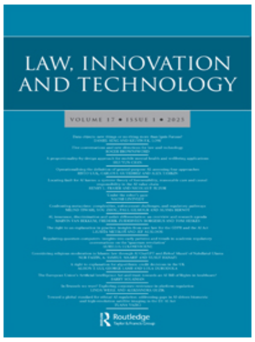

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Artificial intelligence, the earth system, and the law

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ABSTRACT
The speed of development and use of artificial intelligence (AI) is rapidly increasing. While the potential for AI to contribute to tackling global challenges, including climate change and biodiversity is widely acknowledged, various socio-ecological impacts arise during the lifecycle of AI. Such impacts arise from the extraction of rare earth elements in the manufacture of computing equipment, such as graphics processing units, and the operation of energy- and water-intensive computer servers during the training and use of AI models. This article posits that, thus far, insufficient regulatory attention is paid to such impacts. Emerging regulatory initiatives in the European Union and the United Kingdom are briefly discussed, revealing that these approaches are overly human-centric. Focusing on ecological impacts of AI, the chapter explores elements that should be included in AI regulation to contribute to safeguarding the earth system alongside AI's rapid expansion.

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KEYWORDS Artificial intelligence; climate change; earth system; law; regulation; ecological impacts

1. Introduction

Artificial intelligence (AI) has been described as 'the fastest growing deep technology in the world, with huge potential to rewrite the rules of entire industries, drive substantial economic growth and transform all areas of life'.[1] AI also harbours significant potential to contribute to environmental protection, in particular by predicting environmental risks and monitoring compliance with environmental laws.[2] At the same time, AI poses threats to various

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[1]HM Government, *National AI Strategy* (2021) available at https://www.gov.uk/government/publications/national-ai-strategy (accessed 24 Nov. 2023).

[2]Paul Collins, 'The role of artificial intelligence in environmental regulation' (17 Oct. 2023) *London School of Economics* available at https://blogs.lse.ac.uk/politicsandpolicy/the-role-of-artificial-intelligence-in-environmental-regulation/ (accessed 7 Dec. 2023).

components of the earth system, which are becoming increasingly manifest.[3] Thus, AI is associated with pollution, high energy consumption, high water consumption, emission of greenhouse gases, as well as impacts on human health and the exploitation of vulnerable workers.[4] Compared to AI concerns relating to privacy, national security, and cybersecurity, much less attention is paid to these socio-ecological impacts. Fundamentally, the interests of humans and non-humans have been perceived as distinct and distinguishable, with the former trumping the latter.[5]

AI 'promises to be as pervasive as the internet or smartphones and is [therefore] a technology for which we cannot afford to ignore the environmental costs'.[6] The speed of development and use of AI indeed is increasing explosively, the latter being illustrated by the nearly eight billion visits of the ChatGPT website during the first six months of 2024 alone.[7] Regulation of AI therefore is beginning to emerge, which largely fails to address environmental impacts. Yet, against the backdrop of rapidly rising greenhouse gas emissions, species extinctions, accelerating plastic consumption and pollution, and accelerating biodiversity loss, among many other environmental crises,[8] there clearly is no room for AI to compromise the integrity of the earth system further.[9] It therefore is vital for existing and emerging AI regulation to address environmental impacts of AI. Yet, they remain underexplored

[3]Broadly, the earth system is made up of the atmosphere (the layer of air surrounding Earth), the hydrosphere (the Earth's water), the cryosphere (the Earth's frozen areas), and the lithosphere (the Earth's rocky component); the biosphere (all life on Earth); and the anthroposphere (which includes those parts of the Earth that have been made or modified by humans): Sarah Cornell and others (eds), *Understanding the Earth System: Global Change Science for Application* (Cambridge University Press 2012) Box 2, xvii–xviii.

[4]These impacts are discussed in detail in section 3 below.

[5]Andrea Owe and Seth D. Baum, 'Moral Consideration of Nonhumans in the Ethics of Artificial Intelligence' (2021) 1 *AI and Ethics* 517.

[6]Aimee van Wynsberghe, 'Sustainable AI: AI *for* Sustainability and the Sustainability *of* AI' (2021) 1 *AI and Ethics* 213, at 214.

[7]Calculated from data available at Exploding Topics, 'Number of ChatGPT Users (Aug 2024)' <available at https://explodingtopics.com/blog/chatgpt-users> (last accessed 30 August 2024.).

[8]See, *inter alia*, Stockholm Resilience Institute, 'Planetary Boundaries' (undated) available at https://www.stockholmresilience.org/research/planetary-boundaries.html (accessed 26 July 2024); Elizabeth Kolbert, *The Sixth Extinction: An Unnatural History* (Henry Holt and Company 2014); Gerardo Ceballos, Paul R. Ehrlich, and Rodolfo Dirzo, 'Biological Annihilation via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines' (2017) 114 *PNAS* E6089; Roland Geyer, Jenna R. Jambeck, and Kara Lavender Law, 'Production, Use, and Fate of All Plastics Ever Made' (2017) 3 *Science Advances* 1700782; Valerie Masson-Delmotte and others (eds), 'Summary for Policymakers' in *Climate Change 2021: The Physical Science Basis: Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press 2021) available at https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf (accessed 24 Nov. 2023); Sandra Díaz and others (eds), 'Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services' *Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (2019) available at https://www.ipbes.net/global-assessment (accessed 24 November 2023).

[9]By 2023, six of nine planetary boundaries, identified by earth system scientists as demarcating a habitable planet for humans, had been transgressed: Stockholm Resilience Institute (n 8); Katherine Richardson and others, 'Earth Beyond Six of Nine Planetary Boundaries' (2023) 9 *Science Advances* eadh2458.

within (environmental) law and governance. This article, by proposing specific legal requirements to address AI's ecological impacts, addresses that gap.

The next section provides a brief introductory explanation of AI, with attention for some of its applications and benefits. Section 3 then discusses socio-ecological impacts and harms arising from AI development and use. Because data on energy consumption, carbon emissions and water consumption associated with AI is most readily available,[10] this article focuses on those impacts. Section 4 then briefly considers regional (European Union) and national (United Kingdom) examples of AI regulation. While not intended to be comprehensive, they suffice to illustrate the case that regulation of AI's environmental impacts currently is inadequate. Section 5 concludes with elements that should be included in AI regulation to safeguard critical earth systems from AI's rapidly increasing ecological impacts.

2. A brief introduction to AI

2.1. Defining AI

Although there is no universally agreed definition of AI,[11] it has been broadly described as 'the ability of machines to carry out intelligent tasks typically performed by humans'.[12] The EU Artificial Intelligence Act (AI Act)[13], which came into effect on 1 August 2024, defines a general-purpose AI model as:

> an AI model [which] is trained with a large amount of data using self-supervision at scale, that displays significant generality and is capable of competently performing a wide range of distinct tasks regardless of the way the model is placed on the market and that can be integrated into a variety of downstream systems or applications, except AI models that are used for research, development or prototyping activities before they are placed on the market.[14]

An example of a general-purpose AI model is GPT-4 powering ChatGPT. A general-purpose AI system is defined in the AI Act as 'an AI system which is

[10]See notes 52 and 54.

[11]Department of Science, Innovation & Technology, *A Pro-Innovation Approach to AI Regulation* (March 2023) available at https://assets.publishing.service.gov.uk/media/64cb71a547915a00142a91c4/a-pro-innovation-approach-to-ai-regulation-amended-web-ready.pdf (accessed 24 November 2023), at 22; James Tobin, *Artificial Intelligence: Development, Risks and Regulation* (2023) UK Parliament: House of Lords Library available at https://lordslibrary.parliament.uk/artificial-intelligence-development-risks-and-regulation/ (accessed 24 Nov. 2023), at 2.

[12]Cristina Criddle, 'What is artificial intelligence and how does it work?' (20 July 2023) *Financial Times* available at https://www.ft.com/content/bde93e43-7ad6-4abf-9c00-8955c6a9e343 (accessed 29 March 2024).

