

The environmental impacts of digitalization



BEHIND SUGAR AND SPICE AND EVERYTHING NICE

Communiqué #119



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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 electronic 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.

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 the idea of 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.

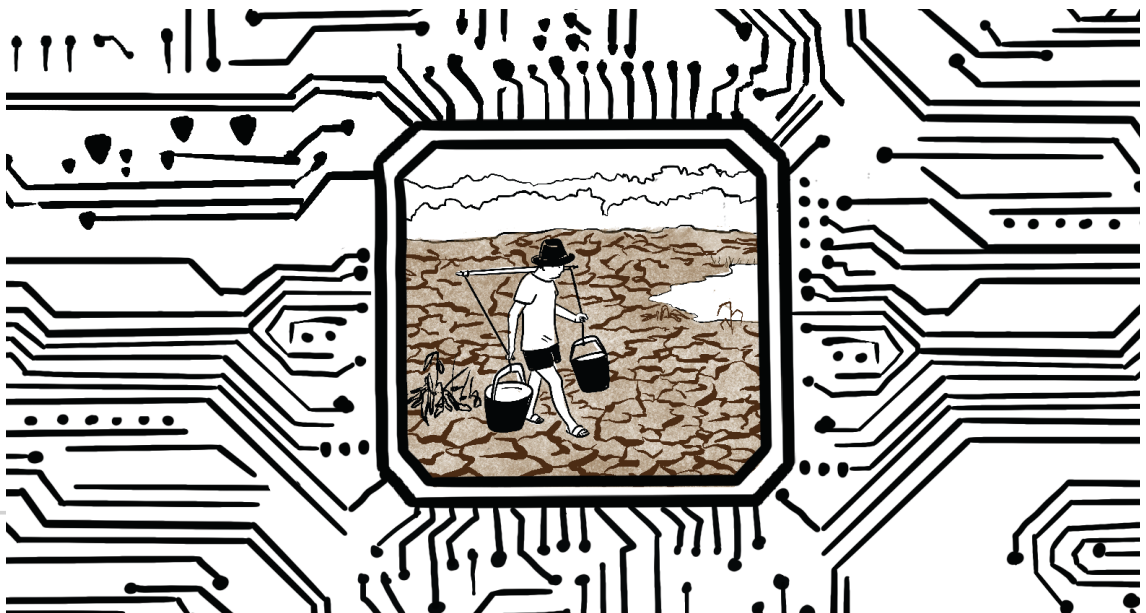
As much as Big Tech’s proponents would like us to believe that data, silicon chips, data storage “clouds”, and the other components of the digital realm – including the batteries that power everything – are made of sugar

and spice and everything nice, it is actually sand, water, coal, fossil fuels, critical minerals, and scores of harmful chemicals³ that power the machines that create, channel, store and analyze data as part of digitalization.

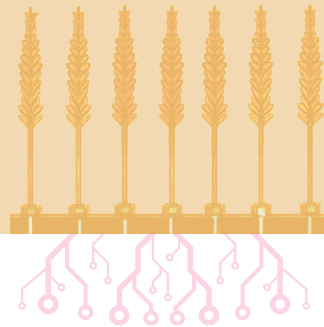
As we will see below, digitalization leads to the displacement of communities from their lands and livelihoods, endangers their food security, and exposes them to harmful chemicals putting their health at risk, among other consequences.

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.



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 Intelligence⁴

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 nanometres wide – are also increasingly in demand because of the 5G boom⁵ 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.⁶ 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 99.9999999999 percent pure—eleven 9s.”⁷ This level of pu-

urity 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.⁸

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 outside air, according to ASML, the world’s largest producer of chip-etching machines),^{9,10} and they use “ultrapure water” (UPW).¹¹ 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.¹² 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.”¹³ 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.¹⁴

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.¹⁵ ASML notes that between 1956 and 2015, computing power increased a trillion-fold because of advances in chip technology.¹⁶ 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.¹⁷ 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 (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.¹⁸

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.¹⁹ 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).²⁰ 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 chip-makers 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.²¹

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)²² – which assumes a concomitant rise in semiconductor sales. In 2022, global semiconductor sales reached US\$574.1 billion.²³

Cobalt (batteries, circuitry, semi-conductors)

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.²⁴

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.²⁵

Cobalt can also be mined from the deep sea, from cobalt-rich crusts.²⁶ 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.²⁷ 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).²⁸ 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.”²⁹ As a consequence of 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.^{30,31}

Nickel (battery technology)

