Behind Sugar and Spice and Everything Nice: The Environmental Impacts of Digitalization

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CONTENTS

Key takeaways

- Data is neither ethereal nor harmless. It is resource intensive, made up of sand, water, coal and harmful chemicals, and it generates toxic wastes. For example, the manufacturing of semiconductor chips, which are the building block of everything digital, requires silica sand, quartz and ultra-pure water.

- The manufacturing units for these chips are built on large plots of land and their workers have been documented as having been exposed to harmful chemicals.

- Cobalt, lithium, nickel and rare earth minerals are integral to the manufacturing of digital technologies, and the AI boom has propelled their extraction from land and sea beds, leading to the displacement of communities, land degradation and an adverse impact on people's livelihoods.

- Corporations are exploring the possibility of mining asteroids for these minerals. The race among billionaires to catapult satellites into space has already resulted in increased corporate control over digital communications, and generated digital trash even in space.

- From the US to Uruguay, communities have clashed with Big Tech over constructing data centres (misleadingly called "clouds") in drought-stricken areas. By 2027, the water removed from ground sources to power data centres is expected to reach between 4.2bn and 6.6bn cubic meters, or about half the amount consumed by the UK each year.[1]

- Water is also needed for the mining, quarrying, processing and milling of mined materials and hydraulic fracturing, creating additional severe strains on local water supplies.

- The International Energy Agency estimates that power demand from the world's data centres could increase to match the total power demand of Germany by 2026,[2] which will lead to an increase in fossil fuel consumption. Renewables are unlikely to solve this rapidly spiralling energy demand from data centres.

- The proliferation of digital technologies is generating vast mounds of e-waste, a large quantity of which is exported to the Global South where chemicals like mercury and flame retardants are released into the environment and impact the health of exposed workers and communities.

- Digitalization is exacerbating existing inequalities, and is spurring extraction of resources from land, ocean and even space.

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[1] Cristina Criddle and Kenza Bryan, "AI boom sparks concern over Big Tech's water consumption," Financial Times, 25 February 2024: https://www.ft.com/content/6544119e-a511-4cfa-9243-13b8cf855c13

[2] Myles McCormick, Jamie Smyth and Amanda Chu, "AI revolution will be boon for natural gas, say fossil fuel bosses," Financial Times, 1 April 2024: https://www.ft.com/content/1f93b9b2-b264-44e2-87cc-83c04d8f1e2b

Introduction

With digital technologies multiplying around us, it can seem impossible to stop, assess and consider their full implications. This includes the reality of ecological damage hidden behind the digitalization narrative, which would have us think of digitalized data as nothing more than "clouds" – harmless and ethereal.

Nothing could be further from the truth. While proponents of digitalization prop up data as wisps in the air, they conveniently ignore – or choose not to talk about – the extractive, polluting and material nature of datafication and digital technologies.

We may talk about data "mining" – and are increasingly aware that data are being extracted from people and communities and even our environment – but there is little discussion about the actual mining and extraction of the physical resources needed for digitalization – including water, energy, land, critical minerals and rare earths – and the subsequent pollution and mountains of e-waste.

As much as Big Tech's proponents would like us to believe that data, silicon chips, data storage "clouds", and the other components of the digital realm – including the batteries that power everything – are made of sugar and spice and everything nice, it is actually sand, water, coal, fossil fuels, critical minerals, and scores of harmful chemicals[3] that power the machines that create, channel, store and analyze data as part of digitalization.

As we will see below, digitalization leads to the displacement of communities from their lands and livelihoods, endangers their food security, and exposes them to harmful chemicals putting their health at risk, among other consequences.

In addition, corporations and governments use digital technologies to amass and analyze granular data points to predict and "nudge" (or manipulate) human behaviour, in order to expand the markets for their products and services, and even to track and attack individuals and organizations deemed a threat to their profits and geopolitical interests.

At the same time, we are being exhorted to believe that "the digital revolution" is a hallmark of progress. But this is far from being a given, as this paper will argue. We need to expose the reality of the situation, recognizing that digitalization has significant environmental and social costs and that it reinforces existing inequalities in the world.

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[3] Cam Simpson, "American Chipmakers Had a Toxic Problem. Then They Outsourced It." *Bloomberg*, 15 June 2017: https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it; see also, Chungsik Yoon, Sunju Kim, Donguk Park, Younsoon Choi, Jihoon Jo, Kwonseob Lee, "Chemical Use and Associated Health Concerns in the Semiconductor Manufacturing Industry," *Safety and Health at Work*, Vol. 11, Issue 4, 2020, pp. 500-508: https://www.sciencedirect.com/science/article/pii/S2093791120302717

Digging up the planet for digital tech

> *"[Artificial Intelligence is] also a manifestation of highly organized capital backed by vast systems of extraction and logistics, with supply chains that wrap around the entire planet."*
>
> *Kate Crawford, Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence, p. 18*

Digitalization assumes the expansion of the extractive sector. For example, semiconductor chips are ubiquitous across the digital realm and are integral to all electronic devices, from laptops, phones and televisions through to farm machinery, automobiles and aeronautics. These tiny chips – with features just a few nanometers wide – are also increasingly in demand because of the 5G boom[4] and expanding internet usage. To make chips, one needs pure-grade silicon (also called "digital gold").

Other critical minerals – such as lithium, nickel, cobalt, manganese and graphite – are needed to manufacture the batteries that power electronics and digital tools, drones and electric vehicles, and to store renewable energy.[5] Batteries are fundamental components in mobile phones, tablets and laptops, enabling them to be used for hours without being connected to a power source; they also power robots, drones, unmanned tractors and electric vehicles, facial recognition tools and automated military weapons systems.

- ## Silicon for microchips

Semiconductor chips are manufactured from silica sand (SiO_2), which is blasted in a furnace to separate the silicon from the oxygen and "needs to be 99.99999999999 percent pure—eleven 9s." [6] This level of purity is achieved by chemical processes that treat the silicon in crucibles made from the purest form of quartz, which is largely available only in an area around the Appalachian Mountain town of Spruce Pine, North Carolina in the USA, with production mainly dominated by a single company, Unimin.[7]

Because of the purity required, the manufacturing process must steer clear of any contaminant that can soil the chips, so factories are equipped with ultra-clean rooms (10,000 times cleaner than the

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[4] Bob O' Donnell, "Major Chip Vendors Driving Revolutionary Changes In 5G Infrastructure," *Forbes*, 10 March 2020: https://www.forbes.com/sites/bobodonnell/2020/03/10/major-chip-vendors-driving-revolutionary-changes-in-5g-infrastructure/?sh=21fbb5226510 and Lauly Li and Cheng Ting-Fang, "Ericsson and Nokia branch into chip design to ride 5G and AI waves," *Nikkei Asia,* 12 March 2024: https://asia.nikkei.com/Business/Tech/Semiconductors/Ericsson-and-Nokia-branch-into-chip-design-to-ride-5G-and-AI-waves

[5] For example, lithium-ion batteries are used to store solar power. For a simple explanation of the process, see Palmetto website, "How Does A Solar Battery Work? Energy Storage Explained," 11 August 2021: https://palmetto.com/learning-center/blog/how-does-a-solar-battery-work

[6] Vince Beiser, "The world in a grain: The story of sand and how it transformed civilization", New York: Riverhead Books, 2019, p. 109.