[13]European Parliament, 'Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act) (Text with EEA Relevance)' (*Official Journal of the European Union*, 2024/1689, 12 July 2024) <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401689> accessed 24 July 2024 ('AI Act').

[14]Ibid., Art. 3(63).

based on a general-purpose AI model and which has the capability to serve a variety of purposes, both for direct use as well as for integration in other AI systems'.[15] AI models 'do not constitute AI systems on their own [and] require the addition of further components, such as … a user interface'.[16]

General-purpose AI, such as ChatGPT, is 'generative' in that it is intended to generate new content, for example in the form of text or images.[17] General-purpose generative AI should be distinguished from 'narrow' or 'weak' AI. The latter refers to AI that is designed to perform narrow specific tasks (such as e-mail spam filters or speech recognition systems), and does not generate new content.[18]

These definitions often refer to 'integration', referencing the fact that companies may integrate AI into their products. For example, Adobe has introduced an 'AI Assistant', which provides overviews of documents. Adobe also invites users to use its AI Assistant, providing sample questions, such as: 'Provide a list of the 5 most important points'. Furthermore, when selecting text in a document, alongside the option to highlight such text, Adobe provides the option to 'Ask AI Assistant' and 'Generate [an] image'. LinkedIn likewise invites users to write posts with the assistance of AI.[19] This obviously promotes the proactive use of AI even in cases when this is not strictly necessary. Some products rely almost entirely on AI. Indeed, it has been argued that, without AI, Facebook could no longer exist.[20]

In view of the proliferation of tools such as ChatGPT,[21] Midjourney,[22] Scribe[23] and Grammarly,[24] which generate new content causing the most socio-ecological impacts (explained in section 3), the focus here is on generative AI.[25] To understand AI's socio-ecological impacts it must first be roughly explained how AI works, however.

2.2. How AI operates

Broadly, the operation of AI can be understood in terms of an AI lifecycle concept distinguishing different stages. These are the identification of the

[15]Ibid., Art. 3(66).
[16]Ibid., para 97.
[17]Also see the description of generative AI in the AI Act (ibid.), Preamble, para 99.
[18]See Tambiama Madiega, 'General-purpose artificial intelligence' (2023) *European Parliament* available at https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/745708/EPRS_ATA(2023)745708_EN.pdf (accessed 26 July 2024).
[19]LinkedIn, available at https://www.linkedin.com/feed/ (accessed 23 July 2024).
[20]Scott Robbins and Aimee van Wynsberghe, 'Our New Artificial Intelligence Infrastructure: Becoming Locked into an Unsustainable Future' (2022) 14 *Sustainability* 4829, at 2.
[21]ChatGPT, available at https://chatgpt.com/ (accessed 19 Aug. 2024).
[22]Midjourney, available at https://www.midjourney.com/home (accessed 19 Aug. 2024).
[23]Scribe, available at https://get.scribehow.com/ai-scribe/ (accessed 19 Aug. 2024).
[24]Grammarly, available at https://www.grammarly.com/ (accessed 19 Aug. 2024).
[25]The use of 'AI' in this paper refers to generative AI, unless indicated otherwise.

kind of problems the AI is intended to address, collection and pre-processing of data, design of the AI model, training of the model, evaluation of the model, and deployment of the model.[26] The discussion that follows focuses on the training and deployment stages.

At the training stage, AI models are trained in data server centres holding extremely large amounts of data. For example, GPT-4, the AI model behind ChatGPT, was 'trained on millions of text sources, including websites, newspapers and books'.[27] This training enables the model to respond to questions ('prompts'). During the training process, the AI model is fine-tuned by adjusting its parameters, making its predictions more accurate.[28] Graphics processing units (GPUs) – '[c]omplex computer chips'[29] capable of processing large amounts of data[30] – are used in the training of AI models. During training GPUs run continuously.[31] Depending on how much data is used to train the system and the complexity of the system model, training can take up to several months. The training data centres rely on water-intensive cooling systems to avoid overheating.[32] Following the deployment of the AI model, when a user prompts a question, the AI model 'first "understands" the query then "thinks" of an answer before sharing the conclusion to the user. Each AI inference requires GPU processing power'.[33]

The socio-ecological impacts associated with these processes are discussed in section 3.

[26]See Daswin de Silva and Damminda Alahakoon, 'An Artificial Intelligence Life Cycle: From Conception to Production' (2022) 3(6) *Patterns* 100489, Figure 1; International Telecommunication Union, *AI and the Environment – International Standards for AI and the Environment* (2024) available at https://www.itu.int/dms_pub/itu-t/opb/env/T-ENV-ENV-2024-1-PDF-E.pdf (accessed 17 Dec. 2024), Figure 1. De Silva and Alahakoon identify 19 stages, which are grouped under three main heads, namely: design, develop and deploy.

[27]Criddle (n 12).

[28]Parameters are internal values that the AI model learns during training and that it uses to make predictions. See, for example, Renée Cho, 'AI's growing carbon footprint' (9 June 2023) *State of the Planet: News from the Columbia Climate School* available at https://news.climate.columbia.edu/2023/06/09/ais-growing-carbon-footprint/ (accessed 24 Nov. 2023).

[29]Chris Stokel-Walker, 'TechScape: Turns out there's another problem with AI – its environmental toll' (1 Aug. 2023) *The Guardian* available at https://www.theguardian.com/technology/2023/aug/01/techscape-environment-cost-ai-artificial-intelligence (accessed 24 Nov. 2023). Google uses tensor processing units (TPUs): ibid.

[30]This description is based on Pengfei Li and others, 'Making AI Less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models' (2023) *ArXiv* available at https://arxiv.org/pdf/2304.03271.pdf (accessed 19 Dec. 2023) and Stokel-Walker (n 29).

[31]Tim Clark, 'Why does AI consume so much energy?' (20 December 2023) *Forbes* available at https://www.forbes.com/sites/sap/2023/12/20/why-does-ai-consume-so-much-energy/ (accessed 29 March 2024).

[32]Li and others (n 30) 4. See also See Ajay Kumar and Tom Davenport, 'How to make generative AI greener' (20 July 2023) *Harvard Business Review* available at https://hbr.org/2023/07/how-to-make-generative-ai-greener (accessed 29 March 2024).

[33]Clark (n 31).

2.3. Uses of AI

AI has been beneficial in a wide range of sectors, including healthcare, cybersecurity, education, traffic management, and agriculture.[34]

More recently, attention has turned to how AI may promote environmental protection. AI is currently used or has the potential to, *inter alia*: monitor deforestation and air and water quality (thereby contributing to environmental compliance); calculate environmental footprints of products; support attainment of sustainable development goals; improve biodiversity protection; improve the accuracy of weather forecasts; predict weather events and droughts (thereby contributing to climate change adaptation); promote recycling; manage energy consumption (for example through the use of smart grids); reduce fuel use and packaging and waste in global supply chains, and track and process data on carbon emissions and temperature change.[35] As regards climate change specifically, several initiatives have been established like the UN Climate Change #AI4Climate Action Initiative, which encourages use of AI to promote climate mitigation

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[34] See, among others, 'Artificial intelligence (AI) cybersecurity' (*IBM*, undated) available at https://www.ibm.com/ai-cybersecurity (accessed 5 April 2024); Debraj Sinha, 'Metropolis spotlight: Nota is transforming traffic management systems with AI' (*Nvidia*, 22 June 2021) available at https://developer.nvidia.com/blog/metropolis-spotlight-nota-is-transforming-traffic-management-systems-with-ai/ (accessed 5 Apr. 2024); Simon Pearson and others, 'Robotics and Autonomous Systems for Net Zero Agriculture' (2022) 3 *Current Robotics Reports* 57; Moussa El Jarroudi and others, 'Leveraging Edge Artificial Intelligence for Sustainable Agriculture' (2024) 7 *Nature Sustainability* 846; Andrew Gregory, 'Sepsis blood test combined with AI could offer early detection tool' (*The Guardian*, 29 March 2024) available at https://www.theguardian.com/society/2024/mar/29/sepsis-blood-test-combined-with-ai-could-offer-early-detection-tool (accessed 5 Apr. 2024); 'AI can transform education for the better' (*The Economist*, 11 January 2024) available at https://www.economist.com/business/2024/01/11/ai-can-transform-education-for-the-better (accessed 5 Apr. 2024).

