommender systems and rely on maximising targeted advert revenues.[39] Intensified political polarisation carries risks for the capacity of state institutions to devise and implement environmental policies in a timely manner, which is required to achieve a sufficiently rapid transformation into climate-neutral economies.

In sum, these remarks indicate that the use of technology for supporting citizen participation in politics also has relevance for environmental policymaking. Given the opportunities and risks of digitalisation for the political process, the ultimate effect of digital technologies on the achievement of sustainability goals arguably hinges, among other factors, on whether the balanced and equitable access of diverse social interests to digital platforms, channels and other digital tools can be achieved, and the extent to which platforms are designed to serve the public interest.

1. Potential dilemma of voice versus speed regarding the green transition

The need for a speedy green and decarbonising transformation of the economy to reach net zero before risky climate-related tipping points are triggered generates significant practical challenges, not only for government officials, but also for private actors and society at large. At the same time, the green transition also offers opportunities.[40] It is also clear that a reallocation of capital of massive magnitude is needed to revamp energy systems so as to make them able to harness sufficient renewable sources to power modern societies.[41] Transmission lines have to be erected at rapid pace to transport energy from locations with large renewable energy supplies all the way to geographically distant, densely populated areas. On a related note, AI can play an important role in more precisely forecasting renewable energy supply, which is helpful for managing an energy system reliant on renewables and the related issue of fluctuating supply, as well as for facilitating transmission line inspection and maintenance.[42]

The construction of large new transmission lines spanning great distances inevitably changes the scenery along their route and can generate resistance from adjacent communities.[43] Ideally, it would be valuable to hear out citizen concerns and objections in the planning phase of such large projects and so enhance democratic legitimacy. However, doing so can increase the chances of delays and could become a problem for the envisioned

[38] However, technological innovation can facilitate non-governmental organisation and civil society communication and links across countries. This could arguably help counterbalance the politically influential organised interests that benefit from a non-sustainable status quo.

[39] S Zhang et al, "Deep Learning Based Recommender System: A Survey and New Perspectives" (2019) 52 ACM Computing Surveys 5; D Acemoglu and S Johnson, *Power and Progress: Our Thousand-Year Struggle Over Technology and Prosperity* (New York, PublicAffairs 2023).

[40] N Stern, *Why Are We Waiting?: The Logic, Urgency, and Promise of Tackling Climate Change* (Cambridge, MA, MIT Press 2015); N Stern, "A Time for Action on Climate Change and a Time for Change in Economics" (2022) 132 The Economic Journal 1259.

[41] PJ Loftus et al, "A Critical Review of Global Decarbonization Scenarios: What Do They Tell Us about Feasibility?" (2015) 6 WIREs Climate Change 93.

[42] R Ahmed et al, "A Review and Evaluation of the State-of-the-Art in PV Solar Power Forecasting: Techniques and Optimization" (2020) 124 Renewable and Sustainable Energy Reviews 109792; VN Nguyen, R Jenssen and D Roverso, "Automatic Autonomous Vision-Based Power Line Inspection: A Review of Current Status and the Potential Role of Deep Learning" (2018) 99 International Journal of Electrical Power & Energy Systems 107.

[43] JJ Cohen, J Reichl and M Schmidthaler, "Re-Focussing Research Efforts on the Public Acceptance of Energy Infrastructure: A Critical Review" (2014) 76 Energy 4.

green transition timeline. Veto tactics and hold-out tactics could be pursued by multiple communities wishing to preserve their current landscape.[44] As a result, a trade-off emerges between offering citizens participation opportunities and achieving the deployment speed required for this extensive new green infrastructure. Perhaps using creatively designed digital participation tools can partly alleviate this trade-off by fomenting citizen deliberation and helping to find acceptable minimum-consensus solutions in the context of the large projects required for the green transition.

2. Digitally enabled citizen participation

Taiwan is a frontrunner jurisdiction in implementing and piloting digitally enhanced tools for political participation. It serves as a unique illustrative example for showcasing the real-world applicability of online citizen engagement systems. Some pilots were also launched in other localities, but at the lower municipal level of government. What makes Taiwan stand out is the fact that it constitutes a case of piloting digital citizen engagement at a large (national) scale, allowing for mass citizen participation.

In the following sections, innovative democratic governance approaches drawing on digital solutions in the context of Taiwan will be introduced. These participatory experiments should provide food for thought regarding their ability to facilitating an ambitiously paced green transition that at the same time satisfies democratic legitimacy criteria.

a. Quadratic voting

It might also be expected that, in addition to existing representative democracy systems, newer and digitally enabled participations forms could emerge and facilitate a more rapid green transition. The new digitised participatory governance system in Taiwan might help to offset some potential criticisms, such as the lack of citizen involvement and the technocratic nature of climate policy.[45]

A key innovation that the Taiwan model put to test was the quadratic voting model that allows voice credits to be allocated to users in order to avoid the common issue raised by social choice and political theorists termed the "tyranny of the majority".[46] Projects are being piloted that rely on quadratic voting to encourage citizen participation for directing public resources to projects that best reflect citizen preferences. An example can be found in the yearly presidential hackathons in Taiwan. Quadratic voting is a form of voting that allows voters to express the intensity of their preferences over certain issues by devoting a larger portion of their "budget of votes" or "voice credits" to items that they deem to be of greatest importance.[47]

The Taiwan presidential hackathon is set up as follows: submitted projects are supposed to offer solutions that aim to contribute to achieving one or more of the SDGs. Approximately 200 projects are submitted, with the goal of receiving government funding. Twenty of these projects are selected for an incubation phase, and then five are ultimately selected for government support funding.

