

Rethinking Sustainable Development in the Digital Age: A Critical Examination of the Environmental and Social Impacts of Digital Technologies

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***Corresponding Author:** dfekpoto@unical.edu.ng; ekpotodavid@gmail.com**Abstract**

Currently, digital technologies are influencing the production and consumption of society, as well as its education, governance, and care. They also have an impact on our material and energy landscape: the data centres that power our electricity, the mobile networks that connect our devices, and the minerals that are essential to smartphone and computer production. This article delves into the environmental and social implications of digitalisation and explores what is needed to achieve a "sustainable digital age. The paper draws on recent research on electricity and water usage in data centres and AI and material footprint, embodied emissions and end-of-life effects of devices. It also tackles long-standing socioeconomic inequities such as unequal connectivity, a laboured and unstable workforce, and exposure to toxic e-waste. This article compares these risks to real sustainability advantages, such as reduced travel emissions from telemedicine and progress in precision agriculture enabled by digital technology, and identifies rebound effects that could offset the efficiency improvements. The paper then reviews policy options, such as the European Union's Right to Repair Directive and international digital governance rules for the Sustainable Development Goals (SDGs). It advocates a pragmatic agenda centred on sustainable-by-design digital ecosystems, such as adopting science-based limits on water and power consumption in computing, extending the useful life of devices, etc. The study concludes that while the digital age in Nigeria has great potential, it comes at a high cost to the environment and society, including e-waste, energy-intensive data centres, the unending digital divide and exploitative supply chains. It, among others, called for a Nigerian Right to Repair Policy.

Keywords: Data centres & AI, e-waste, digital divide, right to repair, sustainable digitalisation.

Introduction

With the onset of the digital age, the way we produce, consume, educate, govern, and take care of each other has radically changed in human society. Digital technologies such as smartphones, cloud computing, artificial intelligence (AI), and the Internet of Things (IoT) are a way of life, driving extraordinary connectivity and innovation. By 2025, it is estimated that 5.3 billion people, or approximately 66 percent of the world's population, will have access to the internet, and over 30 billion devices will generate and process huge amounts of data daily (International Telecommunication Union [ITU], 2024). It is important to highlight some of the greatest benefits of this digital revolution: it has led to more access to information, higher yields for farms, thanks to precision technologies, and the reduction of carbon footprint with the help of virtual technologies, such as telemedicine and remote work (World Bank, 2023). Yet with the rise of digital infrastructure come its own environmental and social concerns, and the implications of whether this transformation can be maintained are key questions.

Digital technologies have a big and complex environmental footprint. In 2023, data centres, which operate cloud and AI applications, used approximately 2% of the world's electricity, and it is expected that this percentage will grow to 4% by 2030 (International Energy Agency [IEA], 2024). These centres also have to cool large volumes of water, and a large-scale data centre consumes millions of litres of water annually, further aggravating the financial situation in water-rich regions (Shehabi et al., 2023). Furthermore, it is important to recognise that the production of digital devices requires rare and high-demand resources, producing embodied carbon emissions and environmental impacts (Greenpeace, 2024). Their lifecycle – production, use and disposal – generates a considerable amount of e-waste, estimated to be 61 million metric tonnes globally in 2024, with most of this informally processed under highly dangerous conditions, which puts workers and communities at risk of suffering adverse health impacts (United Nations Environment Programme [UNEP], 2024). Deeper social inequalities have been exacerbated by the digital age. The digital divide is as pronounced as ever, with 2.6 billion people (mostly in low-income countries) unable to access the internet with confidence and thus not benefiting from the digital economy (ITU, 2024). Furthermore, the rise of automation and AI in the labour market has also increased job market volatility, particularly for low-skilled workers, and the global supply chain for digital devices is heavily dependent on labour policies that are undignified and exploitative (International Labour Organisation [ILO], 2023). In developing countries, the informal e-waste industry puts people at risk of exposure to toxicants and places them in a vicious cycle of poverty and environmental injustice (UNEP, 2024).

