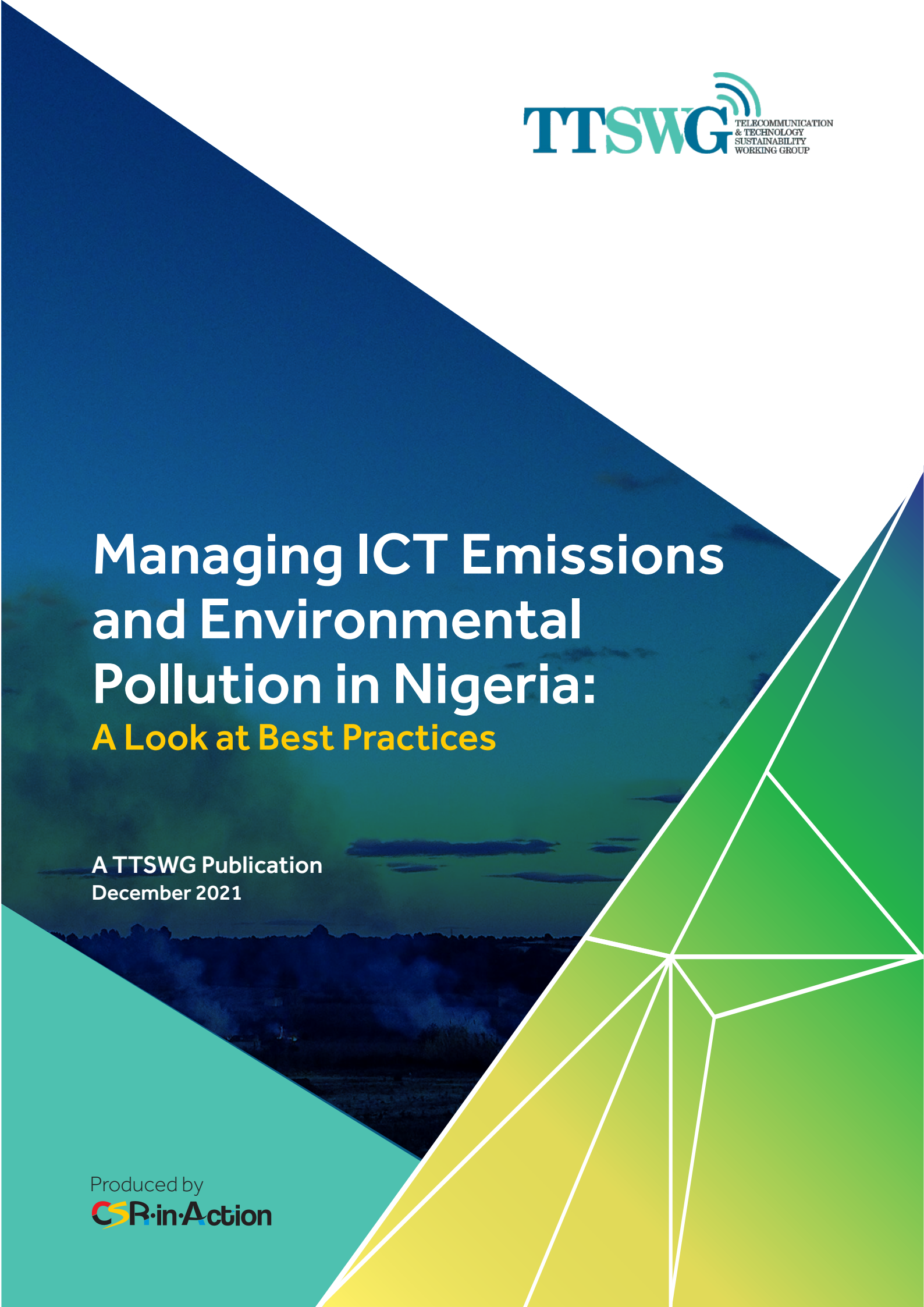
TTSWG
TELECOMMUNICATION & TECHNOLOGY SUSTAINABILITY WORKING GROUP

# Managing ICT Emissions and Environmental Pollution in Nigeria:

## A Look at Best Practices



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**"According to Albiman (2016), many international initiatives have been launched to support African efforts to develop communication infrastructures, with the goal of enabling African countries, including Nigeria, to foster ways of achieving long-term and sustainable development."**