The selection of the 20 projects for incubation out of the original 200 occurs via a quadratic voting selection mechanism. Any person is awarded 99 votes that the person can

[44] BK Sovacool et al, "Conflicted Transitions: Exploring the Actors, Tactics, and Outcomes of Social Opposition against Energy Infrastructure" (2022) 73 Global Environmental Change 102473.

[45] M Ho, "Exploring Worldwide Democratic Innovations – A Case Study of Taiwan" (2022) Exploring Worldwide Democratic Innovations 78.

[46] E Posner and E Weyl, "Voting Squared: Quadratic Voting in Democratic Politics" (2015) 68 Vanderbilt Law Review 441.

[47] ibid; EA Posner and EG Weyl, "Quadratic Voting and the Public Good: Introduction" (2017) 172 Public Choice 1.

allocate to the projects deemed most promising. If a voter intensively favours one project, this voter can cast more than one vote to that project; however, casting two votes to the same project "costs" the voter four votes from their budget, casting three votes to the same project "costs" the voter nine votes, and so forth, hence the term "quadratic voting". The budget of votes was fixed at 99 instead of 100 in order to prevent a voter from using their full vote budget on one single "pet project" (eg the project of an acquaintance) by casting ten votes for that project, which would cost 10^2, totalling 100. With a budget of 99, the most votes someone can cast for their "pet project" is 9, at a cost of 81, which leaves 18 votes in their budget to vote for other projects. This incentivises individuals to scan through and consider other projects.[48] In the 2021 round of the hackathon, citizen expressions of preferences yielded climate-related projects being selected, with four out of the five selected projects that year being focused on environmental and climate-related issues.[49] This shows that, at least in this setting, citizen participation led to strong interest in and support for environmental and climate-focused action.

In sum, quadratic voting as a voting technology is proposed as a way to overcome majority–minority divergences and the related problem of a "populist" tyranny of the majority or plurality that can afflict one-person/one-vote systems typically used in contemporary democracies. It might play a constructive role in encouraging citizen participation in a governance framework for the green transition. It should be noted that critiques have been offered regarding quadratic voting (eg some versions of quadratic voting utilised in certain contexts might pose the risk of undermining democratic values in a way that outweighs its benefits).[50]

b. Crowdsourcing agenda items

A further example of a novel participatory online tool used in Taiwan is the digital platform "polis", which is utilised, for example, to crowdsource public sentiment on a certain regulatory issue. The items deemed most important by the public serve as agenda points that official rule-makers must consider and address when formulating the respective legislation.[51] Polis is designed with the goal of avoiding polarising behaviour of the type that is commonly observed in standard commercial online platforms or social networks. Furthermore, polis as a real-time system for gathering and analysing the opinions or views held by large groups of people, and it uses statistical methods and machine learning to achieve this.

The polis platform aims to achieve consensus-building instead of inducing polarised discussion. A few features of the platform were consciously devised to achieve this aim. First, the user interface of polis is designed such that every participant can contribute an item of concern relating to the regulatory issue for which public views are being collected, with each contribution being limited to a maximum number of characters. Crucially, the interface does not give the opportunity to comment on or respond to any posted contribution, merely to choose to upvote, downvote or pass regarding a specific contribution. This helps to limit the generation of more heated discussion.

[48] "Audrey Tang on What We Can Learn from Taiwan's Experiments with How to Do Democracy" (*80,000 Hours*, 2022) <https://80000hours.org/podcast/episodes/audrey-tang-what-we-can-learn-from-taiwan/> (last accessed 23 February 2023).

[49] ibid.

[50] J Ober, "Equality, Legitimacy, Interests, and Preferences: Historical Notes on Quadratic Voting in a Political Context" (2017) 172 Public Choice 223.

[51] C Small et al, "Polis: Scaling Deliberation by Mapping High Dimensional Opinion Spaces" (2021) 26 RECERCA. Revista de Pensament i Anàlisi <https://www.e-revistes.uji.es/index.php/recerca/article/view/5516> (last accessed 15 February 2023).

Second, polis displays a map or visual depiction of the opinion space based on the many (grouped) views entered into the system. Points of agreement and disagreement are visualised through a combination of principal component analysis (PCA), a standard method used for exploratory data analysis, and *k*-means clustering, a common machine learning algorithm that iteratively assigns data points into *k* clusters by minimising the variance in each cluster. Put simply, PCA is used for dimension reduction, and *k*-means clustering and the so-called silhouette coefficient allow for the grouping of participants into opinion groups.