However, despite these obstacles, digital technologies could impact sustainable development. Precision agriculture, powered by IoT and AI, has helped boost yields by as much as 20 per cent in some regions and cut back on water and pesticide use (Food and Agriculture Organisation [FAO], 2024). The benefits of telemedicine and remote working have reduced travel-related emissions, with studies showing that commuter carbon footprints can be lowered by 10 to 15 percent in urban areas with telemedicine and remote working programs (World Health Organisation [WHO], 2023). However, these benefits are sometimes lost through rebound effects: the more efficient they are, the more they are consumed, thereby reducing their environmental benefits (Otunba-Payne & Onyia, 2023).

In this complexity, sustainable development needs to be redefined in the digital age. Other policies, like the European Union's Right to Repair Directive (European Commission, 2024), are also in place, contributing to extending device lifespans and reducing e-waste by ensuring designs that feature easy-to-repair parts and the availability of spare parts. On the same note, global models of digital governance that align with the United Nations SDGs focus on equal access, sustainable resource utilisation, and equitable digital services (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2021; United Nations, 2024; Ekpoto et al., 2025a). But, besides policy changes, it is a paradigm shift towards sustainable-by-design technologies and towards energy efficiency, circularity, and social equity that are necessary to achieve a truly sustainable digital ecosystem. This paper critically explores the environmental and social implications of digitalisation, drawing on existing literature to highlight the risks and opportunities. The paper identifies

pathways towards resilient digital ecosystems and proposes a practical agenda that balances technological development and policy measures for equity, resource conservation, and climate resilience. This is what the authors consider essential, as they believe they have a vision for the future in which technology will benefit humanity and the planet rather than harm them, guided by the principles of SD.

The Environmental Price of Digitalisation

Today is an age of digital technology, often spoken of as progressive, but it casts a deep shadow over the ecosystems of this planet. Hidden behind the uninterrupted connectivity of smartphones, the inexhaustible nature of the cloud, and the rapid calculations of artificial intelligence is an ecological price: associative digital technologies are endangering the sustainability they are supposed to promote. There's an environmental cost to digitalisation, and the voracious appetite for electricity that data centres have, as well as the bad legacy of electronic waste.

But while the urgent climate of our global pursuit of a sustainable future will be undermined by the environmental footprint of digital technologies, there is also a systemic need to change how they are designed, manufactured, and discarded. We are in the digital era, a miracle, phones, apps and cloud services make life faster, easier and more connected. But the secret is, this comfort is paid for by our planet. In Nigeria, where technology usage is on fire, in Lagos, the big tech city and in rural areas, where farmers are using apps on their phones, the ecological impact cannot be overlooked.

Data centres use energy resources; devices are made using up the earth; and e-waste pollutes communities. Researchers estimate that we will pay an environmental toll that will derail the progress we are making if we do not change the way we design and use digital technologies. Ponder on the energy needs and resources that will be mobilised in Nigeria alone to bring the country's fragile state of electricity supply to an end. Tech companies, including MTN in Nigeria, are already using diesel generators to keep their data centres online, thereby polluting a country highly susceptible to climate change (IEA, 2024). Typical of such systems are those that suck up all the water when they are cooling servers. One hyperscale data centre can use around 10,000 households' worth of water per day in Lagos, where 60% of the population has no access to clean water (Shehabi et al., 2023; World Bank, 2025). The scene of a community queuing for water while the water servers stay cool in Agege is a clear indication of misplaced priorities.

Likewise, examine the real-world space taken up by devices. The manufacturing of smartphones and laptops involves the extraction of rare-earth minerals, such as lithium and cobalt, which are usually found in environmentally sensitive areas. In Nigeria, where 80-100kg of CO₂ equivalent is emitted for every smartphone (Greenpeace, 2024; ITU, 2024), this hidden cost of the gadgets has not been accounted for. This is 2 journeys from Lagos to Ibadan for every phone purchased. Mining, mostly located in countries such as the Democratic Republic of the Congo, disrupts ecosystems and contaminates water sources, thereby indirectly affecting Nigeria through supply chains (Greenpeace, 2024). For any technologically minded person in Nigeria who has upgraded to the latest iPhone, the environmental impact of the latest gadget is unseen but certainly present. This is where it becomes a perfect story of damage in Nigeria in the context of e-waste.