[7] Vince Beiser, "The world in a grain: The story of sand and how it transformed civilization", New York: Riverhead Books, 2019, pp. 104-110.

outside air, according to ASML, the world's largest producer of chip-etching machines),[8,9] and they use "ultrapure water" (UPW).[10] Taiwan Semiconductor Manufacturing Company (TSMC) is the world's largest manufacturer of computer chips, with a whopping global market share of about 60 per cent.[11] Consequently, the company is a leader in the race for global chip supremacy. TSMC's biggest customer is Apple. According to a report by Georgetown University, semiconductor manufacturing plants require "large plots of land, low seismic activity, stable supply of water, stable supply of electricity, talent, and transportation infrastructure."[12] Taiwan boasts that it ticks all the boxes. Also key to chip manufacturing are lithography machines; Netherlands-based ASML (originally, Advanced Semiconductor Materials Lithography, adequately describing their business) holds a virtual monopoly, controlling more than 80 per cent of the global market for lithography equipment used in the semiconductor industry.[13]

In the 1960s and 1970s, Gordon Moore, the co-founder of Intel, predicted that the number of transistors on a single integrated circuit chip would double every two years, which came to be known as "Moore's Law." While more observation than law of science, the trend Moore identified resulted from the continuously decreasing size of chips along with a decrease in the cost of manufacturing them.[14] ASML notes that between 1956 and 2015, computing power increased a trillion-fold because of advances in chip technology.[15] The computer that was used for Apollo Moon missions, for example, had 32.768 bits of Random Access Memory (RAM) and 589.824 bits of Read Only Memory (ROM), while a modern smartphone has around 100,000 times as much processing power, with about a million times more RAM and seven million times more ROM.[16] This has happened largely because billions of transistors can now be etched on a single silicon "wafer". As described by ASML, this is done by depositing a thin layer of conducting, isolating or semiconducting material on the chip, coating it with a photo-sensitive substance called "photoresist" and exposing it to extreme ultraviolet (UV) light in lithography equipment; the UV light is projected through a

[8] ASML web site, "How microchips are made," n. d.: https://www.asml.com/en/technology/all-about-microchips/how-microchips-are-made

[9] Natalia Drozdian and Ellen Proper, "Shielded from Pandemic, Work Continues in World's Cleanest Room," *Bloomberg*, 23 March 2020: https://www.bloomberg.com/news/articles/2020-03-23/shielded-from-pandemic-work-continues-in-world-s-cleanest-room

[10] See, for example, European Commission, "Ultrapure Water Technology - nanoparticle free water for the advanced nanoelectronics industry enabling further miniaturization of electronic devices," CORDIS research project (end 31 January 2023): https://cordis.europa.eu/project/id/811908

[11] Lisa Wang, "TSMC boosts global market share to over 60 percent," *Taipei Times*, 13 June 2023: https://www.taipeitimes.com/News/biz/archives/2023/06/13/2003801420

[12] John VerWey, "No Permits, No Fabs: The Importance of Regulatory Reform for Semiconductor Manufacturing," *CSET Policy Brief*, Center for Security and Emerging Technology, Georgetown University, October 2021, pp. 10-11.

[13] See Moody's Investors Service (Dirk Goedde, Christian Hendker and Djena Kern), *Credit Opinion of ASML Holding N.V.*, 9 August 2023: https://www.moodys.com/credit-ratings/ASML-Holding-NV-credit-rating-600041718?cy=emea

[14] Carla Tardi, "What Is Moore's Law and Is It Still True?" Investopedia, 4 April 2024: https://www.investopedia.com/terms/m/mooreslaw.asp

[15] See ASML web site, "The basics of microchips," n. d.: https://www.asml.com/en/technology/all-about-microchips/microchip-basics

[16] Alison Li and Jessica Timings, "Six crucial steps in semiconductor manufacturing," ASML web site, updated 4 October 2023: https://www.asml.com/en/news/stories/2021/semiconductor-manufacturing-process-steps

(tem)plate made of quartz or glass and reacts with the resist, printing intricate patterns from the plate onto the wafer – these act as minuscule electrical switches.[17]

Mired in trade secrets, the semiconductor-manufacturing industry is rife with very real threats of espionage and intense competition among corporate and scientific players within and across geographies.[18] Contributing to the semiconductor industry's shadowy reality is the difficulty in obtaining information on chemicals used in the lengthy supply chain and in manufacturing. According to some studies, more than 200 high-purity organic and inorganic chemicals are used, but one study (by SK Hynix, one of the largest semiconductor manufacturers in South Korea), claims that semiconductor manufacturing plants use about 430 different chemicals, including more than 130 that are classified as CMR agents (carcinogens, mutagens and reproductive toxins).[19] In the 1990s, when US-based studies showed that chemical exposure in semiconductor manufacturing was causing miscarriages among workers at twice the average rate, American chipmakers vowed to phase out those chemicals from their manufacturing processes. When chip-manufacturing was outsourced to Asian countries with large numbers of women workers, so were the health conditions that afflicted them: infertility, birth defects, miscarriages, cancer and other serious diseases.[20]

Box 1: Massive data extraction = massive use of data chips

Corporations and governments are accelerating the collection, tracking and storage of granular data: patient health data; agricultural data (such as yields, soil health, pest prevalence, farm insurance and agrochemical use); data on consumer preferences (via online retail and grocery, e-commerce and online payments); and the social media activity of users. As digital surveillance of people expands and AI is deployed, data generation is set to balloon. According to International Data Corporation (IDC) estimates, there will be approximately 291 zettabytes (ZB) of digital data generated in 2027 (a zettabyte is one trillion gigabytes)[21] – which assumes a concomitant rise in semiconductor sales. In 2022, global semiconductor sales reached US$574.1 billion.[22]

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[17] Alison Li and Jessica Timings, "Six crucial steps in semiconductor manufacturing," ASML web site, updated 4 October 2023: https://www.asml.com/en/news/stories/2021/semiconductor-manufacturing-process-steps

[18] Cagan Koc and Debby Wu, "ASML says Ex-Employee in China stole chip data," *Bloomberg*, 15 February 2023: https://www.bloomberg.com/news/articles/2023-02-15/asml-says-ex-employee-in-china-misappropriated-chip-data. See also, Anna Gross, "ASML reveals intellectual property theft by China employee," *Financial Times*, 15 February 2023: https://www.ft.com/content/cd1fd7f3-b3ea-4603-8024-db75ec6e1843

[19] Cam Simpson, "American Chipmakers Had a Toxic Problem. Then They Outsourced It." *Bloomberg*, 15 June 2017: https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-ithttps://restofworld.org/2023/nickel-mining-evs-philippines-environment/

[20] Cam Simpson, "American Chipmakers Had a Toxic Problem. Then They Outsourced It." *Bloomberg*, 15 June 2017: https://www.bloomberg.com/news/features/2017-06-15/american-chipmakers-had-a-toxic-problem-so-they-outsourced-it For more information on women in the microelectronics industry, see Inah Kim, Myoung-Hee Kim and Sinye Lim, "Reproductive Hazards Still Persist in the Microelectronics Industry: Increased Risk of Spontaneous Abortion and Menstrual Aberration among Female Workers in the Microelectronics Industry in South Korea," *Plos One*, 4 May 2015: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0123679#pone.0123679.ref020