[35] See, among many others, Mark Coeckelbergh, 'AI for Climate: Freedom, Justice, and Other Ethical and Political Challenges' (2021) 1 *AI and Ethics* 67, at 67; Peter Dauvergne, 'The Globalization of Artificial Intelligence: Consequences for the Politics of Environmentalism' (2021) 18 *Globalizations* 285, at 289–290; Peter Dauvergne, 'Is Artificial Intelligence Greening Global Supply Chains? Exposing the Political Economy of Environmental Costs' (2022) 29 *Review of International Political Economy* 696, at 703–705; Walter Leal Filho and others, 'Deploying Artificial Intelligence for Climate Change Adaptation' (2022) 180 *Technological Forecasting & Social Change* 121662; Daniele Silvestro and others, 'Improving Biodiversity Protection through Artificial Intelligence' (2022) 5 *Nature Sustainability* 415; 'How artificial intelligence is helping tackle environmental challenges' (*United Nations Environment Programme*, 7 November 2022) available at https://www.unep.org/news-and-stories/story/how-artificial-intelligence-helping-tackle-environmental-challenges (accessed 24 November 2023); 'AI could help detect unregulated sources of air pollution in South Asia, new project shows' (*University of Oxford*, 15 June 2023) available at https://www.ox.ac.uk/news/2023-06-15-ai-could-help-detect-unregulated-sources-air-pollution-south-asia-new-project-shows (accessed 4 April 2024); Jane Wakefield, 'The AI trained to recognise waste for recycling' (*BBC*, 3 July 2023) available at https://www.bbc.co.uk/news/business-66042169 (accessed 4 Apr. 2024); Collins (n 2); 'Explainer: How AI helps combat climate change' (*United Nations News*, 3 Nov. 2023) available at https://news.un.org/en/story/2023/11/1143187 (accessed 24 Nov. 2023); 'AI system predicts illegal deforestation: Already prevented the clearing of 30 hectares near a gold mine' (*Wageningen University & Research*, 5 December 2023) available at https://www.wur.nl/en/research-results/research-institutes/environmental-research/show-wenr/ai-system-predicts-illegal-deforestation-already-prevented-the-clearing-of-30-hectares-near-a-gold-mine.htm (accessed 4 Apr. 2024).

and adaptation in developing countries.[36] These applications of AI to achieve environmental benefits has been coined by Van Wynsberghe as 'AI *for* sustainability'.[37]

On the other hand, Dauvergne argues that 'the efficiency and productivity gains from AI are doing far more to accelerate the concentration of wealth and power within leading [transnational corporations] than advance global environmental sustainability'.[38] It is also important to remain alert to the penchant for fetishising technology[39] and 'technological solutionism'.[40] Indeed, '[i]t doesn't make sense to burn a forest and then use AI to track deforestation.'[41]

Furthermore, whilst AI has the potential to contribute to environmental sustainability it also amplifies numerous socio-ecological impacts throughout its lifecycle. In sum, AI presents environmental challenges and opportunities.[42] AI's impacts are turned to next.

3. Socio-ecological impacts of AI

3.1. Introduction

Concern has been raised about potential risks of AI, not least bias and discrimination, for example in recruitment and employment; the security of personal data; cybersecurity risks; job displacement; economic inequality; an AI arms race; loss of human connection; and misinformation and manipulation.[43] It has even been argued that AI poses 'an existential threat to the rule of law'.[44] These risks[45] are of the types that have led to the regulation of AI.[46]

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[36] UNFCCC, 'Artificial intelligence: #AI4ClimateAction' available at https://unfccc.int/ttclear/artificial_intelligence (accessed 28 March 2024).

[37] Aimee van Wynsberghe 'Sustainable AI: AI *for* Sustainability and the Sustainability *of* AI' (2021) 1 *AI and Ethics* 213.

[38] Dauvergne (2022) (n 35) 698.

[39] The term 'technological fetishism' is used by, amongst others, Alf Hornborg. See Alf Hornborg, 'The Political Economy of Techno fetishism: Agency, Amazonian Ontologies and Global Magic' (2015) 5 *HAU: Journal of Ethnographic Theory* 35.

[40] Mark Coeckelbergh (n 35) 71. See also Dauvergne (2022) (n 35) 711.

[41] Sasha Luccioni quoted in Stokel-Walker (n 29).

[42] See, for example, International Telecommunication Union (n 26) 4.

[43] Bernard Marr, 'The 15 biggest risks of artificial intelligence' (*Forbes*, 2 June 2023) available at https://www.forbes.com/sites/bernardmarr/2023/06/02/the-15-biggest-risks-of-artificial-intelligence/?sh=2b6e146b2706 (accessed 24 November 2023). See also Victor Galaz and others, 'Artificial Intelligence, Systemic Risks, and Sustainability' (2021) 67 *Technology in Society* 101741; Tobin (n 11).

[44] Collins (n 2).

[45] See, for example, Galaz and others (n 43): Figure 2 shows that 'transparency', 'accountability' and 'bias' have a significantly higher number of mentions in United Nations, non-governmental and corporate documents than 'climate change', 'sustainability' and 'biodiversity, ecosystems, biosphere'. See also Andrea Owe and Seth D. Baum, 'Moral Consideration of Nonhumans in the Ethics of Artificial Intelligence' (2021) 1 *AI and Ethics* 517.

[46] See, for example, Patricia Gomes Rêgo de Almeida, Carlos Denner dos Santos and Josivania Silva Farias, 'Artificial Intelligence Regulation: A Framework for Governance' (2021) 23 *Ethics and Information Technology* 505, at 506. See also Andreas Kremer and others, 'As gen AI advances, regulators – and risk functions – rush to keep pace' (21 December 2023) *McKinsey & Company* available at https://www.

More recently, attention has started to turn to the socio-ecological impacts of AI. These impacts will now be discussed with reference to the different stages of AI's lifecycle, set out above, while also accounting for harms that arise beyond AI's 'operational phase'.[47]

3.2. Socio-ecological impacts of the manufacture of AI hardware

Harms first arise due to the manufacture of components that are used to develop AI, such as GPUs, including those associated with the extraction of rare earth elements. This extraction alone causes many socio-ecological harms, such as soil and water contamination, air pollution, health impacts on workers and local populations, hazardous working conditions, forced labour, deforestation, violence against indigenous communities, erosion and loss of biodiversity.[48] It has also been argued that the process of extracting rare earth minerals to develop AI 'follows colonial patterns of uneven global trade in which those closest to the source of the minerals often obtain the least value from their extraction'.[49] Increased AI development can be expected to increase demand for these materials, with a corresponding rise in these types of impacts.

In addition, components are packaged in plastics which have many social and ecological impacts throughout their lifecycle.[50] Recently, the severity of these have been recognised as increasingly serious. They include marine plastic pollution, the leaching of chemicals in terrestrial and aquatic environments, impacts on human health, fatal harms to non-humans, the emission of greenhouse gases, and economic costs.[51] Also, the manufacture of servers and GPUs consumes vast amounts of water.[52]

3.3. Socio-ecological impacts of training AI models

For training – the next stage – the need for energy-intensive GPUs means that large amounts of energy are used. For example, creating GPT-3 (the

mckinsey.com/capabilities/risk-and-resilience/our-insights/as-gen-ai-advances-regulators-and-risk-functions-rush-to-keep-pace (accessed 19 Aug. 2024); 'Why AI still needs regulation despite impact' (1 February 2024) *Thomson Reuters* available at https://legal.thomsonreuters.com/blog/why-ai-still-needs-regulation-despite-impact/ (accessed 19 Aug. 2024).