The country is the largest consumer of used electronics in Africa and generates over 500,000 tons of e-waste annually, mostly at the Alaba Market in Lagos (UNEP, 2023). Old circuit boards are frequently burned to recover the copper within them, contaminating the environment with harmful materials such as mercury and lead. The dump sites with neonatal deaths include Oshodi, around which cases of neonatal deaths increase by 4 per 1000 births, with these toxins seeping through the ground and rivers (Forti et al., 2024; Lovo & Rawlings, 2024). This type of exposure causes respiratory health issues and neurological effects – especially impacting vulnerable groups like children, according to WHO (2024). Informal recycling is extensive in places such as Port Harcourt, and in these areas, the whole community exists in the shadow of this unfriendly heritage. This paper asserts that digitalisation is not only harmful to the environment but also a lack of imagination and responsibility. Diesel-fuelled data centres and uncontrolled

e-waste disposal are simply not feasible in Nigeria, where power is a luxury and, in most parts of the country, water is in short supply.

The mining and disposal involved in creating devices are destroying the planet on a global scale. There is a pressing need for action – green data centres powered by renewable energy, for example, as developed in Kenya (IEA, 2024); and stringent water-use standards and a Nigerian Right to Repair policy to push for longer device life and less waste. No artisan in Nigeria should be subjected to toxic fumes and no 'buy a new phone' should cost the earth. Unless we change our ways for sustainable growth, the digital age will plunge Nigeria and the world into a debt trap of environmental goods that we cannot afford.

Nigeria requires technology that uses energy efficiently, regulation of water consumption, and adherence to international standards to effectively deal with e-waste. Unless, as a nation, we act now, the resources we want to conserve will be further drained by the digital age. It's past time to end the collateral damage towards our environment and to create a digital world that treats our planet with respect.

Digital Divides in Social Inequality

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The Promise of Digital Technologies for Sustainability

While the digital age can be a source of pressure and inequality, it can also offer hope for a more sustainable future. Digital technologies are demonstrating their ability to reduce carbon emissions, improve productivity, and engage communities, from farms in northern Nigeria to hospitals in Lagos. The question, however, is how these benefits occur: Gains can be lost due to rebound effects and access inequalities, which can turn the promise into a missed opportunity. One can boldly think digitalisation can be a game-changer for sustainability, but if it's not done intentionally, with a clear focus on equity and efficiency, I'm afraid we may be left with places like Nigeria, benefiting without suffering the side effects of overconsumption. Think about precision agriculture, where technologies such as AI and IoT sensors are revolutionising the agricultural industry. In the world of agriculture, consider precision farming, which relies on technologies such as AI and IoT sensors.

For example, in Kaduna State, northern Nigeria, the Food and Agriculture Organisation (FAO)- supported e-Extension programme has trained farmers to use mobile applications that measure soil moisture and weather conditions. The programme has now been rolled out since 2023 and is expected to help boost yields by up to 20 per cent for 10,000 smallholder farmers, reduce water use by 15 per cent, and reduce pesticide use by 15 per cent (FAO, 2024; Ukwai et al., 2023). That reduces the stress on Nigeria's already strained water resources and reduces soil contamination from chemicals. Such digital tools are helping reduce agricultural emissions worldwide, which account for 14 percent of greenhouse gas (GHG) emissions (FAO, 2024). Telemedicine is reducing emissions of travelling. Helium Health offers remote consultations with medical doctors, which can reduce urban commuter emissions by 10-15 percent in regions where it is adopted (WHO, 2024). The possibilities of having such tools in every Nigerian city are astounding, and a taste of what can be achieved when technology meets the UN's SDGs (UNESCO, 2021; Ekpoto et al., 2025a). Socially, digital platforms can offer access to education, healthcare, and governance, particularly for the underserved communities (Ekpoto et al., 2025b; Ukwai et al., 2026).