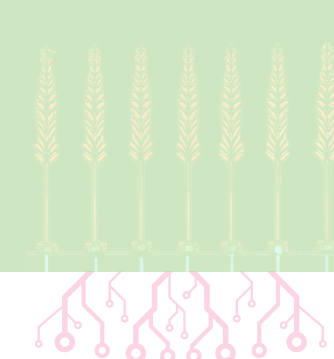
Indonesia, which as of 2022 was supplying about half of the world's nickel – another element critical for battery manufacturing – is facing rampant deforestation and biodiversity loss. Research by Mighty Earth and Brown Brothers Energy and Environment showed that about 23,000 hectares of Indonesia's tropical forests have been cleared to obtain nickel, creating a “palm oil 2.0” situation.³² 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.³³

“Rare earth minerals” (magnets, fibre optics and batteries)

“Rare earth minerals” like Cerium, Lanthanum, Neodymium and others³⁴ 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.³⁵

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 2020.³⁶ Chinese provinces where rare earth mining is carried out have witnessed widespread pollution and water contamination by cadmium and lead,³⁷ leading to multiple evacuations and resettlements due to high rates of cancer and other health problems.³⁸



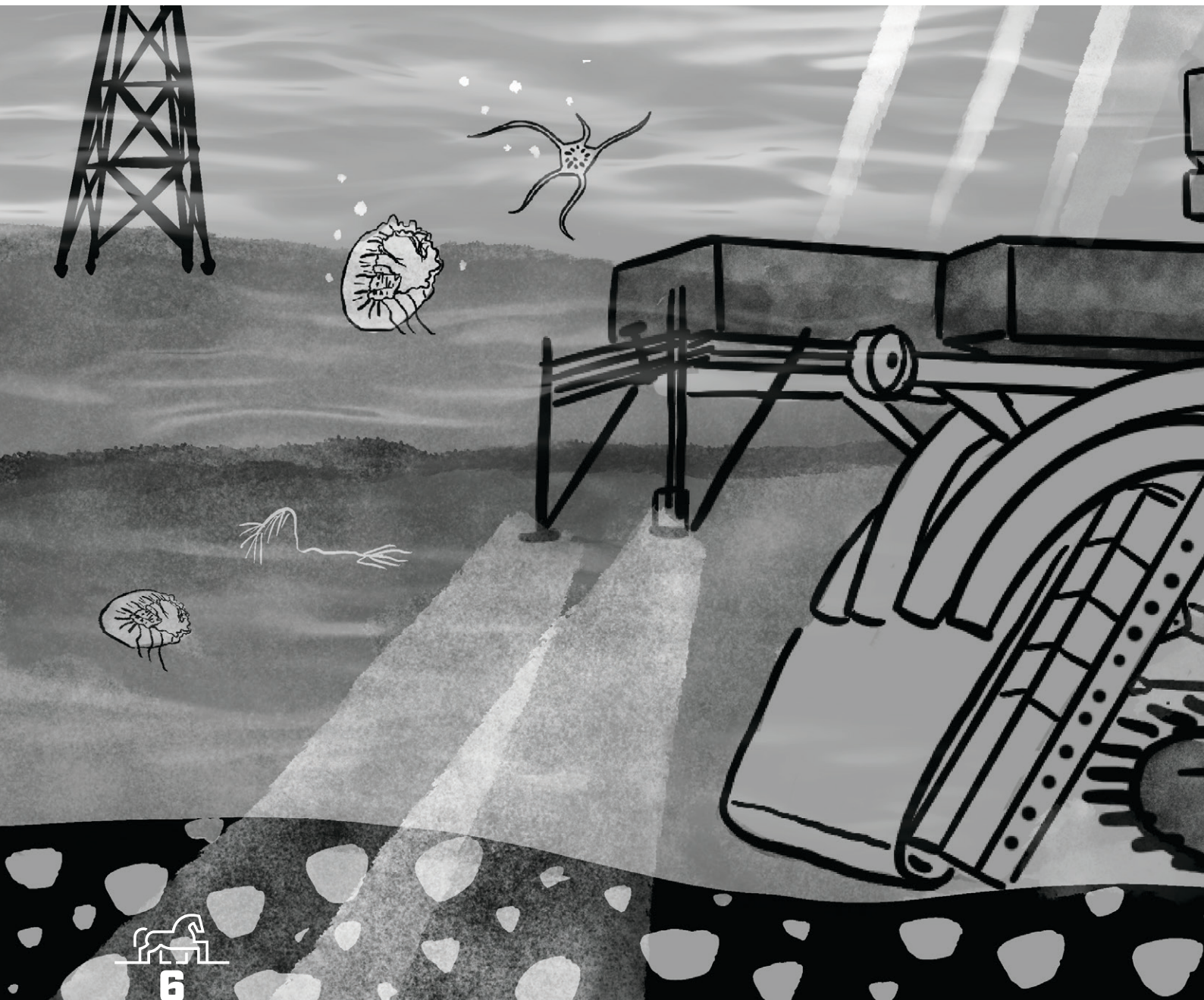


Starting to strip sea beds