[21] Allen Hasham, "A Framework for IP/Optical Convergence: Building from Existing Networks," Ciena, 19 April 2023: https://www.ciena.com/insights/articles/2023/its-time-for-a-new-interconnection-model-for-the-growing-amount-of-data-in-motion. Hasham cites IDC's proprietary figure of 291 zettabytes of data in 2027, which is behind a very high paywall: https://www.idc.com/getdoc.jsp?containerId=US50554523

[22] According to the lobby group Semiconductor Industry Association (USA). See SIA, "Global Semiconductor Sales Increase 3.3% in 2022 Despite Second-Half Slowdown," 3 February 2023: https://www.semiconductors.org/global-semiconductor-sales-increase-3-2-in-2022-despite-second-half-

- ## Cobalt (batteries, circuitry, semiconductors)

As of 2020, more than 70 per cent of the world's cobalt was mined in the Democratic Republic of Congo (DRC), and industry experts report that 70 per cent of the mining sector in the DRC is now backed by Chinese investment.[23]

As is true of other types of mining throughout the Global South, the cobalt mining industry is riddled with stories of worker exploitation and degrading treatment, extremely low wages, precarious job security, racism, lack of worker safety and child labour abuses. The industry also displaces communities, degrades alternative livelihood resources, increases food insecurity, leads to the loss of plant biodiversity for local medicines and increases the risk of violence and even murder for artisanal and small-scale miners who may be attacked at the bidding of industrial mining companies.[24]

Cobalt can also be mined from the deep sea, from cobalt-rich crusts.[25] Intensive deep-sea mining and associated pollution could adversely impact biodiversity, destroy rare species and their habitat, and potentially disrupt marine species dependent upon fauna at the bottom of the ocean. (See below for a discussion of the status and potential impacts of deep-sea mining.)

- ## Lithium (rechargeable lithium-ion batteries)

The demand for lithium, another critical mineral for batteries, has skyrocketed over the last few years and is driving leading electric car manufacturers to directly invest in lithium mines to ensure an uninterrupted and sufficient supply.[26] One of the main sites where lithium is extracted for "Li-ion" batteries for the electromobility sector is the Salar de Atacama salt flats in Chile, an Indigenous ancestral territory of the Lickanantay ethnic group (Atacameños).[27] Recent research documents how the categorization of the abundant local brine as a mining property or mineral and not as a water resource denies "its complexity and hydro-cosmological diversity – another expression of the coloniality of nature that sees the salt flat only as a mining commodity." [28] As a consequence of

slowdown/

[23] RAID and CAJJ, *The road to ruin? Electric vehicles and workers' rights abuses at DR Congo's industrial cobalt mines*, 20 September 2023, pp. 3-4: https://raid-uk.org/post-library/the-road-to-ruin-electric-vehicles-and-workers-rights-abuses-at-dr-congos-industrial-cobalt-mines/

[24] Benjamin K. Sovacool, "The precarious political economy of cobalt: Balancing prosperity, poverty, and brutality in artisanal and industrial mining in the Democratic Republic of the Congo," *The Extractive Industries and Society*, Vol. 6, Issue 3, 2019, pp. 915–939: https://doi.org/10.1016/j.exis.2019.05.018

[25] For more information on cobalt-rich crusts, see Geomar (Helmholtz Centre for Ocean Research, Kiel, Germany), "Cobalt-rich Crusts – Ore Treasure on the Slope of Seamounts," n. d.: https://www.geomar.de/en/discover/marine-resources/cobalt-rich-crusts

[26] Clifford Krauss and Jack Ewing, "Lithium Scarcity Pushes Carmakers into the Mining Business," *New York Times*, 2 July 2023: https://www.nytimes.com/2023/07/02/business/lithium-mining-automakers-electric-vehicles.html

[27] Bárbara Jerez, Ingrid Garcés, Robinson Torres, "Lithium extractivism and water injustices in the Salar de Atacama, Chile: The colonial shadow of green electromobility," *Political Geography*, Vol. 87, 102382, 2021: https://doi.org/10.1016/j.polgeo.2021.102382 The full text is available here: https://media.business-humanrights.org/media/documents/Lithium_extractivism_and_water_injustices_in_the_Salar_de_Atacama_Chile.pdf

[28] Bárbara Jerez, Ingrid Garcés, Robinson Torres, "Lithium extractivism and water injustices in the Salar de Atacama, Chile: The colonial shadow of green electromobility," *Political Geography*, Vol. 87, 102382, 2021: https://doi.org/10.1016/j.polgeo.2021.102382 The full text is available here: https://media.business-humanrights.org/media/documents/Lithium_extractivism_and_water_injustices_in_the_Salar_de_Atacama_Chile.pdf

lithium extraction, there has been a decrease in freshwater availability in the area, along with a decline in agricultural and livestock activities; rivers and other bodies of water have been drained, and people's access to water has been cut off (they now depend on water tanks); flamingos have disappeared and other native flora and fauna have also been impacted.[29,30]

- **Nickel (battery technology)**

Indonesia, which as of 2022 was supplying about half of the world's nickel – another element critical for battery manufacturing – is facing rampant deforestation and biodiversity loss. Research by Mighty Earth and Brown Brothers Energy and Environment showed that about 23,000 hectares of Indonesia's tropical forests have been cleared to obtain nickel, creating a "palm oil 2.0" situation.[31] The second largest producer of nickel, the Philippines, is also encountering unrest and protest by communities over foreign mining companies' plans to explore and mine its nickel reserves.[32]

- **"Rare earth minerals" (magnets, fibre optics and batteries)**

"Rare earth minerals" like Cerium, Lanthanum, Neodymium and others[33] are used to manufacture magnets and fibre optics for internet cables, as well as batteries for smartphones and electric vehicles. Despite their name, they are not particularly difficult to find: The word "rare" denotes extraction challenges, as the minerals are bound to other minerals in low concentrations, making them difficult to isolate.[34]

Rare earth minerals are largely extracted via open pit mining and then put into leaching ponds where chemicals are used to separate the rare earths from the ore. China is the biggest supplier, accounting for 85 per cent of global refined rare earth minerals production in 2020.[35] Chinese provinces where rare earth mining is carried out have witnessed widespread pollution and water

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[29] Bárbara Jerez, Ingrid Garcés, Robinson Torres, "Lithium extractivism and water injustices in the Salar de Atacama, Chile: The colonial shadow of green electromobility," *Political Geography*, Vol. 87, 102382, 2021: https://doi.org/10.1016/j.polgeo.2021.102382 The full text is available here: https://media.business-humanrights.org/media/documents/Lithium_extractivism_and_water_injustices_in_the_Salar_de_Atacama_Chile.pdf

[30] Danae Tapia and Paz Peña, "White gold, digital destruction: Research and awareness on the human rights implications of the extraction of lithium perpetrated by the tech industry in Latin American ecosystems," Global Information Society Watch, 2020: https://giswatch.org/node/6247