The OER Hub, a digital education platform introduced in 2023, offers free online materials for more than 50,000 secondary school students in rural Ogun State, western Nigeria, giving all children equal access to learning, particularly if they don't have the budget for private tuition (UNESCO, 2024). Mobile banking applications such as Kuda have enabled easier access to loans and financial management for women, thereby enhancing the growth of handiwork without requiring travel to urban banks (World Bank, 2025).

There are also gains in digital governance, with Nigeria's e-Government portal, expanded in 2024, facilitating online access to services such as tax payments and voter registration for citizens in remote areas, thereby lowering barriers to bureaucratic service delivery (World Bank, 2025). These examples illustrate the power of digital tools to enable a community, but they are only powerful if they are accessible to everyone; otherwise, they are a privilege for the connected few. It is important to note that all these benefits come with a hidden price tag: the rebound effect. With the introduction of digital technologies, things become more efficient, and we're left with more, not less.

For instance, ride-hailing apps in Nigeria, such as Bolt, have reduced fuel consumption per trip by optimising ride routing while simultaneously increasing demand for car transportation, leading to a greater car-related carbon footprint (Otunba-Payne & Onyia, 2023). Research worldwide indicates that digital tools could increase consumption by 20-30 percent, either by allowing people to stream more content, purchase more devices, or travel more when costs are reduced (Otunba-Payne & Onyia, 2023). It's similar to dieting by eating lower-calorie snacks, but then doubling the amount – all the calories are consumed in the end. Smartphone penetration in Nigeria has increased from 44 per cent in 2020 to 60 per cent in 2024, as demand for data has grown, compounding the energy needs of data centres, contrary to digitalisation's green agendas (ITU, 2024).

It is important to highlight that digital technologies can be a strong enabler of sustainability, but can also be fragile. Nigeria's e-Extension and OER hub demonstrates what can be achieved with a well-designed, well-used technology, but if it is not equally available, it is a pilot project for the lucky. Like ride-hailing apps, ricocheting effects remind us that efficiency alone is not sufficient; policies to reduce overconsumption must be in place. The digital age must be made truly sustainable, with e-Extension programmes scaling up to reach millions of people, platforms to reach rural areas, and data centre energy use limited and regulated to prevent runaway demand. It is the responsibility of the government, tech firms and global partners to work together to make access and efficiency more important than profit in Nigeria. Until we get this right, digitalisation cannot be a lifeline for sustainability - not in Nigeria, nor anywhere.

Policy Solutions for a Sustainable Digital Age

The digital age is an incredible one, but it's also highly expensive on both the environment and the social level, and as such, more than just hoping, it's time to take action. Structures are needed to capitalise on and address the negative effects of digitalisation. The journey towards a sustainable digital age involves both bold and practical solutions. Bold and practical solutions are the key to achieving a sustainable digital age. Sustainable-by-design ecosystems, when given high priority, can drive digitalisation for equity and environmental stewardship for both Nigeria and the world at large. But it will take a well-coordinated effort from governments, tech firms and citizens to make it happen. Consider a comprehensive regulatory regime that can establish a sustainable attitude. The European Union's Right to Repair Directive is a paradigm shift that will be fully enforced in 2024, forcing manufacturers to create devices that are easier to repair and longer-lasting (European Commission, 2024). This approach can help save lives in Nigeria, where 60 percent of smartphones are second-hand (ITU, 2024). What if the electronics workers in Aba could fix phones without dismantling them for parts?

If a Nigerian version of the Right to Repair is adopted, it will open repair shops in the country, create jobs, reduce the 500,000 tons of e-waste Nigeria produces annually, and establish local repair centres (UNEP, 2023). Not only would these policies reduce waste, but they would also strengthen local economies and demonstrate that sustainability and opportunity can coexist. It is essential to link digital governance with

the United Nations' SDGs on a global scale. The UN's 2024 roadmap calls for digital infrastructure that promotes equitable access and responsible resource use (United Nations, 2024).