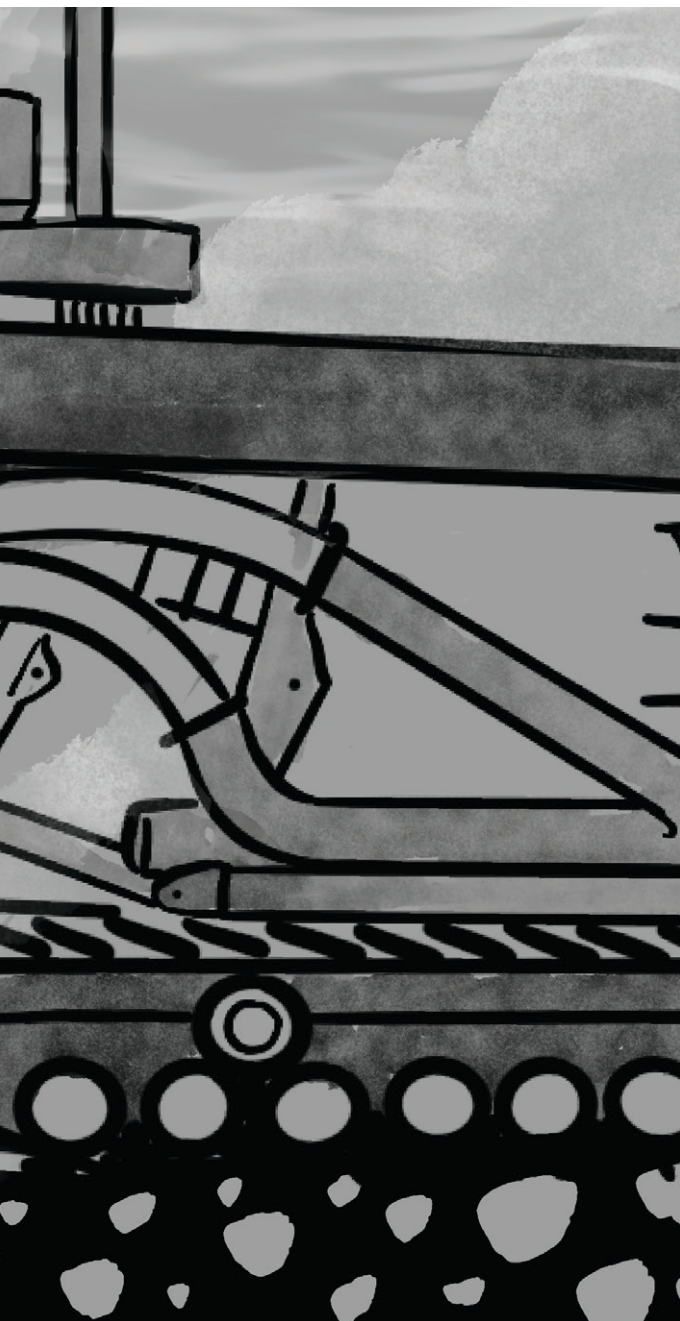
Mining of critical minerals for computing and electromobility is now effectively transcending the planet's terrestrial limits. As terrestrial sources become exhausted or too expensive to extract – or become mired in conflict between mining companies, governments and communities – the targets for mineral extraction have shifted to sea beds where so-called polymetallic nodules abound.³⁹ 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).⁴⁰

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

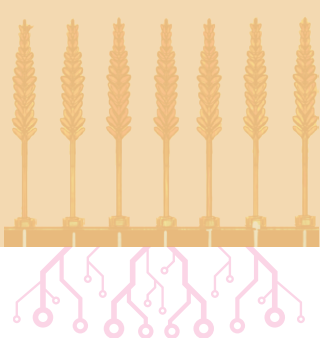


of species in the CCZ region are yet undescribed and that the CCZ is one of “the few remaining areas of the global ocean with high intactness of wilderness.”⁴¹ Pacific Indigenous communities have long opposed exploitation of the ocean, as the deep sea is the source of their creation⁴² and their livelihoods depend on it. In 2022, the governments of Fiji, Palau and Samoa formed an alliance to oppose deep-sea mining.⁴³ 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.”⁴⁴