[47] International Telecommunication Union (n 26) 4.

[48] Kate Crawford and Vladan Joler, 'Anatomy of an AI system' (2018) available at https://anatomyof.ai/index.html (accessed 5 Apr. 2024); James Muldoon and Boxi A. Wu, 'Artificial Intelligence in the Colonial Matrix' (2023) 36 *Philosophy and Technology* article number 80. See also Coeckelbergh (n 35) 68.

[49] Muldoon and Wu (n 48) 10.

[50] Coeckelbergh (n 35) 68.

[51] See, among others, Tamara S. Galloway and Ceri N. Lewis, 'Marine Microplastics Spell Big Problems for Future Generations' (2016) 113(9) *Proceedings of the National Academy of Sciences* 2331; David Azoulay and others, *Plastic and Health: The Hidden Costs of a Plastic Planet* (2019) available at https://www.ciel.org/wp-content/uploads/2019/02/Plastic-and-Health-The-Hidden-Costs-of-a-Plastic-Planet-February-2019.pdf (accessed 27 March 2024); Amy Whitchurch, 'Fossil Plastics' (2019) 29(9) *Geoscientist* 5; Laura E. Revell and others, 'Direct Radiative Effects of Airborne Microplastics' (2021) 598(7881) *Nature* 462.

[52] Li and others (n 30).

predecessor to GPT-4) with 175 billion parameters[53] consumed 1287 megawatt hours (MWh) of electricity and generated 502 tons of carbon dioxide equivalent.[54] This is approximately 28 times the carbon dioxide emitted by the average American person in one year.[55] Training larger AI models requires the use of a larger number of more powerful GPUs, which obviously are also more energy intensive.[56] Although data about energy consumption and carbon emissions of GPT-4 are not in the public domain, GPT-4 is a larger model than GPT-3 and thus is likely more carbon- and energy-intensive than GPT-3.[57]

Regarding water consumption, it has been estimated that training GPT-3 in Microsoft's data centres in the United States consumed 700 000 litres of freshwater for electricity generation and cooling data centres. More broadly, it has been projected that, by 2027, global demand for water (for AI) will amount to 4.2–6.6 billion cubic metres.[58]

It should be noted that water and energy consumption depend on where the AI model was trained, as different countries have different energy mixes. Accordingly, it has been observed that if GPT-3 had been trained in Microsoft's data centres in Asia, water consumption would have been significantly higher.[59]

Further energy and water are consumed, and carbon is emitted, during the retraining or updating of AI models.[60]

[53]Parameters may provide a measure of the size of AI models: Lynn H Kaack and others, 'Aligning Artificial Intelligence with Climate Change Mitigation' (2022) 12 *Nature Climate Change* 518, at 519. For example, GPT-3, which is larger than the earlier GPT-2, had 175 billion parameters compared to GPT-2's 1.5 billion parameters: Cho (n 28).

[54]Alexandra S. Luccioni, Sylvain Viguier and Anne-Laure Ligozat, 'Estimating the Carbon Footprint of BLOOM, a 176B Parameter Language Model' (2022) available at https://arxiv.org/pdf/2211.02001 (accessed 29 July 2024), Table 4. For an earlier attempt to quantify the energy consumption and carbon emissions of AI models, see Emma Strubell, Ananya Ganesh and Andrew McCallum, 'Energy and Policy Considerations for Deep Learning in NLP' *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics* (Florence, Italy, 28 July – 2 August 2019) 3645, Table 3 at 3648. In this research, it was not possible to quantify the emissions of GPT-2, which uses tensor processing units (TPUs), as the relevant information for TPUs was not made publicly available: ibid., at 3648. See also Carole-Jean Wu and others, 'Sustainable AI: Environmental Implications, Challenges and Opportunities' (2022) available at https://arxiv.org/pdf/2111.00364 (accessed 29 July 2024), which considers the environmental impacts of Facebook.

[55]See Nestor Maslej and others, *The AI Index 2024 Annual Report* (Apr. 2024) (AI Index Steering Committee, Institute for Human-Centred AI, Stanford University) available at https://aiindex.stanford.edu/wp-content/uploads/2024/05/HAI_AI-Index-Report-2024.pdf (accessed 23 July 2024), Figure 2.13.1.

[56]Brian Calvert, 'AI already uses as much energy as a small country. It's only the beginning.' (28 March 2024) *Vox* available at https://www.vox.com/climate/2024/3/28/24111721/ai-uses-a-lot-of-energy-experts-expect-it-to-double-in-just-a-few-years (accessed 29 March 2024).

[57]Li and others (n 30).

[58]Ibid.

[59]Stokel-Walker (n 29).

[60]Kate Saenko, 'Is generative AI bad for the environment? A computer scientist explains the carbon footprint of ChatGPT and its cousins' (23 May 2023) *The Conversation* available at https://theconversation.com/is-generative-ai-bad-for-the-environment-a-computer-scientist-explains-the-carbon-footprint-of-chatgpt-and-its-cousins-204096 (accessed 24 Nov. 2023). See also Kaack and others (n 53) 519.

Regarding social impacts, concerns have been raised about exploitation of workers in the Global South, who work under precarious conditions for 'data labelling' services, work which includes the labelling of harmful content.[61]

3.4. Socio-ecological impacts of the deployment and use of AI

Beyond training, regard must also be had to impacts associated with the use of AI. Research shows that most of the carbon emissions attributed to AI arise from its use rather than the development of the system. It is predicted that emissions associated with the use of large generative models will overtake emissions associated with training in just a few weeks.[62] While figures differ, a query using generative AI, such as ChatGPT, is ten times as energy intensive as a simple search engine query.[63] The more queries made, the more energy is consumed.[64]

More generally, generative tasks are more energy- and carbon-intensive than discriminative tasks (those that do not generate new content).[65] It is also notable that using a multi-purpose AI model to perform a discriminative task is more energy- and carbon-intensive than a task-specific model performing the same task. Similarly, image generation is more energy-intensive than text generation.[66] These findings suggest that generative or multi-purpose AI should not be used to perform tasks that can also be performed by discriminative or task-specific AI, a point further elaborated below.[67]

The justice-related implications of rising greenhouse gas emissions have been well-documented,[68] and the proliferation of AI hence is likely to exacerbate such injustices.

[61] Karen Hao and Andrea Paola Hernández, 'How the AI industry profits from catastrophe' (*MIT Technology Review*, 20 April 2022) available at https://www.technologyreview.com/2022/04/20/1050392/ai-industry-appen-scale-data-labels/ (accessed 24 July 2024); Anmol Arora, Michael Barrett, Edwin Lee, Eivor Osborn and Karl Prince, 'Risk and the Future of AI: Algorithmic Bias, Data Colonialism, and Marginalization' (2023) 33 *Information and Organization* 100478; Muldoon and Wu (n 48) 13.

[62] Melissa Heikkilä, 'Making an image with generative AI uses as much energy as charging your phone' (1 Dec. 2023) *MIT Technology Review* available at https://www.technologyreview.com/2023/12/01/1084189/making-an-image-with-generative-ai-uses-as-much-energy-as-charging-your-phone/ (accessed 29 March 2024).

[63] Katherine Bourzac, 'Fixing AI's energy crisis' (17 Oct. 2024; correction 25 November 2024) *Nature* available at https://www.nature.com/articles/d41586-024-03408-z (accessed 17 Dec. 2024). See also Saenko (n 60); Heikkilä (n 62); Calvert (n 56).

[64] Clark (n 31).

[65] Heikkilä (n 62).

[66] Alexandra S. Luccioni, Yacine Jernite and Emma Strubell, 'Power Hungry Processing: Watts Driving the Cost of AI Deployment?' (2023) available at https://arxiv.org/pdf/2311.16863.pdf (accessed 30 March 2024), at 13.