[31] Mighty Earth, "Sourcing Responsible Nickel for EVs," 10 November 2023 (update): https://mightyearth.org/electric-vehicles-evs-are-vital-to-the-transition-away-f-efficient-than-cars-that-run-on-gasoline-even-better-th/

[32] Nick Aspinwall, "Angry Philippine islanders are trying to stop the great nickel rush," *rest of world*, 30 August 2023: https://restofworld.org/2023/nickel-mining-evs-philippines-environment/

[33] U.S. Geological Survey, *Mineral Commodity Summaries, January 2024*, prepared by Daniel J. Cordier: https://pubs.usgs.gov/periodicals/mcs2024/mcs2024-rare-earths.pdf

[34] Michael Meyer, "Industrial Vitamins," *Distillations Magazine*, Science History Institute (USA), 22 March 2012: https://www.sciencehistory.org/stories/magazine/industrial-vitamins/

[35] Ryan Seah and Yogesh Joshi, "China's Rare Earth Dominance: Exploring Australia-India Partnership," *ISAS Insights*, 25 May 2021: https://www.isas.nus.edu.sg/papers/chinas-rare-earth-dominance-exploring-australia-india-partnership/

contamination by cadmium and lead,[36] leading to multiple evacuations and resettlements due to high rates of cancer and other health problems.[37]

Starting to strip sea beds

Mining of critical minerals for computing and electromobility is now effectively transcending the planet's terrestrial limits. As terrestrial sources become exhausted or too expensive to extract – or become mired in conflict between mining companies, governments and communities – the targets for mineral extraction have shifted to sea beds where so-called polymetallic nodules abound.[38] These nodules can contain copper, nickel, cobalt, iron, manganese, and rare earth elements and are extracted using ship-dragged buckets or self-propelled collection devices (such as miniature submarines).[39]

The resource-rich Clarion-Clipperton Zone (CCZ) in the central Pacific is being targeted for deep-sea mining as it contains cobalt, manganese and nickel. A 2023 study reported that an estimated 88 per cent of species in the CCZ region are yet undescribed and that the CCZ is one of "the few remaining areas of the global ocean with high intactness of wilderness." [40] Pacific Indigenous communities have long opposed exploitation of the ocean, as the deep sea is the source of their creation[41] and their livelihoods depend on it. In 2022, the governments of Fiji, Palau and Samoa formed an alliance to oppose deep-sea mining.[42] Hundreds of marine scientists have called for a moratorium on deep-sea mining in light of the potential loss of "biodiversity and ecosystem functioning that would be irreversible on multi-generational timescales." [43]

In 2021, the Republic of Nauru submitted its intention to start deep-sea mining to the International Seabed Authority (ISA); the submission triggered an obscure rule within the UN's Law of the Sea, which requires the ISA to adopt regulations to govern the proposed commercial activity within two

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[36] He Guangwei, "China's Dirty Secret: The Boom Poisoned Its Soil and Crops," *YaleEnvironment360*, Yale School of the Environment, 30 June 2014: https://e360.yale.edu/features/chinas_dirty_pollution_secret_the_boom_poisoned_its_soil_and_crops

[37] Keith Bradsher, "China Tries to Clean Up Toxic Legacy of Its Rare Earth Riches," *New York Times*, 22 October 2013: https://www.nytimes.com/2013/10/23/business/international/china-tries-to-clean-up-toxic-legacy-of-its-rare-earth-riches.html

[38] NOAA, "Deep-sea Mining Interests in the Clarion-Clipperton Zone," n. d.: https://oceanexplorer.noaa.gov/explorations/18ccz/background/mining/mining.html

[39] Xingsen Guo, Ning Fan, Yihan Liu, Xiaolei Liu, Zekun Wang, Xiaotian Xie and Yonggang Jia, "Deep seabed mining: Frontiers in engineering geology and environment," *International Journal of Coal Science & Technology*, Vol. 10, article number 23, 18 April 2023: https://link.springer.com/article/10.1007/s40789-023-00580-x

[40] Muriel Rabone, Joris H. Wiethase, Erik Simon-Lledó, Helena Wiklund, Tammy Horton, Adrian G. Glover, "How many metazoan species live in the world's largest mineral exploration region?" *Current Biology*, Vol. 33, Issue 12, 19 June 2023, pp. 2383-2396: https://doi.org/10.1016/j.cub.2023.04.052

[41] Maud Oyonarte, "Deep sea mining concerns from the Pacific need to be heard," Greenpeace, 1 August 2023: https://www.greenpeace.org/international/story/61087/isa-must-hear-pacific-voices-stop-deep-sea-mining/

[42] Greenpeace news release, "Palau, Fiji, and Samoa launch Alliance Against Deep Sea Mining," 27 June 2022: https://www.greenpeace.org/usa/news/palau-fiji-and-samoa-launch-alliance-against-deep-sea-mining/

[43] See *Marine Expert Statement Calling for a Pause to Deep-Sea Mining*, n. d.: https://seabedminingsciencestatement.org/

years of the submission[44] (in July 2023, the deadline to adopt the mining regulations was extended to July 2025, which is still considered unrealistic by some.[45]) The move is highly ironic for a tiny island-nation that was virtually destroyed by industrial agriculture's insatiable appetite for phosphate fertilizer. Nauru allowed the extraction and exportation of millions of metric tonnes of phosphate over the last century and, as a result, lost at least 80 per cent of its vegetation; with a shattered economy, it was then forced to rely on offshore banking, selling passports, housing Australian asylum seekers, and today has little available freshwater, relies on imported food, and its people suffer from high rates of heart disease, diabetes and obesity.[46] Regardless of the outcome of Nauru's deep-sea mining proposal, other countries aren't far behind. China sees deep-sea mining as the "new frontier of international competition" [47] and countries like Japan, Norway, South Korea and Russia are ready to move ahead with their own plans to mine the deep seas.[48]

Apart from the extraction of critical minerals as described above, the seabed plays another role in digitalization: as an efficient route for the undersea cables that link data centres and carry data across the world. A *Nature* study claims that "more than 99% of all international digital data traffic is routed via >400 interconnected submarine cable systems," which translates to the disturbance of up to 2.82–11.26 Mt of organic carbon on the seafloor, in water depths of up to 2,000 meters.[49] The marine ecosystems impacts of those undersea cables remain under-researched.[50]

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[44] Alexander Kozul-Wright, "Naura prepares to mine deep seas in big climate controversy," *Al Jazeera,* 09 July 2023: https://www.aljazeera.com/economy/2023/7/9/nauru-prepares-to-mine-deep-seas-in-big-climate-controversy

[45] For more information on Nauru's deep-sea mining application and its implications, see Chris Pickens, Hannah Lily, Ellycia Harrould-Kolieb, Catherine Blanchard, Anindita Chakraborty, "From what-if to what-now: Status of the deep-sea mining regulations and underlying drivers for outstanding issues," *Marine Policy*, 2024, 105967:

[46] Ben Doherty, "A short history of Nauru, Australia's dumping ground for refugees," *The Guardian*, 9 August 2016: https://www.theguardian.com/world/2016/aug/10/a-short-history-of-nauru-australias-dumping-ground-for-refugees

[47] Zhao Lei, "China to up its deep-sea mining efforts," *China Daily*, 12 March 2023: https://www.chinadaily.com.cn/a/202303/12/WS640d6330a31057c47ebb3e34.html