Third, in a gamified way, the system nudges participants towards posting items that promote consensus by attracting support from participants across the otherwise diverging opinion groups. Only the items that receive support across all of the different clusters get selected as agenda items, which incentivises the proposal of original or moderate statements that could receive support from across the aisle. The visualisation is updated continuously, and the underlying data are open, ensuring transparency. In parallel, discussion and deliberation are facilitated via tools such as Sli.do, Discord and Hackpad in order to support the search for common ground.

The polis platform system as a whole strives to facilitate the bottom-up expression of citizen demands and needs at scale, which adds an important participatory element to representative democracy. Technological tools make this feasible for large populations. In the case of Taiwan, more than half of the country's 24 million citizens participated in one of its digitally enabled decentralised governance initiatives. The question remains as to whether a specific historical and political context was essential for the success of these participatory governance experiments in Taiwan or whether they can be successfully employed in other democracies. Especially for the crafting of ambitious climate and environmental policy, the legitimacy afforded by novel forms of citizen engagement could play an important role.

3. Large language models and sustainability

The last subsection relied on the illustrative case of Taiwan, which is a frontrunner jurisdiction in piloting large-scale citizen engagement projects, and it was explored whether creative, open-source digital tools could play a constructive role in facilitating citizen participation, in some cases drawing on AI algorithms for processing and visualising the large amounts of citizen inputs. And earlier in the article, how digitalisation could affect democratic processes was explored (eg how digitally enhanced communication could affect opportunities for political deliberation). Large language models (LLMs) represent an important new development, with these having become widely available at the end of 2022 in form of OpenAI's ChatGPT. These types of models could potentially lower the cost of engaging in polarising campaigning, which could negatively affect the quality of political deliberation and civic discourse.

Hence, these new machine learning advances introduce their own set of challenges, which shall be briefly discussed. Text-generating LLMs such as ChatGPT could be misused to create and disseminate misinformation online, which can also include climate change denialist misinformation and add to a polarised political environment that makes pragmatic climate policy harder to achieve.[52] However, at the same time, powerful AI systems can also be employed to detect posts containing disinformation, making it possible to filter them out or flag them.[53] AI-reliant disinformation campaigners will attempt to tweak and adapt their models in order to escape automated detection. As observed by

[52] KMd'I Treen, HTP Williams and SJ O'Neill, "Online Misinformation about Climate Change" (2020) 11 WIREs Climate Change e665.

[53] N Bontridder and Y Poullet, "The Role of Artificial Intelligence in Disinformation" (2021) 3 Data & Policy e32.

commentators, this results in an incessant "algorithm race" between models capable of creating manipulative text containing falsehoods and models created with the purpose of detecting these.[54]

This relates to the question of potential policy frameworks that can address the evolving field of LLMs, also called foundational models, and the related challenges regarding their more immediate sustainability implications. These foundational models are closest to an existing version of an AI system that can slowly start to be deployed for a broad range of different tasks. Therefore, this is the version of AI technology that will first be tested in terms of its capacity to become a general-purpose tool. Depending on whether it proves to be useful in various application areas (which as yet is difficult to anticipate), these foundational models could potentially be highly demanded and disseminate very rapidly. In addition, the training of foundational models is hugely energy intensive, therefore representing a source of concern regarding the sustainability dimension.[55]

Others are less alarmed by the overall energy demands of foundational models, especially if certain best practices are followed.[56] It is argued that relying on pre-trained large models – which are trained on some data category or dataset – as input for tackling a specific new domain can be cost-saving because the requirement for only one (surely energy intensive) pre-training process, without it having to be repeated each time, can then serve as basis for adjustment or fine-tuning and deployment in numerous different domains.[57] Furthermore, it is argued that the main climate change challenge is the lifecycle costs of manufacturing computing equipment of all kinds and sizes and not the operational costs of machine learning.[58]

Besides training, inference could also create sustainability risks linked to high energy demands. It is not yet clear how much energy would be consumed by edge devices utilising and relying on large models for multiple everyday situations across populations of users.[59]

A complex scenario with a few challenges emerges with regard to how a governance regime might look that could address LLMs and their specific features. Given the potential power of LLMs to boost and transform economic activity, it is unlikely that they will lose relevance anytime soon. There are a few features that characterise the ecosystem of LLMs. First, only a few different players hold the resources to develop such sizeable models. Second, given their potential general-purpose applicability and economic importance, the major jurisdictions competing at the technology frontier will seek to incentivise the development of such foundational models. An (international) governance regime attuned to the sustainability risks of LLM development and deployment would need to factor in geopolitical rivalry realities and the difficulty that governments face in regulating effectively when (market) dynamics lead to power concentration around a few oversized and influential organisations.

[54] K-C Yang et al, "Arming the Public with Artificial Intelligence to Counter Social Bots" (2019) 1 Human Behavior and Emerging Technologies 48.