[67] See Luccioni, Jernite and Strubell (n 66) 13.

[68] See, among many others, Tahseen Jafry (ed), *Routledge Handbook on Climate Justice* (Routledge, 2019); United Nations General Assembly, Human Rights Council, 'Climate Change and Poverty: Report of the Special Rapporteur on Extreme Poverty and Human Rights' (A/HRC/41/39) (25 June 2019); Carmen Gonzalez, 'The Sacrifice Zones of Carbon Capitalism: Race, Expendability, and Loss and Damage' in Meinhard Doelle and Sara Seck (eds), *Research Handbook on Climate Change Law and Loss & Damage* (Edward Elgar, 2021).

3.5. Socio-ecological impacts of the disposal of AI hardware

Further down the supply chain, electronic waste ('e-waste') is a primary concern, as less than twenty per cent of e-waste is properly recycled and disposed of.[69] Increased manufacture of equipment necessary to support AI will necessarily increase e-waste (much of it exported to developing countries), responsible for numerous harmful socio-ecological impacts, including exposures (of humans and ecosystems) to toxic chemicals, air pollution and groundwater contamination.[70]

3.6. Wider concerns

Due to lack of transparency on the part of AI developers and component manufacturers, determining the ecological impacts of AI is not straightforward.[71] Luccioni and others observe that 'it is hard to quantify the environmental impacts of this transition given the lack of transparency of technology companies regarding both the number of parameters, architecture and carbon emissions of their products'.[72] Indeed, large AI developers do not disclose information on the amount of data AI models are trained on, nor on the energy consumption or carbon emissions associated with training. This means that, despite efforts by researchers, assessing the full impact of AI remains challenging. Large companies may further obscure carbon emissions through the use of renewable energy certificates to 'offset' them.[73] In their research quantifying water consumption related to GPT-3, Li and others state that 'such information has been kept a secret'.[74]

In sum, increased use of AI will exacerbate its social and ecological impacts, as will the race by companies such as Google and OpenAI to build ever larger and more sophisticated models.[75] While AI developers highlight efforts to improve efficiency and reduce emissions, these are overshadowed by rapidly increasing demand, demonstrating the so-called Jevons paradox.[76] Thus, in spite of Google's efforts to improve the efficiency of its data centres,[77] due

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[69]UNEP (n 35).

[70]Dauvergne (2022) (n 35) 710. See also Robbins and Van Wynsberghe (n 20) 8.

[71]See, for example, Anders Nordgren, 'Artificial Intelligence and Climate Change: Ethical Issues' (2023) 21(1) *Journal of Information, Communication and Ethics in Society* 1, at 3; Stokel-Walker (n 29).

[72]Luccioni, Jernite and Strubell (n 66) 14. See also Bourzac (n 63).

[73]Akshat Rathi and Natasha White, 'How tech companies are obscuring AI's real carbon footprint' (21 August 2024) available at https://www.bloomberg.com/news/articles/2024-08-21/ai-tech-giants-hide-dirty-energy-with-outdated-carbon-accounting-rules (accessed 22 Aug. 2024).

[74]Li and others (n 30) 1. See also Van Wynsberghe (n 37) 216.

[75]Cho (n 28).

[76]Wu and others (n 54) Figure 8 at 6. See also Kaack and others (n 53) 520–521.

[77]Google Research, 'Good news about the carbon footprint of machine learning training' (15 February 2022) available at https://research.google/blog/good-news-about-the-carbon-footprint-of-machine-learning-training/ (accessed 23 July 2024).

to the increased demand for AI products since 2019 its emissions have increased by 48 per cent.[78]

Ethical concerns have also been raised about the uses to which AI is being put. For instance, AI tools developed by high-tech companies are used by oil and gas producers to increase production of fossil fuels and profits, enabling such fossil fuel companies to pursue business-as-usual even in the face of the climate crisis.[79]

AI is also used to increase cattle farming, which accounts for a significant share of global greenhouse emissions.[80] Likewise, AI can contribute to monoculture, which reduces biodiversity and increases plant disease.[81] AI use more generally is expected to boost consumerism and consumption.[82] Concerns also exist about 'AI colonialism' through the exercise of control of data resulting in inequalities in 'informational power'.[83] Finally, potential risks posed by AI to the functioning and safety of environmental activists and environmentalism more generally deserves consideration.[84]

Although full acknowledgment of AI's socio-ecological impacts and the nature of relevant regulation therefore is imperative, a narrow focus on human-centric concerns informing emerging regulation, discussed next, has the opposite effect. The next section explores the limited extent to which emerging AI regulation takes heed of ecological concerns.

4. An overview of AI regulation in the European Union and United Kingdom

4.1. Introduction

Regulation of AI is in its infancy and there are still few comprehensive AI laws. Between 2016 and 2023, 148 AI-related laws were passed in 128 countries.[85] Although these laws contain the term 'artificial intelligence', they are not necessarily primarily concerned with AI. For example, a Spanish law on the right to equal treatment and non-discrimination is

[78]Dan Milmo, 'Google's emissions climb nearly 50% in five years due to AI energy demand' (2 July 2024) available at https://www.theguardian.com/technology/article/2024/jul/02/google-ai-emissions (accessed 24 July 2024).

[79]Dauvergne (2022) (n 35) 705–706. See also Coeckelbergh (n 35) 68; Kaack and others (n 53) 522; Exxon-Mobil, 'Applying digital technologies to drive energy innovation' (undated) available at https://corporate.exxonmobil.com/who-we-are/technology-and-collaborations/digital-technologies (accessed 23 July 2024).

[80]Kaack and others (n 53) 522.

[81]Robert Sparrow, Mark Howard and Chris Degeling, 'Managing the Risks of Artificial Intelligence in Agriculture' (2021) 93 *NJAS: Impact in Agriculture and Life Sciences* 172 at 184.

[82]Dauvergne (2021) (n 35) 294.

[83]See Nick Couldry and Ulises A Meijas, 'Today's colonial "data grab" is deepening global inequalities' (1 May 2024) available at https://blogs.lse.ac.uk/inequalities/2024/05/01/todays-colonial-data-grab-is-deepening-global-inequalities/ (accessed 24 July 2024).

[84]Dauvergne (2021) (n 35) 290–293.

[85]Nestor Maslej and others (n 55) Figure 7.2.1 at 376.

classified as 'AI-related' because it requires that, when technically feasible, AI algorithms used in public administration decision-making take account of bias, transparency and accountability.[86]

Where AI-specific regulation has been introduced or proposed, national and regional approaches differ and range from broad AI regulation, as in the EU, to sector-specific laws, as in the United States, to non-binding fragmented approaches, as in the UK.[87] Generally, however, these laws or regulations focus on issues of direct concern to humans, such as cybersecurity, disinformation, impacts on employment, biosecurity, national security, and consumer protection.[88]

This section considers one example of AI-specific legislation (in the EU) and one example of non-binding regulation (under development in the UK). While by no means comprehensive, these examples will suggest that AI's ecological impacts are not adequately addressed.

4.2. European Union

A regulatory framework for AI was proposed by the European Commission in 2021.[89] This process culminated in the Artificial Intelligence Act (AI Act),[90] which was adopted in March 2024 and came into force on 1 August that year. The AI Act has been described as the 'world's first comprehensive law'.[91] It consists of 113 provisions and 13 Annexes, and only the most pertinent provisions are hence discussed here.