[48] Akira Kitado, "China, South Korea push for deep-sea mining as global talks begin," *Nikkei Asia*, 10 July 2023: https://asia.nikkei.com/Spotlight/Environment/China-South-Korea-push-for-deep-sea-mining-as-global-talks-begin

[49] M.A. Clare, A. Lichtschlag, S. Paradis, N.L.M. Barlow, "Assessing the impact of the global subsea telecommunications network on sedimentary organic carbon stocks," *Nature Communications,* published online 12 April 2023: https://doi.org/10.1038/s41467-023-37854-6

[50] M.A. Clare, A. Lichtschlag, S. Paradis, N.L.M. Barlow, "Assessing the impact of the global subsea telecommunications network on sedimentary organic carbon stocks," *Nature Communications*, published online 12 April 2023: https://doi.org/10.1038/s41467-023-37854-6

Asteroid mining, Starlink and the race for space

While mineral extraction is happening under our feet and under the sea, it could happen in Outer Space too. Despite failed attempts at asteroid mining by start-ups such as Planetary Resources and Deep Space Industries[51] a decade ago, a new start-up called AstroForge wants to give it another go,[52] citing the high concentration of minerals and a drop in the cost of space exploration. Despite many critics pointing out that it is a far-fetched idea, which is economically unfeasible,[53] researchers from the Colorado School of Mines and the International Monetary Fund have started investigating whether space mining could play a part in "sustainable growth" [54] by reducing the need for mining on Earth, thereby reducing its environmental damages.

Furthermore, while current discussions among UN member states revisiting the 1967 Outer Space Treaty are focused on the space race, the imminent threats of weaponization of space, and space debris, little attention is being paid to one particular elephant in the sky: the increasingly outsized role of the private sector (especially the "tech bro billionaires") in space-related activities. Elon Musk's SpaceX provides internet services from the low earth orbit via Starlink, and undertakes cargo resupply missions and astronaut launches to the International Space Station (ISS) under multi-billion dollar contracts with NASA. Instead of building its own lunar lander, NASA awarded contracts to Jeff Bezos's space company, Blue Origin.

Elon Musk's SpaceX accounted for 22 per cent of the world's operational satellites in April 2020,[55] highlighting its outsized control over communication channels. SpaceX now operates around 5,500 Starlink satellites in low-earth orbit, beaming internet and communication signals the world over, particularly targeting clients in underserved areas that can afford to pay for its services. There are now so many Starlink satellites in the sky (not counting the hundreds of surveillance satellites launched by its spin-off company Starshield, under US government contracts) that astronomers have raised concerns about interference with observations of the universe.[56] In 2023, the U.S. Federal Aviation Administration (FAA) also reported on the dangers of SpaceX satellites relative to space debris and the non-negligible risks to people on the ground when satellites "de-orbit"; SpaceX's principal engineer vociferously criticized the FAA's concerns.[57]

Wanting to secure its own tiny spot in the space race limelight, Indonesia has presented itself as a key launching ground for blasting rockets and satellites into space. The government of the world's

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[51] Shriya Yarlagadda, "Economics of the Stars: The Future of Asteroid Mining and the Global Economy," *Harvard International Review*, 8 April 2022: https://hir.harvard.edu/economics-of-the-stars/

[52] Alex Knapp, "This Asteroid Mining Startup Is Ready To Launch The First-Ever Commercial Deep Space Mission," *Forbes*, 18 October 2023: https://www.forbes.com/sites/alexknapp/2023/10/18/this-asteroid-mining-startup-is-ready-to-launch-the-first-ever-commercial-deep-space-mission/?sh=cefb23f674a

[53] Javier Blas, "If Gold Surges 140,000-Fold, Then Asteroid Mining Works," *Bloomberg*, 28 September 2023: https://www.bloomberg.com/opinion/articles/2023-09-28/commercial-asteroid-mining-has-a-astronomical-cost-issue

[54] Maxwell Fleming, Ian Lange, Sayeh Shojaeinia and Martin Stuermer, "Mining in space could spur sustainable growth," *PNAS*, 16 October 2023: https://www.pnas.org/doi/10.1073/pnas.2221345120

[55] Therese Wood, "Who owns our orbit: Just how many satellites are there in space?" World Economic Forum, 23 October 2020: https://www.weforum.org/agenda/2020/10/visualizing-easrth-satellites-sapce-spacex/

[56] Nicholas Gordon, "Satellites like Elon Musk's Starlink are ruining the night sky for astronomers—even for those using telescopes in space," Fortune, 3 March 2023: https://fortune.com/2023/03/03/starlink-spacex-study-hubble-space-telescope-brightness-elon-musk/

[57] Jason Rainbow, "SpaceX slams FAA report on falling space debris danger," *SpaceNews*, 9 October 2023: https://spacenews.com/spacex-slams-faa-report-on-falling-space-debris-danger/

largest archipelago offered Biak island in its easternmost province of Papua as a spaceport for rocket launches for both Elon Musk's SpaceX and Russia's Roscosmos.[58] The island's location just one degree south of the equator means less fuel is needed for rockets to reach Earth's orbits. Indigenous peoples on the island have protested against the plan, citing environmental degradation and displacement of their homes and livelihoods as imminent costs of the Indonesian government's space island ambition.[59]

The 'fluffy cloud' con: diverting water and energy resources

Just as water (liquid) and energy (latent heat) are key to the formation of clouds floating above our heads, water and energy are also fundamental to the digital "clouds" needed to store and process data 24/7. The myth of these "ephemeral" entities has already been busted: they aren't clouds, they are actually massive data centres.

All of our digital activity is stored in these data centres, also called data farms, which require an uninterrupted water supply to prevent the servers from getting overheated. They consist of thousands of rows of servers and electronic devices spread over vast terrestrial tracts, which require colossal amounts of cooled water to keep running. Many cities in the USA, where a quarter of the world's data centres are currently located, are concerned about their water supply, especially in the Western US, which is facing an ongoing drought. For example, in The Dalles, Oregon, local communities clashed with Google, which wanted to protect its local data centre water use as a trade secret.[60] It was eventually revealed that Google's water use in the area has nearly tripled in the past five years, and the company's data centres now consume more than a quarter of all the water used in the city." [61]

Similarly, local protests broke out in Uruguay when Google announced a plan to build a data centre that would consume millions of litres of water while the country is going through its worst drought in 74 years. Google bought 72 acres of land in Uruguay to build its data centres requiring 7.6 million litres of water each day to cool its servers.[62]

Water consumption in manufacturing semiconductors, in particular microchips, also competes directly with agricultural production as the world witnessed in the priority enjoyed by the world's top chipmakers over agricultural areas in Taiwan during the 2021 drought. The Taiwanese

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[58] Kate Duffy, "Indonesia's government wants Elon Musk to build a new SpaceX launchpad on a small island. Residents say it would threaten livelihoods and the environment." *Business Insider*, 10 March 2021: https://www.businessinsider.com/residents-indonesia-offer-elon-musk-spacex-launchpad-threaten-livelihoods-environment-2021-3

[59] Rory James, "Anger after Indonesia offers Elon Musk Papuan island for SpaceX launchpad," *The Guardian*, 9 March 2021: https://www.theguardian.com/world/2021/mar/10/anger-after-indonesia-offers-elon-musk-papuan-island-for-spacex-launchpad