[55] R Bommasani et al, "On the Opportunities and Risks of Foundation Models" (arXiv, 12 July 2022) <http://arxiv.org/abs/2108.07258> (last accessed 21 February 2023).

[56] D Patterson et al, "Carbon Emissions and Large Neural Network Training" (arXiv, 23 April 2021) <http://arxiv.org/abs/2104.10350> (last accessed 14 February 2023).

[57] ibid; P Hacker, A Engel and M Mauer, "Regulating ChatGPT and Other Large Generative AI Models" (arXiv, 10 February 2023) <http://arxiv.org/abs/2302.02337> (last accessed 21 February 2023).

[58] D Patterson et al, "The Carbon Footprint of Machine Learning Training Will Plateau, Then Shrink" (2022) 55 Computer 18.

[59] Kaack et al, supra, note 5; Wu et al, supra, note 6.

III. Digitalisation and climate justice

In this section, observations on a number of links between digitalisation and climate justice considerations will be made. This is in order to contribute to the policy discussion by highlighting the importance of the sustainability-related effects of digitalisation not only for high-income regions, but also for jurisdictions in the Global South. Climate justice as an idea and concept revolves around the issues of: (1) which nations most contributed historically to the current stock of CO_2 in the atmosphere; (2) which nations, regions and communities are most dangerously exposed to a changing climate, while also considering the fact that often these locations did not contribute significantly to the atmospheric carbon stock; (3) how do we determine the allocation of expenses for climate mitigation and adaptation taking into account the first two points; and (4) how do we provide the opportunities for non-industrialised nations to elevate their per-capita material well-being without such a trajectory being emission-intensive and imposing a large burden on the global climate.[60] With that background in mind, it is worth exploring what role AI and digitalisation can play in connection to some of these climate justice considerations.[61]

Regarding the emissions of greenhouse gas (GHG) linked to digitalisation, unequal patterns are also found here. High-income countries presently still account for vastly higher per-capita GHG emissions compared to countries of the Global South. Similarly, there are discrepancies regarding digitalisation rates – for instance, the percentage of the population owning a smartphone is significantly higher in these high-income countries in comparison to developing countries. Digital devices account for 8–10% of global electricity consumption and are responsible for 2.1–3.9% of global GHG emissions, and these numbers are estimated to increase.[62] With digitalisation in high-income countries occurring at a more extensive scale or per-capita use being more intense, this is a further factor contributing to emissions inequality.

Next, the unequal incidence of harms due to climate change shall be considered. For instance, more agriculture-intensive countries and regions that historically contributed little to the global emissions stock are more vulnerable and therefore could face more serious impacts stemming from extreme weather events related to climate change.[63] Now, in principle, digitally supported techniques could play a positive role in increasing the resilience of agricultural regions to more unstable weather conditions, hence helping with adaptation to climate change in these areas.[64] A conglomeration of methods relying on sensors, large-scale data collection and the processing of these data via machine learning could ideally help both reduce the amount of pesticide utilisation and identify crops and farming processes that are more resilient to extreme weather events. On the other hand, such "precision farming" methods could also come with their own challenges, such as unequal access to data and tools and deployment difficulties in regions with less developed ICT and energy infrastructures.[65]

Besides the issue of enhancing adaptation specifically for agricultural economies, digital tools could be relevant for tracking and measuring various climate change impacts. The

[60] C Okereke, "Climate Justice and the International Regime: Climate Justice and the International Regime" (2010) 1 Wiley Interdisciplinary Reviews: Climate Change 462.

[61] T Santarius, "Climate Justice and Digitalization: A Plea to Consider Broader Socio-Economic Implications of Digitalization and Climate Change" (2022) 31 GAIA – Ecological Perspectives for Science and Society 146.

[62] ASG Andrae, "New Perspectives on Internet Electricity Use in 2030" (2020) 3 Engineering and Applied Science Letters 19.

[63] M Kummu et al, "Climate Change Risks Pushing One-Third of Global Food Production Outside the Safe Climatic Space" (2021) 4 One Earth 720.

[64] L Klerkx and D Rose, "Dealing with the Game-Changing Technologies of Agriculture 4.0: How Do We Manage Diversity and Responsibility in Food System Transition Pathways?" (2020) 24 Global Food Security 100347.

[65] JE Addicott, *The Precision Farming Revolution: Global Drivers of Local Agricultural Methods* (Berlin, Springer 2020); Santarius, supra, note 61.

generated information can then inform both mitigation and adaptation activities. Digital tools for monitoring and forecasting weather conditions can help predict extreme weather, and early alerts can help communities prepare accordingly. Additionally, sensor devices can be used for data collection to measure the state of ecosystems, help track species populations, measure soil health or identify impending droughts, as well as gauge the risk of forests fires.[66]