The AI Act establishes a uniform legal framework for the development of 'human-centric and trustworthy' AI in the EU and supporting innovation while also ensuring 'protection of health, safety, fundamental rights as enshrined in the Charter of Fundamental Rights including democracy, the rule of law and environmental protection, against the harmful effects of [AI] systems'.[92] The AI Act applies to both providers and deployers of AI, whether located within the EU or beyond. It also applies to importers and distributors of AI systems.[93]

In its Preamble, the AI Act acknowledges that AI can 'support socially and environmentally beneficial outcomes, for example in … resource and energy

[86]Nestor Maslej and others, *The AI Index 2023 Annual Report* (2023) (AI Index Steering Committee, Institute for Human-Centred AI, Stanford University) available at https://aiindex.stanford.edu/wp-content/uploads/2023/04/HAI_AI-Index-Report_2023.pdf (accessed 29 March 2024), Figure 6.1.5 at 270.
[87]See Kremer and others (n 46).
[88]See Maslej and others (n 55) particularly section 7.1.
[89]European Parliament, 'EU AI Act: First regulation on artificial intelligence' (8 June 2023, last updated 19 Dec. 2023) available at https://www.europarl.europa.eu/topics/en/article/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence (accessed 19 Dec. 2023).
[90]AI Act (n 13).
[91]European Parliament (n 89).
[92]AI Act (n 13) Preamble, para. 1 and Art. 1.
[93]The application of the AI Act is set out in Art. 2.

efficiency, environmental monitoring, the conservation and restoration of biodiversity and ecosystems and climate change mitigation and adaptation'.[94] While noting that the AI Act's risk-based approach is 'the basis for a proportionate and effective set of binding rules', it also recalls the 2019 Ethics Guidelines for Trustworthy AI, developed by the AI High-level Expert Group appointed by the European Commission.[95] The latter includes a principle relating to 'societal and environmental well-being and accountability'. The AI Act states that this means that 'AI systems are developed and used in a sustainable and environmentally friendly manner as well as in a way to benefit all human beings, while monitoring and assessing the long-term impacts on the individual, society and democracy'.[96]

The AI Act classifies AI according to level of risk and imposes different requirements for each category of risk. However, as will be shown, the types of ecological impacts discussed in section 3 generally play no part in the determination of an AI system's risk category.

Certain uses of AI, including the use of manipulative techniques that have the object of impairing the ability of persons to make informed decisions, are prohibited.[97] Furthermore, certain AI systems are 'high-risk'. These include AI systems used 'as a safety component of a project',[98] for biometric categorisation based on 'sensitive or protected attributes', or systems that are intended to determine, for example, access to or eligibility for education and vocational training, job applications or essential services.[99] Requirements for high-risk AI systems are imposed relating to, *inter alia*, the establishment of a risk management system, data governance, transparency and provision of information, and human oversight.[100]

Generative AI is not deemed high-risk AI. Indeed, ecological considerations are not explicitly referred to in the determination of an AI system as 'high-risk' for the purposes of the AI Act. General-purpose AI, of which generative AI is a subset, is lower risk. Providers are subject to certain obligations, including maintaining technical documentation of the AI model, which must contain the information set out in Annex XI, to be provided to the AI Office upon request.[101] This involves general information on the AI model and a detailed description of the elements of the AI model,

[94]Ibid., Preamble, para. 4.
[95]Ibid., Preamble, para. 27.
[96]Ibid., Preamble, para 27. See also Art. 95(2).
[97]Ibid., Art. 5.
[98]Ibid., Art. 6(1).
[99]Ibid., Art. 6(2) read with Annex III.
[100]Ibid., chap. III, section 2. See also chap. VIII dealing with the establishment of an EU database for high-risk AI systems.
[101]Ibid., Art. 53(1)(a). The fact that most AI is assumed, in terms of the AI Act, to pose low (or no) risk has been criticised: see 'There are holes in Europe's AI Act – and researchers can help to fill them' (10 Jan. 2024) *Nature* available at https://www.nature.com/articles/d41586-024-00029-4 (accessed 17 Dec. 2024).

including design specifications, the data used for training, and, notably, the 'known or estimated energy consumption of the model'.[102]

Providers are also required to supply certain information to those intending to integrate the general-purpose AI model into their AI systems. This again includes general information on the AI model and a description of the elements of the model and development process including on the data used for training.[103] However, providers of general-purpose AI are not required to disclose information on energy consumption. These obligations in any event do not apply where the models are open-source, and the relevant information is publicly available.[104]

Additional information is to be supplied by providers of general-purpose AI models carrying systemic risk, notably when this involves testing to identify and mitigate systemic risk.[105] 'Systemic risk' is defined as:

> a risk that is specific to the high-impact capabilities of general-purpose AI models, having a significant impact on the Union market due to their reach, or due to actual or reasonably foreseeable negative effects on public health, safety, public security, fundamental rights, or the society as a whole, that can be propagated at scale across the value chain.[106]

Some large AI models might meet the requirements of 'high-impact capabilities'. However, it is not clear whether the types of ecological risks discussed above will be considered to 'hav[e] a significant impact on the Union market'. Therefore, it also remains uncertain whether general-purpose AI model providers will be subject to such additional requirements.

The AI Act provides for the drawing up of Codes of Conduct for the voluntary application of specific requirements, including 'assessing and minimising the impact of AI systems on environmental sustainability, including as regards energy-efficient programming and techniques for the efficient design, training and use of AI'.[107] There is hence scope for requirements that mitigate the types of harms described above, for example those associated with the energy- and carbon-intensity of AI systems. Obviously, all will depend on, first, the drafting of such Codes of Conduct and, second, compliance with the Codes.

In sum, the AI Act, acknowledges the potential benefits of AI in relation to sustainability, environmental protection and climate change.[108] It also pays

[102]Ibid., Annex XI, section 1(1) and (2).
[103]Ibid., Art. 53(1)(b) read with Annex XII.
[104]Ibid., Art. 53(2).
[105]Ibid., Art. 55 and Annex XI, section 2.
[106]Ibid., Art. 3(65). An AI model has 'high-impact capabilities' where 'the cumulative amount of computation used for its training measured in floating point operations is greater than 10': Art. 51(2). Floating point operations (FLOPs) provide a measure of the computational requirements of AI models and 'more FLOPs generally correspond[] to higher energy use': Kaack and others (n 53) 520.
[107]Ibid., Art. 95(2)(b).
[108]See, AI Act (n 13) Art. 59.

attention to AI's ecological impacts and affirms the need to take such impacts into account in its governance. However, ecological impacts are not a predominant concern. As noted, while the AI Act requires that AI systems be 'developed and used in a sustainable and environmentally friendly manner',[109] there are few specific requirements operationalising that ambition. Promisingly, provision is made for the supply of information on energy consumption by providers of general-purpose AI to the AI Office, and this could partly address concerns regarding lack of transparency. However, that disclosure is only required when specifically requested by the AI Office. Likewise, Codes of Conduct specifying requirements pertaining to environmental sustainability remain voluntary.[110]

More generally, the AI Act is explicitly anthropocentric. Indeed, the Act states that '[a]s a prerequisite, AI should be a human-centric technology. It should serve as a tool for people, with the ultimate aim of increasing human well-being'.[111]

4.3. United Kingdom

In the United Kingdom, there is no AI-specific legislation and AI instead is regulated by existing laws, in particular product safety laws, consumer law and tort law. However, certain risks of AI may not be covered by existing regulation.[112] In response to uncertainty and inconsistency caused by the absence of overarching AI regulation, in March 2023 the government published a White Paper, 'A Pro-Innovation Approach to AI Regulation'[113] (the White Paper).

The White Paper highlights several opportunities of AI, in fields such as science, health, crime and cybersecurity. Brief mention is also made of the potential of AI to contribute to technologies that respond to climate change.[114] The White Paper also sets out several risks associated with AI, such as threats to human rights, safety, privacy and fairness.[115] It does not explicitly refer to any ecological risks.