[60] Andrew Selsky, "Oregon City drops fight to keep Google Water Use Private," *AP News*, 15 December 2022: https://apnews.com/article/technology-business-oregon-the-dalles-climate-and-environment-f63f313b0ebde0d60aeb3dd58f51991c

[61] Mike Rogoway, "Google's water use is soaring in The Dalles, records show, with two more data centers to come," *oregonlive*, 22 February 2023: https://www.oregonlive.com/silicon-forest/2022/12/googles-water-use-is-soaring-in-the-dalles-records-show-with-two-more-data-centers-to-come.html

[62] Grace Livingstone, "'It's pillage': Thirsty Uruguayans decry Google's plan to exploit water supply," *The Guardian*, 11 July 2023: https://www.theguardian.com/world/2023/jul/11/uruguay-drought-water-google-data-center

government's actions are a red flag: the government diverted water from 183,000 acres of farmland, around one-fifth of Taiwan's irrigated land, to its semiconductor industry, and in particular to the chipmaker giant TSMC.[63]

Water is not only consumed for data "mining" of course, it is also needed for "conventional" mining – the quarrying, processing and milling of mined materials and hydraulic fracturing[64] – and this often competes with other water consuming activities, putting severe strains on local water supplies especially in areas where water is scarce.[65] Counting the water use in extracting and processing of critical minerals and rare earths, the overall water use of industries that make digitalization possible is staggering.

Operating data centres and transmitting data across networks also involve massive fossil fuel consumption. For instance, a town in the Netherlands protested against a proposed data centre to be built by Meta, which was reported as potentially consuming at least 1.38 terawatt-hours per year and needing land equivalent to nearly 310 football fields.[66] In Ireland, electricity use by data centres has tripled since 2015, accounting for 14% of the country's total electricity consumption by 2021; and in Denmark, energy use in the data centre sector is expected to triple by 2025 to account for around 7 per cent of the country's electricity use.[67] The International Energy Agency (IEA) estimates that, together, data centres and data transmission networks globally accounted for 2-3 per cent of global electricity use in 2022.[68] (Consider that the whole of the African continent consumed about the same amount of electricity in the same year.[69])

Cryptocurrencies such as bitcoin, enabled by blockchain technology – and key in delivering the promises of "techno-utopia" in the financial sector – have been so mired in controversies and scandals in recent years that their environmental costs, also scandalous, have been largely overlooked. Annual energy consumption of cryptocurrency mining worldwide is said to have doubled in 2023, putting it on a par with the annual electricity use of Ukraine, while its annual carbon emissions are equal to petro-state Oman's.[70] On 1 February 2024, the US Energy Information

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[63] Raymond Zhong and Amy Chang, "Drought in Taiwan Pits Chip Makers Against Farmers," *The New York Times*, 8 April 2021: https://www.nytimes.com/2021/04/08/technology/taiwan-drought-tsmc-semiconductors.html

[64] USGS Water Resources Mission Area, "Mining Water Use," 1 March 2019: https://www.usgs.gov/mission-areas/water-resources/science/mining-water-use

[65] Simon Meißner, "The Impact of Metal Mining on Global Water Stress and Regional Carrying Capacities—A GIS-Based Water Impact Assessment" *Resources* 10, no. 12: 120, 2021: https://doi.org/10.3390/resources10120120

[66] Tracy Brown Hamilton, "In a small Dutch town, a fight with Meta over a massive data center," *The Washington Post*, 01 June 2022: https://www.washingtonpost.com/climate-environment/2022/05/28/meta-data-center-zeewolde-netherlands

[67] Mar Hidalgo, "Energy and water consumption in data centers: sustainability risks," *IEEE Analysis Paper* #69, 2022: https://www.ieee.es/en/Galerias/fichero/docs_analisis/2022/DIEEEA69_2022_MARHID_Datos_ENG.pdf

[68] International Energy Agency website, "Data Centres and Data Transmission Networks," n. d.: https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks#

[69] IEA, *Electricity Market Report 2023,* February 2023, p. 15. See chart (right) showing shares of electricity consumption by region in 2022: https://www.iea.org/reports/electricity-market-report-2023

[70] Karin Rives, "Bitcoin mining energy use doubled in 2023 as crypto prices rose," S&P Global Market Intelligence, 21 December 2023: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/bitcoin-mining-energy-use-doubled-in-2023-as-crypto-prices-rose-79854382

Administration reported that "annual electricity use from cryptocurrency mining probably represents from 0.6% to 2.3% of U.S. electricity consumption." [71]

While proponents are quick to point out the supposed resource efficiency of data centres, particularly those owned by Big Tech with their green aspirations, how these plans might actually fare in the face of the new normal of severe drought remains to be seen.

We can also anticipate that the current worldwide energy and water consumption of data centres will soon be dwarfed by the looming demand from Artificial Intelligence systems, which proponents say will perform tasks on a par with or better than humans. According to the *Financial Times*, Microsoft already opens one new data centre somewhere in the world every three days, and the International Energy Agency estimates that power demand from the world's data centres could increase to match the total power demand of Germany by 2026.[72]

Sam Altman, a co-founder of OpenAI, quipped at the 2024 World Economic Forum in Davos that future AI will consume vast quantities of energy, requiring an energy breakthrough based on nuclear fusion or vastly cheaper solar power and storage.[73] The natural gas industry, which falsely promotes itself as renewable,[74] has also been getting in on the act, proclaiming that AI expansion "will usher in a golden era for natural gas."[75]

Then there remains the question of who is accessing energy resources, of whatever type. For example, data centres and bitcoin miners have been flocking to Iceland where energy from geothermal and hydroelectric sources is relatively cheap and abundant, enabling them to proclaim that their operations are carbon-free.[76] Yet data centres are estimated to consume 30 per cent more electricity than the total consumption of households in Iceland (cryptocurrency miners account for about 90 per cent of data centre consumption there).[77]

Similarly, according to a 2023 Forbes investigation, Bhutan, which mainly relies on hydropower from its myriad rivers draining from the great Himalayas, has, over the last four to five years, quietly built

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[71] Mark Morey, Glenn McGrath, and Hiroaki Minato (contributors), "Tracking electricity consumption from U.S. cryptocurrency mining operations," U.S. Energy Information Administration, 1 February 2024: https://www.eia.gov/todayinenergy/detail.php?id=61364

[72] Myles McCormick, Jamie Smyth and Amanda Chu, "AI revolution will be boon for natural gas, say fossil fuel bosses," *Financial Times*, 1 April 2024: https://www.ft.com/content/1f93b9b2-b264-44e2-87cc-83c04d8f1e2b

[73] At Davos, Altman was quoted: "There's no way to get there without a breakthrough." Jeffrey Dastin (reporter) and Emelia Sithole-Matarise (editor), "OpenAI CEO Altman says at Davos future AI depends on energy breakthrough," *Reuters*, 16 January 2024: https://www.reuters.com/technology/openai-ceo-altman-says-davos-future-ai-depends-energy-breakthrough-2024-01-16/

[74] Kate Griffin, "Is natural gas renewable?" *Green Economy Journal*, 18 January 2023: https://greeneconomyjournal.com/explainer/is-natural-gas-renewable/