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 years of the submission⁴⁵ (in July 2023, the deadline to adopt the mining regulations was extended to July 2025, which is still considered unrealistic by some.⁴⁶) 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 off-shore banking, selling passports, housing Australian asylum seekers, and today has little available freshwater. Today it relies on imported food, and its people suffer from high rates of heart disease, diabetes and obesity.⁴⁷ 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”⁴⁸ and countries like Japan, Norway, South Korea and Russia are ready to move ahead with their own plans to mine the deep seas.⁴⁹

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.⁵⁰ The marine ecosystems impacts of those undersea cables remain under-researched.⁵¹



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 Industries⁵² a decade ago, a new start-up called AstroForge wants to give it another go,⁵³ 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,⁵⁴ 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”⁵⁵ by reducing the need for mining on Earth, thereby reducing its environmental damages.

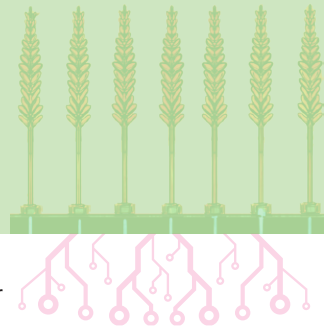
Furthermore, while current discussions among UN member states revisiting the 1967 Outer Space Treaty are focused on the space race, and the imminent threats of the weaponization of space and space debris, little attention is being paid to one particular elephant in the sky: the increasingly outsized 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 2020,⁵⁶ 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.⁵⁷ 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.⁵⁸

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 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.⁵⁹ 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.⁶⁰

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.⁶¹ 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.”⁶²

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.⁶³

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 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.⁶⁴

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 fracturing⁶⁵ – and this often competes with other water consuming activities, putting severe strains on local water supplies especially in areas where water is scarce.⁶⁶ 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.⁶⁷ 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.⁶⁸ 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 2022.⁶⁹ (Consider that the whole of the African continent consumed about the same amount of electricity in the same year.⁷⁰)

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.⁷¹ On 1 February 2024, the US Energy Information Administration reported that “annual electricity use from cryptocurrency mining probably represents from 0.6% to 2.3% of U.S. electricity consumption.”⁷²

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

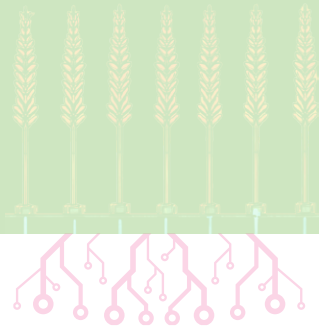
match the total power demand of Germany by 2026.⁷³

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.⁷⁴ The natural gas industry, which falsely promotes itself as renewable,⁷⁵ has also been getting in on the act, proclaiming that AI expansion “will usher in a golden era for natural gas.”⁷⁶

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.⁷⁷ 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).⁷⁸

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 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.⁷⁹