In addition, ongoing monitoring of forest cover via satellite imagery produces deforestation alerts that can help activate remedial action on the ground earlier. Machine learning tools for image analysis can play a role in the continuous scanning of these satellite images (eg for improving the accuracy in the detection of deforestation activity).[67] For this purpose, these remote satellite detection systems need to be integrated with actors on the ground who can take action against the perpetrators of illegal logging. Actors on the ground can also ascertain whether such remote alerts are false positives, such as a small clearing due to, for example, a naturally occurring limited forest fire, which would lead to rapid vegetation regrowth. It can be further noted that remote satellite technology on its own cannot solve the problem; sufficient incentives must exist for local communities and local authorities to act on the remote alerts and combat illegal deforestation activities. To provide a concrete example of a study on such forest monitoring initiatives, a randomised controlled trial was conducted in the Peruvian Amazon assessing the effect of non-governmental organisation (NGO)-delivered training for enhancing community forest monitoring practices and integrating this training with the remote alert system, including remunerated monitoring patrols by locals and making available a smartphone mapping application.[68] The study concluded that the programme helped reduce forest cover loss, especially for areas facing high levels of deforestation threat, but also that the strength of the effect declined over time.

However, some caveats are in order. First, the approach envisaged in the study might lose effectiveness if the forests in question sit on oil or valuable minerals or hold other resources of considerable value to prospective offenders, in which case the efforts of communities to drive out determined illegal intruders might not suffice as a deterrent. Julio Berdegué, Food and Agriculture Organization (FAO) Assistant Director-General and Regional Representative for Latin America and the Caribbean, alerts that organised crime threatens the lives of many social leaders of indigenous and tribal communities.[69] Second, communities must have enough trust in state enforcement authorities to activate them if they observe high-threat intruders. State capacity and determination are not always existent to a sufficient degree. Third, community monitoring efforts probably are most effective if they are scaled up comprehensively. Otherwise, one might expect displacement of illegal deforestation activities to less monitored portions of the forest, which would not bring total deforestation levels down. In sum, technology-facilitated community monitoring of forests, supported by (external) capacity-building NGOs, can achieve favourable results. Overall effectiveness probably depends on contextual conditions and on significant scaling up of monitoring programmes to prevent leakage and displacement

[66] Santarius, supra, note 61.

[67] In the future, machine learning-based approaches could even generate near-future predictions of deforestation risk based on a range of contextual variables (topography, accessibility, precipitation seasonality, land use, socio-economic indicators), which could inform preventative patrolling and monitoring of relevant forest units.

[68] T Slough, J Kopas and J Urpelainen, "Satellite-Based Deforestation Alerts with Training and Incentives for Patrolling Facilitate Community Monitoring in the Peruvian Amazon" (2021) 118 Proceedings of the National Academy of Sciences of the United States of America e2015171118.

[69] R Montes, "El crimen organizado está matando a muchos líderes de las comunidades indígenas y tribales" (*El País*, 30 March 2021) <https://elpais.com/internacional/2021-03-30/el-crimen-organizado-esta-matando-a-muchos-lideres-de-las-comunidades-indigenas-y-tribales.html> (last accessed 14 February 2023).

effects. Lastly, critical voices point out that approaches relying on climate-related large data collection, as are currently being pursued, might insufficiently account for or might distract from contested issues of sovereignty, responsibility and accountability within international climate politics.[70]

Regarding making burden-sharing fairer, digital data collection and processing also have a potential role to play. At the 2022 UN Climate Change Conference (COP27) in Egypt, for the first time an agreement was reached on establishing a fund for loss and damage, a third pillar in the climate policy conversation besides mitigation and adaptation. The fund is set up to channel financing in response to economic harms from climate-fuelled disasters, such as floods, hurricanes and wildfires, in addition to harms from slow-onset climate impacts, such as sea-level rise, which can inflict irreversible destruction. Even if countries invest in adaptation, there are climate-related impacts that adaptation cannot protect against, and these fall under the loss and damage category.[71] Over the years of climate talks, industrialised countries have opposed the creation of an official regime for providing financing for loss and damage, but at COP27 a first cautious step was taken, although it is important to note that many details were left undetermined. One of the challenges pertains to estimating and quantifying climate-related loss and damage as well as ascertaining responsibility, an effort that would rely on computational modelling, running climate simulations and drawing on repositories of extensive climate and economic data.[72] The costs of the loss and damage caused by climate change are substantial – for instance, an estimated 20% of GDP was lost due to climate change impacts in Vulnerable Twenty (V20) countries over the last two decades. It is argued that AI could help to predict and prevent future losses.[73] Other voices point out risks in taking such an approach – for example, relying on digitalisation and algorithms in the context of loss and damage could represent deploying externally designed methods of quantification that might not align with community preferences.[74]

Another challenge connected to digitalisation concerns the environmental and human rights challenges of minerals extraction. Digitalisation and machine learning can be in some respects beneficial for achieving climate goals; however, they generate a harmful footprint of their own. The latter can be expressed in terms of energy consumption, but also in terms of the negative impacts of rare earths and materials extraction for building the hardware underpinning digitalisation. Extraction can occur in a form that relies upon unethical conditions for local labour, and extraction sites can be destructive for surrounding ecosystems, negatively affecting local communities.[75] It shall be noted that extraction of these resources frequently occurs in less developed countries, where redress opportunities afforded to impacted communities can be very limited.