[75] Myles McCormick, Jamie Smyth and Amanda Chu, "AI revolution will be boon for natural gas, say fossil fuel bosses," *Financial Times*, 1 April 2024: https://www.ft.com/content/1f93b9b2-b264-44e2-87cc-83c04d8f1e2b

[76] David Pan and Matt Goldman, "Bitcoin Miners Draw From Iceland's Surplus of Renewable Energy," *Bloomberg*, 30 August 2023: https://www.bloomberg.com/news/articles/2023-08-30/bitcoin-btc-miners-like-bit-digital-draw-from-iceland-s-renewable-energy-surplus

[77] Jelena Ćirić, "Bitcoin Mining a Growing Waste of Energy in Iceland," *Iceland Review*, 13 June 2023: https://www.icelandreview.com/nature-travel/bitcoin-mining-a-growing-waste-of-energy-in-iceland/

a vast digital crypto-mining infrastructure resulting in a 63 per cent spike in power usage in 2022, and requiring imports of more than US$220 million worth of chips from China for bitcoin mining.[78]

Renewables as salvation?

A decade ago, the Union of Concerned Scientists in the U.S. was already raising concerns about the potential impacts of solar power, including land degradation, habitat loss and toxins from the manufacturing of photovoltaic cells; more recently, they have raised concerns about "solar trash" (solar panels that have been discarded and might be considered hazardous waste because they contain pollutants such as cadmium and lead)[79,80] and their high cost of recycling. In Gujarat, India, land acquired for solar parks reduced the access of the Maldhari pastoral community's access to communal grazing resources along with water sources for animals, leading to the community leaving livestock-rearing and relying on daily wage labour in agriculture or as cleaners in the solar park.[81,82] Such cases of unjust transitions to renewable energy, found in other countries as well, have been called "green grabbing".[83]

In general, the switch to renewables is being heralded as a silver bullet that will enable a clean and green earth, the implication being that this can happen without dismantling capitalism. Yet the harsh reality seems to be that renewable energy sources can't replace fossil fuels in a world in which rampant resource use is fuelled by capitalism – specifically, by unending and growing consumption and now boosted by digitalization. No amount of revolutionary energy breakthroughs can satisfy the ballooning demands for resources; only societal transformation can put a stop to this ever-expanding extraction.

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[78] Iain Martin and Sarah Emerson, "Bhutan Built A Bitcoin Mine On The Site Of Its Failed 'Education City'", *Forbes*, 22 November 2023: https://www.forbes.com/sites/iainmartin/2023/11/22/bhutan-secret-bitcoin-mine-locations/?sh=69d9d65b4a4e

[79] Union of Concerned Scientists Explainer, "Environmental impacts of solar power," 5 March 2013: https://www.ucsusa.org/resources/environmental-impacts-solar-power

[80] Atalay Atasu, Serasu Duran, Luk N. Van Wassenhove, "The dark side of solar power," *Harvard Business Review*, 19 April 2022: https://hbr.org/2021/06/the-dark-side-of-solar-power

[81] Karthikeyan Hemalatha, "'Our livelihood depends on this land': A solar park in Gujarat is hurting a pastoral community," *Scroll.in*, 6 August 2019: https://scroll.in/article/932881/our-livelihood-depends-on-this-land-a-solar-park-in-gujarat-is-hurting-a-pastoral-community

[82] Rejitha Nair, "Ten years on, Maldharis await compensation for lands acquired for Charanka solar park in Gujarat," Land Conflict Watch, 21 July 2022: https://www.landconflictwatch.org/conflicts/ten-years-on-maldharis-await-compensation-for-lands-acquired-for-charanka-solar-park-in-gujarat

[83] Hamza Hamouchene, "The energy transition in North Africa: Neocolonialism again!" *TNI*, 14 October 2022: https://www.tni.org/en/article/the-energy-transition-in-north-africa

At the end of the rainbow: a mountain of e-waste and space

According to Global eWaste Monitor, the world generated 53.6 Mt of e-waste in 2019, growing by 9.2 Mt since 2014; the rate of growth is projected to grow significantly, creating a total of 74.7 Mt by 2030.[84,85] The Monitor's 2020 report stated that the biggest contributor to the growing amount of e-waste was higher consumption rates of "EEE" (electric and electronic equipment), unnecessarily short digital equipment and software life cycles, and limited repair options. In the same year, the formal documented collection and recycling of e-waste was calculated to be 9.3 Mt – just 17.4 per cent of the total e-waste generated.[86]

Electronic waste contains several toxic additives (e.g. mercury, brominated flame retardants (BFR), and chlorofluorocarbons (CFCs)), which adversely impact human health and the environment, including by contributing to global warming.[87] A total of 50 t of mercury and 71 kt of flame retardants are found in globally undocumented flows of e-waste annually, which is mostly being released into the environment as well as impacting the health of exposed workers and surrounding communities.[88,89]

Countries in the global South are major importers of e-waste from countries in the global North, and, as documented in a harrowing WHO report, *Children and digital dumpsites,* millions of children and women of childbearing age are exposed to more than 1,000 harmful substances[90] while working in "a sprawling, globalized informal system of waste recovery sites,"[91] looking for valuable materials ranging from iron to aluminium, gold, palladium, silver and cobalt.[92] Electronic waste and batteries, which are non-biodegradable and full of toxins, do not end up only in dumpsites and landfills, but also in aquatic and marine environments either from direct disposal or by leaching.

As the world struggles with how to deal with waste from electronic and digital products on land and also in bodies of water (in addition to the ubiquitous plastic waste which goes hand in hand with e-waste), space debris or space junk up in the sky is also a growing concern. Materials from disused or

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84 Vanessa Forti, Cornelis Peter Baldé, Ruediger Kuehr, Garam Bel, T*he global E-waste monitor 2020: Quantities, flows, and the circular economy potential*, 1 July 2020, p. 15: https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

85 Mar Hidalgo, "Energy and water consumption in data centers: sustainability risks," *IEEE Analysis Paper* #69, 2022: https://www.ieee.es/en/Galerias/fichero/docs_analisis/2022/DIEEEA69_2022_MARHID_Datos_ENG.pd f

86 Vanessa Forti, Cornelis Peter Baldé, Ruediger Kuehr, Garam Bel, *The global E-waste monitor 2020: Quantities, flows, and the circular economy potential*, 1 July 2020, p. 15: https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

87 Vanessa Forti, Cornelis Peter Baldé, Ruediger Kuehr, Garam Bel, *The global E-waste monitor 2020: Quantities, flows, and the circular economy potential*, 1 July 2020, p. 15: https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

88 Vanessa Forti, Cornelis Peter Baldé, Ruediger Kuehr, Garam Bel, *The global E-waste monitor 2020: Quantities, flows, and the circular economy potential*, 1 July 2020, p. 15: https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

89 Undocumented wastes are those that are declared or labelled as "recyclable" or "for recycling" and mixed in with other non-biodegradables. Documented wastes are labelled and segregated as such, but only a little of that actually gets recycled.