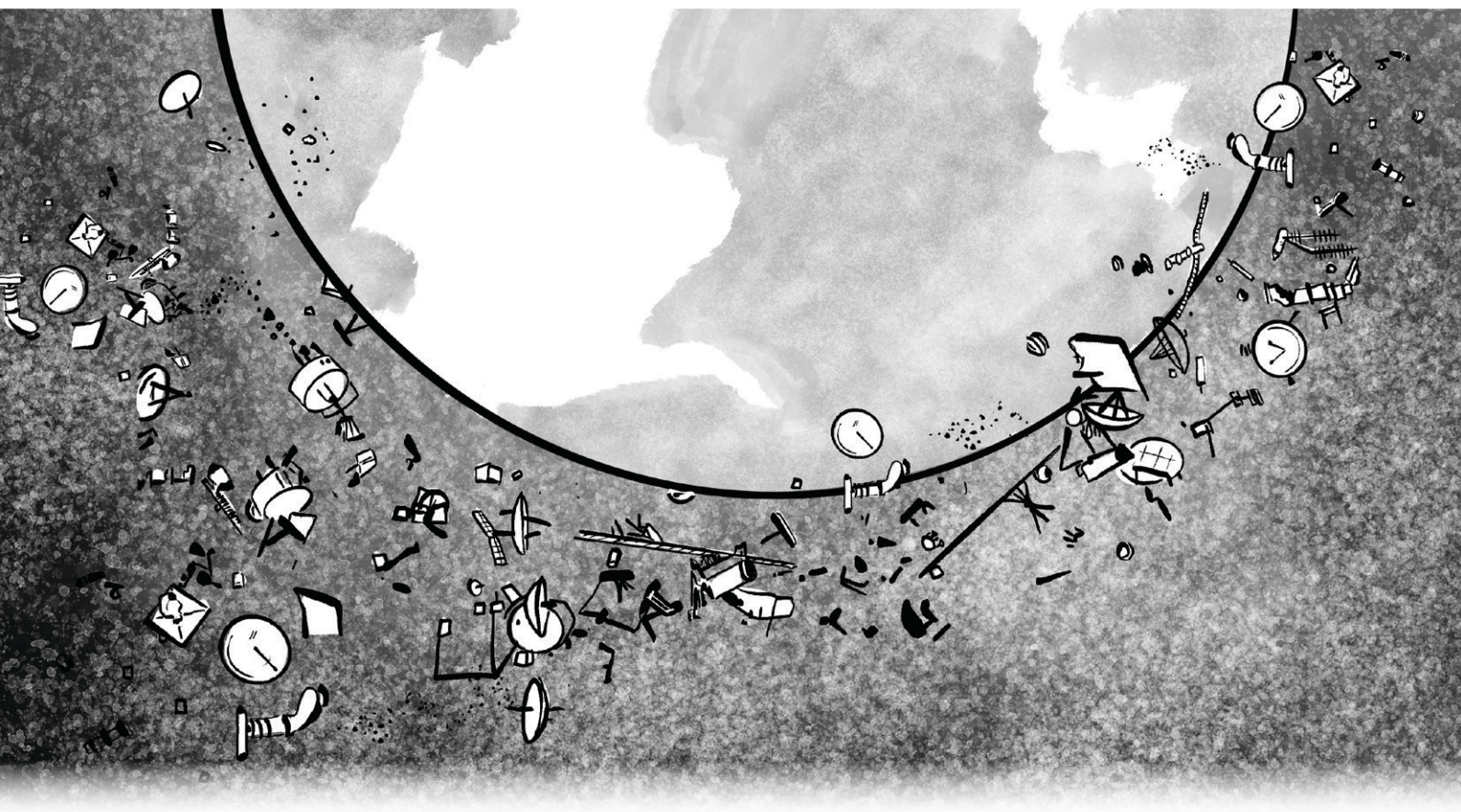
Renewables as salvation?

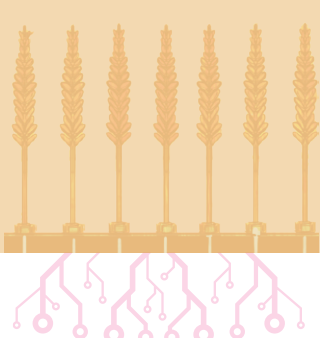


A decade ago, the Union of Concerned Scientists in the U.S. was already raising concerns about the potential impacts of solar power, including land degradation, habitat loss and toxins from the manufacturing of photovoltaic cells; more recently, they have raised concerns about “solar trash” (solar panels that have been discarded and might be considered hazardous waste because they contain pollutants such as cadmium and lead)^{80,81} 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.^{82,83} Such cases of unjust tran-

sitions to renewable energy, found in other countries as well, have been called “green grabbing”⁸⁴

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.





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

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.^{85,86} 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.⁸⁷

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.⁸⁸ 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.^{89,90}

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 substances⁹¹ while working in "a sprawling, globalized informal system of waste recovery sites,"⁹² looking for valuable materials ranging from

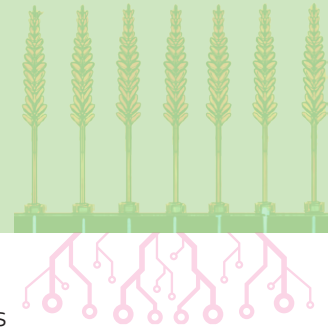
iron to aluminium, gold, palladium, silver and cobalt.⁹³ Electronic waste and batteries, which are non-biodegradable and full of toxins, do not end up only in dumpsites and landfills, but also in aquatic and marine environments either from direct disposal or by leaching.

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 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 1957.⁹⁴

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.

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.

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 the space debris littering 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

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,⁹⁵ 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
- 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.

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 evaluated before development and deployment, taking into account the precautionary principle, and with a view to prioritizing and promoting the well-being of all people, our environment and our planet.

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