The European Union (EU) is creating legislation for making (international) supply chains more transparent in an attempt to reduce the occurrence of, for example, human rights-infringing practices along the supply chain.[76] The question remains as to whether

[70] A Gupta, "The Advent of 'Radical' Transparency: Transforming Multilateral Climate Politics?" (2023) 2 PLoS Climate e0000117.

[71] EA Page and C Heyward, "Compensating for Climate Change Loss and Damage" (2017) 65 Political Studies 356; R Mechler and T Schinko, "Identifying the Policy Space for Climate Loss and Damage" (2016) 354 Science 290.

[72] CW Callahan and JS Mankin, "National Attribution of Historical Climate Damages" (2022) 172 Climatic Change 40; G Bettini, G Gioli and R Felli, "Clouded Skies: How Digital Technologies Could Reshape 'Loss and Damage' from Climate Change" (2020) 11 WIREs Climate Change e650.

[73] Stern and Romani, supra, note 18.

[74] Bettini et al, supra, note 72.

[75] Crawford, supra, note 6.

[76] H Jones, "EU Lawmakers Back Pulling More Companies into ESG 'Due Diligence' Net" (*Reuters*, 9 February 2023) <https://www.reuters.com/business/sustainable-business/eu-lawmakers-back-pulling-more-companies-into-esg-due-diligence-net-2023-02-09/> (last accessed 23 February 2023).

the proposed legislation will be appropriately enforced, especially when it comes to securing minerals for producing chips and other hardware that are essential for digital infrastructure and products deemed of great economic importance. In addition, given the scarcity of some inputs and the competition between main global economic players for securing sufficient supply, considerations of human rights and environmentally friendly practices might become deprioritised.

Another leverage point would be reducing e-waste by implementing a circular economy strategy.[77] In the EU, plans for "digital product passports" (DPPs) are becoming more concrete, and they are an element of the proposed Ecodesign for Sustainable Products Regulation and one of the major initiatives under the Circular Economy Action Plan (CEAP).[78] DPPs represent in essence a method for collecting and sharing product data throughout its lifecycle, and they can carry information on a product's sustainability and recyclability attributes. Stored product data from across the supply chain (including, for instance, raw material sourcing and manufacturing processes) are contained in the DPP. This information is made available so that different actors, including consumers, can become aware of the materials and products they use and, for example, their embodied environmental impact.[79] Somewhat ironically, the DPP idea is itself a digital solution that would require significant data collection and storage regarding the characteristics of a great number of covered products.

To finalise, it shall be pointed out that the EU and the USA are making declarations of intent with regard to aligning digitalisation and AI with climate objectives in the context of international cooperation initiatives. On 28 April 2022, the EU and the USA, together with other international partners, proposed a "Declaration of the Future of the Internet".[80] The declaration states that the signatory partners "actively support a future for the Internet that is open, free, global, interoperable, reliable, and secure".[81] In order to promote this vision, the declaration makes several references to the importance of democracy and democratic institutions, and it also highlights that for trust in the digital ecosystem to emerge, there should be an effort to "[c]ooperate to maximize the enabling effects of technology for combatting climate change and protecting the environment whilst reducing as much as possible the environmental footprint of the Internet and digital technologies".[82] The weight dedicated to environmental issues and sustainability was even stronger in the January 2023 Administrative Arrangement to strengthen research on AI for the public good, signed

[77] T Götz et al, "Digital Product Passport: The Ticket to Achieving a Climate Neutral and Circular European Economy?" (*University of Cambridge Institute for Sustainability Leadership*, 2022) <https://epub.wupperinst.org/frontdoor/deliver/index/docId/8049/file/8049_Digital_Product_Passport.pdf> (last accessed 12 May 2023).

[78] G van Capelleveen et al, "The Anatomy of a Passport for the Circular Economy: A Conceptual Definition, Vision and Structured Literature Review" (2023) 17 Resources, Conservation & Recycling Advances 200131; A Gumbau, "Digital Product Passports Become the Norm in EU's Green Economy Plan" (<www.euractiv.com>, 21 November 2022) <https://www.euractiv.com/section/circular-economy/news/digital-product-passports-become-the-norm-in-eus-green-economy-plan/> (last accessed 23 February 2023); Götz et al, supra, note 77.

[79] Götz et al, supra, note 77.

[80] As of 30 January, the countries that have signed the declaration in addition to the EU Member States and the USA are: Albania, Andorra, Argentina, Australia, Belize, Bosnia and Herzegovina, Cabo Verde, Canada, Chile, Colombia, Costa Rica, Dominican Republic, Georgia, Iceland, Israel, Jamaica, Japan, Kenya, Kosovo, Liechtenstein, Maldives, Marshall Islands, Micronesia, Moldova, Monaco, Montenegro, New Zealand, Niger, North Macedonia, Norway, Palau, Peru, Republic of Korea, San Marino, Serbia, Taiwan, Trinidad and Tobago, the UK, Ukraine and Uruguay. "Declaration for the Future of Internet | Shaping Europe's Digital Future" (28 April 2022) <https://digital-strategy.ec.europa.eu/en/library/declaration-future-internet> (last accessed 30 January 2023).