In our local context, Nigeria, it could be the scaling up of the Universal Service Provision Fund (USPF) that has brought internet access to 15,000 rural people in remote areas such as Borno at low cost since 2023 (World Bank, 2025). But the USPF's reach is still limited - only 5 percent of its target communities were covered by 2024, leaving millions of low-lives offline (World Bank, 2025). If scaled up with international support, this type of programme could help close the digital divide in Nigeria and make SDG 9 (industry, innovation, and infrastructure) a reality. Global cooperation is also required now to manage supply chains, as Amnesty International has documented, for cobalt in the Democratic Republic of Congo, whose devices are imported into Nigeria, with child labour. If there are no binding international standards, there will be exploitation.

The sustainable digital age is about designing sustainable-by-design ecosystems. This includes science-based restrictions on the energy and water consumption of data centres, which is particularly important in Nigeria, where energy shortages make data centres reliant on diesel generators, increasing emissions (IEA, 2024). For instance, the city of Lagos, as a developing tech hub, could implement the green data centre standards adopted in Kenya, which aim to reduce energy consumption by 30 per cent and use renewable energy for data centre cooling (IEA, 2024). Another necessity is to extend the devices' lifespans. E-waste (UNEP, 2023) will be reduced by 80 percent in Nigeria, with 80 percent of its electronics being imported used. Incorporating repair and reuse infrastructure, such as training programmes for recyclers in the Alaba Market, would help safeguard workers from toxic exposure and generate decent work opportunities (Forti et al., 2024).

As far as access is concerned, Nigeria needs to expand its 3 Million Technical Talent (3MTT) programme to reach the 1.7 million who applied by its March 2024 target of training 30,000 youths in tech skills (WEF, 2024). The truly sustainable digital ecosystem ensures that “no one is left behind.” The digital age can be a pillar of sustainable development if relevant actors analyse it in detail. Nigeria's problems—from power failures to a huge digital divide to piles of e-waste in places like Oshodi—require specific policies and even one-size-fits-all solutions, as the EU's Right to Repair demonstrates; Nigeria can pioneer the way for Africa to tailor these policies to its own needs. Global agreements such as the SDGs need to be translated into action, including fully funding the USPF to connect rural areas. For the above, sustainable-by-design ecosystems – green data centres, repair hubs, and fair training programmes – should be considered as a given. Governments, tech companies, and communities need to work together and transform the mindset from profit to people and planet. Nigeria's ‘we can make it’ outlook is what makes innovation and resilience thrive – and even in the face of these odds, this is our opportunity to set an example for the world in creating a digital future that is inclusive and inclusive.

Conclusion

The digital age in Nigeria presents immense promise but carries high environmental and social costs, from e-waste and energy-hungry data centres to the persistent digital divide and exploitative supply chains. Sustainable digitalisation is achievable only through ecosystems designed for energy efficiency, equitable access, and circular economies. Policymakers, tech companies, global partners, and citizens must collectively champion initiatives such as a Nigerian Right to Repair, expanded connectivity, green data centres, and ethical supply chains to ensure that technology empowers rather than harms. With strategic investment in skills, infrastructure, and innovation, Nigeria can harness digital tools to advance agriculture, education, entrepreneurship, and healthcare while safeguarding people and the planet. By embracing this vision, Nigeria can lead globally and prove that a just, inclusive, and sustainable digital future is possible.

Recommendations

The following recommendations were made:

1. Enactment of a Nigerian Right to Repair Policy: The government should enact legislation empowering citizens and small businesses to repair and maintain digital devices, reducing e-waste and fostering local innovation.
2. Expansion of Nationwide Digital Connectivity: Critical stakeholders should scale up initiatives such as the Universal Service Provision Fund to ensure equitable access to the internet, aiming for at least 80% coverage by 2030, particularly in underserved northern regions.
3. Investment in Green Data Centres: The government should encourage public-private partnerships to develop renewable energy-powered data centres, reducing energy and water consumption while supporting Nigeria's tech ecosystem sustainably.
4. Enforcement of Ethical and Circular Supply Chains: A strong collaboration with global partners should be instituted to eliminate exploitative practices in mining and manufacturing, while promoting recycling, refurbishment, and circular-economy models for digital devices.
5. Strengthening Skills Development and Digital Literacy: Programmes like 3MTT should be expanded to train millions of youths in digital skills, ensuring the workforce can fully leverage technology for agriculture, healthcare, education, and entrepreneurship.

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