The White Paper sets out the government's intention to establish a framework to realise three objectives, i.e. to: 'drive growth and prosperity', 'increase public trust in AI' and 'strengthen the UK's position as a global leader in AI'.[116] The framework is underpinned by five cross-sectoral

[109]Ibid., Preamble, para. 27.
[110]See Kate Crawford, 'Generative AI's Environmental Costs are Soaring – and Mostly Secret (2024) *Nature* available at https://www.nature.com/articles/d41586-024-00478-x (accessed 24 July 2024.).
[111]Ibid., Preamble, para. 6.
[112]Department of Science, Innovation & Technology (n 11) 14–16; Tobin (n 11) 12.
[113]Ibid. (n 11).
[114]Ibid. (n 11) 8–11, particularly at 8.
[115]Ibid., at 11–13.
[116]Ibid., at 19–20.

principles that will guide regulatory responses to AI risks and opportunities. These are: safety, security and robustness; appropriate transparency and explainability; fairness; accountability and governance; and contestability and redress.[117] These principles are not binding and will not be legislatively entrenched so as not to stifle innovation.[118]

Stakeholder views on the absence of environmental sustainability from the principles in the White Paper's predecessor invoked the government's response that '[h]uman rights and environmental sustainability are not explicitly named in the revised principles as we expect regulators to adhere to existing law when implementing the principles'.[119] The White Paper in similar vein states:

> *The proposed regulatory framework does not seek to address all of the wider societal and global challenges that may relate to the development or use of AI. This includes issues relating to … sustainability … .* These are important issues to consider – especially in the context of the UK's ability to maintain its place as a global leader in AI – but *they are outside of the scope of our proposals for a new overarching framework for AI regulation.*'[120]

Unlike the EU AI Act, the White Paper does not classify AI according to levels of risk, preferring instead to pursue a 'context-specific approach', which involves 'empower[ing] existing UK regulators to apply the cross-cutting principles'.[121] The White Paper also does not provide for the establishment of a separate AI regulator.

In 2024, the government published a 'Consultation outcome' in response to comments on the White Paper.[122] This document confirms the government's prioritisation of innovation and safety, reiterating that it is unnecessary for environmental sustainability to be included within the principles.

Like the EU AI Act, the White Paper (less prominently) recognises the role AI can play in environmental protection, for example in tackling climate change.[123] However, the White Paper is little concerned with the ecological impacts of AI. Indeed, it is silent about both the imperative of sustainability and the ecological impacts of AI itself.[124] Neither do environmental considerations feature in the objectives or principles that form the heart of the White Paper. As signalled in its title, promoting AI innovation clearly is the central concern.

[117]Ibid., at 21 and 26.
[118]Ibid., at 6.
[119]Ibid., at 79.
[120]Ibid., at 20. Emphasis added.
[121]Ibid., at 25.
[122]Department of Science, Innovation & Technology, 'Consultation Outcome: A Pro-Innovation Approach to AI Regulation: Government Response' (2024) available at https://www.gov.uk/government/consultations/ai-regulation-a-pro-innovation-approach-policy-proposals/outcome/a-pro-innovation-approach-to-ai-regulation-government-response (accessed 24 July 2024).
[123]Department of Science, Innovation & Technology (n 11) 8.
[124]See, for example, Department of Science, Innovation & Technology (ibid.) 1.2 at 11.

Because the White Paper's principles are to be applied by regulators in different sectors, it is likely that regulatory responses to AI's ecological impacts will be inconsistent, and it will therefore be important to monitor future policy-consistency.

5. Evaluation

Whereas the two different regulatory responses to AI may acknowledge its potential environmental benefits, this brief analysis shows that they do not prioritise AI's ecological impacts. Furthermore, these regulatory approaches are overtly anthropocentric, which reflects the regulatory approach to AI more generally.[125] For example, a recently adopted United Nations General Assembly Resolution emphasises that 'safe, secure and trustworthy' AI systems should be human-centric and that these should protect human rights and freedoms 'while keeping the human person at the centre'.[126]

A human-centred paradigm hinders due regard being given to interests and values of non-humans.[127] To be sure, the co-called principle of integration enshrined in primary EU law offers solid legal authority for the argument that this position, at least for the EU, is untenable. Hence, Article 11 TFEU proclaims that 'Environmental protection requirements must be integrated into the definition and implementation of the Union's policies and activities, in particular with a view to promoting sustainable development.'

The interests of non-humans can be integrated in AI regulation in several ways, for example by explicitly acknowledging the intrinsic value of non-humans in statements of AI principles, and by taking account of the implications of AI systems for non-humans when deciding about the development and deployment of AI systems.[128] This would also help address concerns relating to anthropocentric bias in the algorithms.[129]

There are similar calls for AI's socio-ecological impacts to be addressed in regulation. Galaz argues that although ecological impacts can be engaged in part by principles and standards on AI deployment, these 'need to be complemented with governance mechanisms that are able to integrate sustainability dimensions explicitly'.[130]

Governance mechanisms that address ecological risks should be flexible and therefore include both mandatory obligations and self-

[125]See, for example, Owe and Baum (n 5).
[126]United Nations General Assembly, 'Seizing the Opportunities of Safe, Secure and Trustworthy Artificial Intelligence Systems for Sustainable Development' (11 March 2024) A/78/L.49 available at https://documents.un.org/doc/undoc/ltd/n24/065/92/pdf/n2406592.pdf (accessed 19 July 2024).
[127]Owe and Baum (n 5) 525–526.
[128]Ibid.
[129]See Owe and Baum (ibid.) 526 and Seth D. Baum and Andrea Owe, 'Artificial Intelligence Needs Environmental Ethics' (2023) 26 *Ethics, Policy & Environment* 139 at 140.
[130]Galaz and others (n 43) 8. See also Gregory Falco and others, 'Governing AI Safety Through Independent Audits' (2021) 3 *Nature Machine Intelligence* 566, at 567.

regulation.[131] Such governance mechanisms at national and regional levels will often be context-specific and therefore offer a complex regulatory landscape. In the UK, for example, quoted and larger companies are required, under the Streamlined Energy and Carbon Reporting (SECR) framework, to report on their energy use and carbon emissions whilst smaller companies are not.[132] Many AI providers – particularly those that are unquoted companies or limited liability partnerships (LLPs) – do not meet these criteria and would thus be exempt from SECR's reporting requirements. Regulation, both mandatory and voluntary, must avoid or address such gaps.

5.1. Specific provisions

5.1.1. Monitoring and reporting

Regulatory frameworks should require mandatory monitoring and reporting of all significant environmental impacts, such as rare earth elements extracted, energy and water consumed, plastic used and carbon dioxide emitted, 'for all training and tuning of AI systems'.[133] Several tools or calculators to help monitor carbon emissions, such as 'Carbontracker', have been proposed.[134] Likewise, it has been suggested that carbon emissions associated with the training of a model should be estimated, and training should cease if actual emissions are excessive.[135] As noted, the EU's AI Act makes very limited provision for reporting on energy consumption, which by dint of the EU principle of integration alluded to earlier amounts to a striking omission.

By way of positive example, the recently introduced US Bill – the Artificial Intelligence Environmental Impacts Act of 2024 – provides for the voluntary reporting of AI's environmental impacts, which include energy consumption, water consumption, pollution and e-waste.[136] Although voluntary, the envisaged (potential) reporting is broader than that provided for under

[131]Galaz and others (n 43) 8.

[132]HM Government, 'Environmental Reporting Guidelines: Including Streamlined Energy and Carbon Reporting Guidance' (March 2019) available at https://assets.publishing.service.gov.uk/media/5de6acc4e5274a65dc12a33a/Env-reporting-guidance_inc_SECR_31March.pdf (accessed 23 March 2024).

[133]Van Wynsberghe (n 37) 217.

[134]See Alexandre Lacoste and others, 'Quantifying the Carbon Emissions of Machine Learning' (2019) available at https://arxiv.org/pdf/1910.09700 (accessed 29 July 2024); Lasse F Wolff Anthony, Benjamin Kanding and Raghavendra Selvan, 'Carbontracker: Tracking and Predicting the Carbon Footprint of Training Deep Learning Models' (2020) available at https://arxiv.org/pdf/2007.03051 (accessed 29 July 2024).

[135]Van Wynsberghe (n 37) 217.