[81] "A Declaration for the Future of the Internet" (2022) <https://www.whitehouse.gov/wp-content/uploads/2022/04/Declaration-for-the-Future-for-the-Internet_Launch-Event-Signing-Version_FINAL.pdf> (last accessed 30 January 2023).

[82] ibid.

by the Directorate-General for Communications Networks, Content and Technology (DG CONNECT) and the US Department of State.[83] It was reported that the collaboration will aim to develop "AI research results that have the potential for broad societal benefits in areas ranging from climate change, natural disasters, health and medicine, electric grid optimisation to agriculture", building on the principles outlined in the aforementioned declaration.

In sum, digitalisation and AI could, in principle, be deployed for numerous undertakings aimed at ameliorating climate justice concerns. However, significant challenges exist regarding the issue of equitable or balanced access, the climate footprint stemming from powering digital infrastructures, their unequal distribution within and particularly across countries and lastly the challenge of assuring the sustainable sourcing of rare earths and minerals used to produce the hardware for digital infrastructure and devices.

IV. Multi-layered governance

In this section, we put forward ideas on how multi-layered governance arrangements for international climate policy could draw on innovative participatory methods in order to explore whether this could facilitate concerted international efforts towards a swift green transition and achieving climate objectives.

The role of digital technologies, including AI, and their relation to environmental governance regimes is a promising area for social science research. A few potential research directions that fall under this overall theme will be briefly discussed. First, going forward, it will also become ever more important to further study the linkages between national and international governance and in what ways these multi-layered governance structures shape the incentives of various institutional actors to address transnational challenges such as climate change or other global commons problems.[84]

Even if originally conceived for large-scale citizen participation, some of the democratic innovations discussed in Section II.2 in the context of applications trialled in Taiwan could also play a constructive role in a different context, namely the multi-layered international climate governance regime. Some of the ideas that emerge from this discussion are readily applicable, while others are less realistic or feasible for the near future.

For a start, transnational city networks for climate action could use a digital platform relying on quadratic voting inspired by the Taiwan presidential hackathon example to identify and rank from a large pool of submitted municipal climate projects which ones are believed to potentially have the most promising climate mitigation or adaptation impacts.[85] A predetermined number of best-placed projects, according to the quadratic voting exercise, could then qualify for funding from an international climate fund or from an associated international organisation. The actors casting the votes could be representatives for each participating city or municipality administration. A concern

[83] "The European Union and the United States of America Strengthen Cooperation on Research in Artificial Intelligence and Computing for the Public Good | Shaping Europe's Digital Future" (27 January 2023) <https://digital-strategy.ec.europa.eu/en/news/european-union-and-united-states-america-strengthen-cooperation-research-artificial-intelligence> (last accessed 31 January 2023).

[84] KW Abbott, "Strengthening the Transnational Regime Complex for Climate Change" (2014) 3 Transnational Environmental Law 57; T Bernauer, "Climate Change Politics" (2013) 16 Annual Review of Political Science 421; H Fuhr, T Hickmann and K Kern, "The Role of Cities in Multi-Level Climate Governance: Local Climate Policies and the 1.5°C Target" (2018) 30 Current Opinion in Environmental Sustainability 1.

[85] T Lee, "Global Cities and Transnational Climate Change Networks" (2013) 13 Global Environmental Politics 108.

here would arise if transnational municipal networks happen to be skewed towards Europe and North America while the Global South is underrepresented.[86]

To offer a more aspirational type of argument, some form of reliance on a decision-making system utilising quadratic voting within international climate negotiations might have advantages from a moral or ethical standpoint. Quadratic voting is an attempt to better reflect the intensity of preferences in collective decision-making. Given that some countries are more vulnerable to climate-related events that cause significant damage, these countries have arguably relatively strong preferences in favour of effective international climate mitigation policy and international funding mechanisms for adaptation. A one-state/one-vote system would not allow these more intense preferences to be reflected.[87] Relying on quadratic voting for international negotiations would allow vulnerable countries to express the intensity of their preferences regarding climate policy, and this would represent a form of governance innovation aligned with certain ethical maxims derived from climate justice considerations.[88] However, it is unrealistic to believe that this type of voting method will be adopted in international politics anytime soon, especially for binding collective decisions. States would arguably not accept giving up sovereign decision-making to the degree that a quadratic voting system would demand. Furthermore, quadratic voting as a method would probably need to be tested out at a lower scale and within a lower-stakes context; only after consistently satisfactory outcomes in real-world settings are demonstrated would actors be more willing to rely on it in the future for reaching binding decisions.