90 World Health Organization, *Children and Digital Dumpsites*, 2021, p. xvi: https://apps.who.int/iris/bitstream/handle/10665/341718/9789240023901-eng.pdf

91 World Health Organization, *Children and Digital Dumpsites*, 2021, p. 4: https://apps.who.int/iris/bitstream/handle/10665/341718/9789240023901-eng.pdf

92 World Health Organization, *Children and Digital Dumpsites*, 2021, p. xii: https://apps.who.int/iris/bitstream/handle/10665/341718/9789240023901-eng.pdf

damaged satellites, rockets and other man-made wastes left in space have been accumulating over the decades, mostly hovering in orbit around the Earth.

But the question about who cleans up this space waste is often drowned out by the frenzy over multi-billion dollar contracts from public funds to be awarded to private companies undertaking new activities in space, including the construction of futuristic space crafts, the launching of thousands of satellites in low and high orbits for high-speed internet beaming to all corners of the earth, mining asteroids for critical minerals, and some billionaires' ultimate dream of building human colonies on the Moon or Mars. There are at least 25,000 pieces of man-made debris or junk from decrepit and damaged satellites, rockets, space crafts and other objects that humanity has launched into space since the Soviets first achieved that milestone in 1957.[93]

Conclusions: Forget the Nirvana narrative, let's address digitalization's real impacts

It's time to pour cold water on Big Tech's "fluffy cloud" con trick. Digitalization is not a cost-free immaterial Nirvana, but a form of living and communicating – mostly embedded in and being used to entrench a very particular capitalist economic model – that can already come with extremely high environmental and social costs. These need to be acknowledged and addressed as part of a comprehensive process of assessment of digitalization and other technologies. Adopting the Silicon Valley culture of "move fast and break things", the creation of disruption and the winner-takes-all mentality are all inherently antithetical to foresight, precaution, and care for Mother Earth and humanity.

The long and complex supply chains involved in the various industries that drive or are otherwise dependent upon digitalization criss-cross the planet, and we can already see repeating colonial patterns of exploitative extraction and pollution being driven forward in the name of digitalization.

Technology-linked corporations are literally digging up planet Earth and the oceans that sustain life for the minerals, fuel and water needed to create and operate often short-lived digital technologies – and then dumping the resulting e-waste on land, at sea and in space. They are also beginning to look beyond Earth, with aspirations to mine asteroids.

At the same time, they are promoting their sector by peddling a false story, promising a digitalization Nirvana for all. But this seductive story masks the fact that, as with all new technologies, there are winners and losers. Big Tech companies are quietly amassing vast treasure troves of data and ramping up their power and influence as we become dependent on proprietary and opaque digitalization technologies. This is happening while local communities suffer from existing and increasing exploitation and ever more contamination of their environment, impacting their health and livelihoods, in the name of advancing digitalization in every aspect of peoples' lives.

We need to ditch the mistaken assumption that digitalization is a cost-free and logical next step for human civilization. It would be short-sighted and irresponsible to gloss over the need for society to evaluate all new and emerging technologies, including digitalization technologies, with their extensive impacts on people, our environment and our climate.

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[93] Washington Post editorial board, "Space junk is out of control. Here's why — and what to do about it." *Washington Post*, 02 November 2023: https://www.washingtonpost.com/opinions/interactive/2023/space-junk-debris-removal/

Communities whose lives are impacted by these technologies need to actively participate in evaluating their social, economic and environmental impacts before they are deployed. The argument that democratic technology assessment would delay innovation and would be costly is outweighed by the damages and costs of deploying profit-oriented technologies that wreak havoc on society, environment, climate and our humanity.

Box 2: The Global Digital Compact as the holy grail in the Summit of the Future

The Summit of the Future, scheduled for September 2024, is convened by the United Nations General Assembly (UNGA) and presents an opportunity for the international community to address the societal and environmental costs of digitalization.

The negotiations around the proposed Global Digital Compact, considered to be the holy grail in the package of UN decisions that will come out of the Summit of the Future, will be critical to this. Yet even though UNGA and the UN Secretary General have acknowledged concerns about the impacts of artificial intelligence and machine learning on human rights, society and global security,[94] no such concerns have yet been raised about the impact of digitalization technologies and related industries more generally – even though these will impinge on all aspects of our communities, lands, water and livelihoods, and in particular on food sovereignty and the rights of peasants, smallholders, and Indigenous peoples whom the international community committed not to leave behind.

A responsive Global Digital Compact that would be relevant in the years to come should bravely address core issues at the heart of digitalization: equity, societal impacts, environmental and climate consequences – instead of just reiterating the need to bridge the digital divide, which could, perversely, be used to open up markets for technology companies under the guise of providing equal access for all.

Discussion on human rights in relation to digitalization should not just be limited to issues of privacy and cyber rights. They must encompass rights to land and territories, as these are impacted by the excessive extraction of the critical minerals involved in digitalization. They need to uphold the right to food sovereignty and the role of the peasant food web, as drones and robots invade territories. They must also address impacts on women, whose roles in agriculture are further invisibilized by digitalization.

In short, it is essential that the Global Digital Compact negotiations recognize the varied risks of digitalization with respect to our planet, communities and peoples, and that it adopts a framework to regulate corporations that:

- requires participatory, anticipatory and informed evaluation of technologies before they are deployed, including access to information about how the various technologies function and the resources required to produce and make them function
- holds technology companies accountable for their products' social, climate and environmental damages

[94] United Nations Press Release, "General Assembly Adopts Landmark Resolution on Steering Artificial Intelligence towards Global Good, Faster Realization of Sustainable Development," 21 March, 2024: https://press.un.org/en/2024/ga12588.doc.htm

- compels technology companies to stop exploitative and extractive business practices
- raises critical understanding and provides effective guard rails for governments and communities to anticipate and address the impacts of digitalization
- enables viable and equitable alternatives to digitalization (not necessarily technological) and appropriate use of new technologies that address specific needs, assert community control, and harness local capacities and innovation.

Current UN deliberations updating the Outer Space Treaty adopted in 1967 (another component of the Summit of the Future) should also be advanced in a transparent and equitable manner in parallel, in order to ensure the accountability of all nations and private entities involved in space-related activities. This should include the cleaning up of space debris, especially the littering of the Earth's orbit, and the prevention of any activities or processes that: obstruct scientific research for the common good; damage public infrastructure such as climate observation satellites; and/or trigger any other adverse consequences to the planet and humanity.

The private ownership of satellites that are deployed according to the commercial and strategic interests of their billionaire owners raise questions of accountability, liability and redress in cases of misuse leading to harm. A forward-looking and responsive Outer Space Treaty should provide for an enforceable liability and redress mechanism that would make those responsible answerable to the international community for damages. It is also imperative to prevent the use of satellites and other infrastructures for war, as dictated by private interests, as has been seen in Musk's capricious unilateral decisions on the deployment of Starlink in the Russia-Ukraine War and in the Israeli genocide in Gaza. Similarly, the use of satellites and other technologies for solar geoengineering activities in space should be banned.

A genuine Summit for the Future must, above all, reverse the current winner-takes-all approach that dominates digitalization and the 'space race' at present, favouring military and geoengineering technologies and other forms of Earth manipulation, instead ensuring that all current and future digitalization and space-related technologies are carefully and thoughtfully developed and deployed, with a view to promoting the well-being of all people, our environment and our planet.