[136]*Artificial Intelligence Environmental Impacts Act of 2024* S.3732 – 118th Congress (2023-2024) available at https://www.congress.gov/bill/118th-congress/senate-bill/3732/text (accessed 23 July 2024) section 6. This Bill was introduced in February 2024 and must go through various stages, including being passed by Senate, before it can become law.

the EU's AI Act. Data obtained from such monitoring and reporting should then come to inform targets and limits, discussed next.

5.1.2. Targets and limits

Once the environmental impacts of AI are more fully understood, through reporting obligations or otherwise, it will be necessary to adopt standards and targets pertaining to the design and operation of AI. These standards may concern, *inter alia*, carbon emissions, water use, and energy efficiency and their rationale is to secure the sustainability of AI.

Several suggestions have been made on how the aim of sustainable AI can be operationalised through design and planning. For example, research shows that training an AI model on a less carbon-intensive grid results in significantly lower carbon emissions.[137] This also results in reduced water consumption. It has also been noted that it is possible to schedule training when and where renewable energy is most available.[138] Scheduling can likewise contribute to reduced water consumption.[139] Furthermore, energy efficiency of AI can be improved through more efficient data storage and management.[140] Research is also underway into other technological solutions, including 'in-memory computing' and optical (rather than electronic) data transmission, and the development of optical AI systems and '3D stacked' chips,[141] which improve energy efficiency. Conventional environmental standards (limit values, emission standards, etc.) may likewise target the carbon-, water-, and energy-efficiency of AI models.[142]

The risk that such standards incentivise problem-shifting must be borne in mind and anticipated, however.[143] For example, higher demands for renewable energy infrastructure will result in new and different socio-ecological impacts,[144] and limited access to cooling water has given rise to proposals to move data centres to space or in the ocean bed.[145]

[137] Luccioni, Viguier and Ligozat (n 54) Table 4.
[138] Saenko (n 60).
[139] Li and others (n 30) 8.
[140] See International Telecommunication Union (n 26) 6–7.
[141] These technologies are discussed in detail in Bourzac (n 63).
[142] Payal Dhar, 'The Carbon Impact of Artificial Intelligence' (2020) 2 *Nature Machine Intelligence* 423.
[143] Rakhyun E Kim and Harro van Asselt, 'Global Governance: Problem Shifting in the Anthropocene and the Limits of International Law' in Elisa Morgera and Kati Kulovesi (eds) *Research Handbook on International Law and Natural Resources* (Edward Elgar, 2016).
[144] See, for example, Union of Concerned Scientists, 'Environmental impacts of renewable energy technologies' (14 July 2008, updated 5 March 2013) available at https://www.ucsusa.org/resources/environmental-impacts-renewable-energy-technologies (accessed 29 July 2024); Alexander Dunlap, 'The "Solution" is Now the "Problem:" Wind Energy, Colonisation and the "Genocide-Ecocide Nexus" in the Isthmus of Tehuantepec, Oaxaca' (2017) *The International Journal of Human Rights*.
[145] Cho (n 28). See also Thales Alenia Space, 'Press release: ASCEND: Thales Alenia Space to lead European feasibility study for data centres in space' (14 Nov. 2022) available at https://www.thalesaleniaspace.com/en/press-releases/ascend-thales-alenia-space-lead-european-feasibility-study-data-centers-space (accessed 19 Aug. 2024).

5.1.3. Provision of information to consumers

In addition to obligations to report to regulators, consumers must also be informed of the often hidden impacts of AI use.[146] Again, there are different options.

AI developers and those integrating AI into their products can be required to inform consumers of, amongst others, energy consumption, carbon emissions, and water consumption. This may take the form of a 'warning', informing users how much carbon dioxide is emitted, water consumed, for each query, prior to the submission of that query, etc. In that vein, several AI tools already provide disclaimers about accuracy, which offer a model for warnings about ecological impacts, coaxing users to use AI only when absolutely necessary.

An obvious option in this respect is a labelling system for AI, reflecting environmental impacts and resource use, mirroring existing (EU) energy efficiency labelling schemes.[147] Proposals include the development of an AI 'energy star' rating system,[148] reflecting energy consumption, and a social and environmental certification system.[149] These enable consumers to make informed choices for AI systems with the lowest environmental impacts. More intrusively, restrictions could be placed on actively encouraging AI use.

5.1.4. Fiscal measures

Proposals have been made relating to providing tax incentives for the building of data centres where renewable energy is available,[150] and making funding available to 'SMEs actively pursuing sustainable AI innovation'.[151]

As noted, specific governance measures should be considered with due regard to existing legislation and regulation, bearing in mind risks of duplication. It must then also be decided whether it is preferable to incorporate such measures in existing AI regulation or develop new regulation on AI's environmental impacts.[152]

Moreover, further work to understand and quantify all of AI's socio-ecological impacts will be necessary, involving careful consideration of recommendations of computer scientists and AI ethics researchers.[153] Regard

[146]See, for example, Stokel-Walker (n 29).

[147]See European Commission, 'Factsheet: The new energy label' (10 January 2024) available at https://www.newenergylabelt.eu/sites/default/files/pdf-blocco-link/Belt%20-%20Factsheet%20ENG_0.pdf (accessed 19 Aug. 2024).

[148]Sasha Luccioni and others, 'Light Bulbs Have Energy Ratings – So Why Can't AI Chatbots?' (2024) 632 *Nature* 736.

[149]Abhishek Gupta, Camylle Lanteigne and Sara Kingsley, 'SECure: A Social and Environmental Certificate for AI Systems' (2020) available at https://arxiv.org/pdf/2006.06217 (accessed 19 Aug. 2024).

[150]Cho (n 28).

[151]Van Wynsberghe (n 37) 217.

[152]Specific legislation dealing with AI's environmental impacts has been proposed in the US: see n 136.

[153]See, for example, Nicola Jones, 'The US Congress is taking on AI – this computer scientist is helping' (2024) *Nature* available at https://www.nature.com/articles/d41586-024-01354-4 (accessed 24 July 2024).

should also be had to the work of relevant non-governmental organisations, such as the Montreal AI Ethics Institute[154] and the Coalition for Digital Environmental Sustainability.[155]

6. Concluding reflections

As the development and use of AI continue to accelerate, so too do the socio-ecological impacts associated with such development and use. Integration of environmental policy into AI regulation in the context of the EU is a legal imperative flowing from Article 11 TFEU. In light of current planetary crises, too, it is crucial that appropriate responses to environmental impacts of AI are implemented and enforced.

The rapid expansion of AI highlights the necessity of economic and societal change[156] and reform of environmental law and regulation.[157] This article has shown that AI's socio-ecological impacts currently are far from sufficiently addressed, however. A range of measures therefore should be included in AI regulation, exemplified in this article by the EU and the UK. The types of measures discussed above are of paramount importance for the integration of 'sustainability dimensions' in AI governance mechanisms,[158] as they will contribute to addressing the socio-ecological challenges arising from the development and use of AI.

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[154] Montreal AI Ethics Institute, available at https://montrealethics.ai/ (accessed 28 March 2024).
[155] Coalition for Digital Environmental Sustainability, *Action Plan for a Sustainable Planet in the Digital Age* (2022) available at https://wedocs.unep.org/bitstream/handle/20.500.11822/38482/CODES_ActionPlan.pdf?sequence=3&isAllowed=y (accessed 28 March 2024).
[156] See, for example, Geoffrey Garver, 'A Systems-based Tool for Transitioning to Law for a Mutually Enhancing Human-Earth Relationship' (2019) 157 *Ecological Economics* 165; Jason Hickel, *Less is More: How Degrowth Will Save the World* (Penguin, 2021).
[157] See, for example, Louis J Kotzé and Rakhyun E Kim, 'Earth System Law: The Juridical Dimensions of Earth System Governance' (2019) 1 *Earth System Governance* 100003.
[158] Galaz and others (n 43) 8.

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