A system akin to the digital polis platform, in which items are made public and then dynamically voted up or down or passed and the opinion configurations are visually displayed and continuously updated with the help of statistical analysis and machine learning, could be used in the context of the yearly UN climate conferences (COP). Participants in this exercise could be the members of all COP country delegations in the preparatory phase in advance of the yearly COP, who could generate suggested agenda items for the actual event. The polis system rewards posted items that elicits broad support from across opinion camps, thereby encouraging or nudging contributors to post consensus-seeking items or items that are creative or unconventional in a way that attracts support from actors who have otherwise disparate and diverging views. Building consensus around certain items in advance could then, ideally, help induce faster and more pragmatic progress in reaching concrete agreements at these conferences. The question remains as to whether all participating countries, especially the larger ones holding more diplomatic weight, would agree to such a system, or whether it would be perceived as threatening their interests. On the one hand, such a platform would be a preliminary idea-generating exercise for agenda items and would not produce any binding outcomes, which might make it more acceptable to the major players. However, controlling what gets elevated to the agenda is probably also of importance to major countries, given that they might be exposed if items that are inconvenient for them get to be discussed and attract support among a large majority of countries, compelling these major countries to publicly justify their divergent positions.

One concern or objection regarding using a polis-like platform in this context might be the issue of representativeness (eg if a wealthier country has a very large COP delegation

[86] JS Bansard, PH Pattberg and O Widerberg, "Cities to the Rescue? Assessing the Performance of Transnational Municipal Networks in Global Climate Governance" (2017) 17 International Environmental Agreements: Politics, Law and Economics 229.

[87] E Posner and A Sykes, "Voting Rules in International Organizations" (2014) 15 Chicago Journal of International Law 195.

[88] On the other hand, oil-producing countries could have intense preferences against rapid decarbonisation and against ambitious climate policy. They still might be outvoted in a context in which there is also a group of countries intensely concerned with potentially irreversible climate-induced damage.

whose size does not accurately reflect or correspond to the country's share of the global population, or the members of a wealthier country's delegation are afforded more time to engage in the digital platform). One counterpoint to this representativeness critique is that the polis platform is programmed to count the configuration of preferences instead of head-counting upvotes and downvotes. The opinion camps resulting from participants that engage less or in smaller numbers in the platform or any significant minority opinion groups within the high-dimensional space of statements and clusters must be "convinced" for an item to emerge as a broadly supported statement that gets put forward as a winning item that makes it to the agenda.

Another example where innovative governance arrangements and opportunities for participation can play a role would be in the context of the nationally determined contributions (NDCs), which is the term for each country's non-binding GHG reduction targets and plans under the UN Framework Convention on Climate Change (UNFCCC) that, since the Paris Agreement, apply equally to both developed and developing countries.[89] NDCs are a government obligation under the Paris Agreement, and one or more national ministries will generally lead their development.[90] However, to implement the NDCs in an effective manner, it would help if they were commonly understood, supported and followed by businesses, civil society and citizens. Using digital open-source platforms such as polis or other related tools for crowdsourcing citizen views can potentially help us to identify appropriate and implementable solutions at different levels for achieving these targets. Since NDCs are reviewed and redefined at certain intervals, digitally enabled participatory governance mechanisms could facilitate ministries to draw on dispersed citizen insights and wisdom for defining and legitimising the NDC priorities that are achievable and sufficiently ambitious.

V. Conclusion

This policy-oriented paper explored the sustainability dimension of digitalisation, including the use of technologies such as AI. While digitalisation can contribute to halting climate change via, for instance, targeted applications in specific domains, it could also have detrimental effects on climate policy goals. This paper outlined the opportunities and risks brought by digitalisation to climate justice issues as well as citizen participation regarding environmental and climate policymaking. With a case example from Taiwan, where AI-facilitated digital tools have been used to help set up frameworks for bottom-up citizen participation, it was discussed how this could generate the legitimacy and popular buy-in required for rapid green transformation. The idea is to put forward suggestions of how to escape from or ameliorate a potential dilemma of voice versus speed regarding the green transition, given that significant infrastructure (re)development is needed to reach net zero, such as radically revamping the energy infrastructure, among other crucial elements, to implement a comprehensive decarbonisation strategy. The article offered a critical look at digitally facilitated citizen participation in addition to debating its potential relevance within a multi-layered climate governance system.

It should also be highlighted that digitally enabled governance tools are likely to only bring about positive impacts under certain contextual conditions. For instance, if they are deployed under circumstances characterised by uneven access, then these

[89] A Vogt-Schilb and S Hallegatte, "Climate Policies and Nationally Determined Contributions: Reconciling the Needed Ambition with the Political Economy" (2017) 6 WIREs Energy and Environment e256; M Winning et al, "Nationally Determined Contributions under the Paris Agreement and the Costs of Delayed Action" (2019) 19 Climate Policy 947.

[90] To date, all 193 Parties to the Paris Agreement have put forward at least a first NDC.

tools could even exacerbate previous inequalities of participation or create new ones. Another issue to be considered is whether there are open-source digital applications, platforms and infrastructures available that are geared towards pursuing the public interest and do not rely on a business model that thrives upon inducing or inviting emotional reactions that can drive societal polarisation.

Competing interests. The author declares none.

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