Information Communication Technology (ICT) is simply technology that supports activities involving information. Such activities include gathering, processing, storing, and presenting data. It is a combination of informatics with other related technologies, specifically communication technology. Increasingly, these activities also involve collaboration and communication. In addition, ICT could be referred to as Information Technology (IT), which lays emphasis on the function of the role of unified communications and the harmonisation of telecommunications, which include computers, telephone lines and wireless signals, as well as necessary applications software, storage, and audio-visual systems that enable users to process information. ICT covers any product that stores, retrieves, manipulates, transmits or receives information electronically in a digital form. Mobile, fixed, and internet networks are part of its infrastructure; for example, personal computers, digital television, email and robots.

ICT has reduced the operational cost of financial institutions, manufacturing plants, and diverse sectors of the Nigerian economy, and has helped in expanding their businesses. Banks, for instance, are more flexible now and are providing better services, as a result of the efficiency of ICT. They work more securely and are more inclusive. Mobile banking is one of the best examples. ICT also helps with better information collection, which is required for detecting the credit score of customers. The financial integration of countries is improving due to the ICT sector. It has been widely proven and accepted that ICT is the engine of the 21st Century and beyond; as it will chart the economic, religious, cultural, legal, and social life of nations, particularly that of developing countries.

The application of ICT has emerged as the most radical development of the 21st Century, providing economic opportunities to both urban and rural populations. While one of the common contributions is that it increases productivity and efficiency, the magnitude of the economic growth is likely to be different. The fact that virtually all new mobile customers in the coming years will be in developing countries, and more specifically in rural areas, means that ICT is reaching a population with low levels of income and literacy. As a result, ICT is rapidly becoming the largest distribution platform for providing public and private services to millions of people in rural and impoverished areas.

Global System for Mobile Communications (GSM) dominates the Nigerian telecom industry, accounting for almost 98% share of the market. GSM is one of the world's fastest-growing and most in-demand telecommunications applications, particularly in Nigeria. It presents a constantly growing telephone subscription around the globe. Nigeria is a major consumer of GSM for communication in Africa, with over 60% of the total population relying on GSM as the fastest means of communication. Four GSM operators (Airtel, 9mobile, Globacom, and MTN) control the industry in Nigeria.

According to a study on GSM station radiation, the number of structured Base Transceiver Stations (BTSs), or mast sites, by the four service operators, grew from zero in 2001 to about 44,000 in 2014. The four major GSM providers in Nigeria have a subscription base of over 143.05 million people. Ever since the launch of mobile phone service in Nigeria in early 2001, it has played a crucial role in the dissemination of information (communication, SMS and data for internet usage). The sector recorded a significant growth from 2.27 million subscribers in 2002, when the first mobile permit was issued, to 143.05 million at the end of the first quarter of 2015.

The role and distribution of mobile phones and supplementary wireless communication services around the world has not merely eased the world into a universal group, but a global home. What was once exclusively a business instrument such as remote telephones are presently a mass business sector customer gadget contributing to the Gross Residential Items (Gross Domestic Product) of different nations and providing jobs to many young people, experts, and dealers.

Thioune in 2003, posited that in today's world, modern

digital telecommunication networks are necessary for economic growth and attracting foreign investment. Furthermore, a reliable telecommunication network can improve the productivity and effectiveness of other sectors of the economy and also improve the quality of life.

In a technology-driven society, communication is vital for both sender and receiver. According to Albiman (2016), many international initiatives have been launched to support African efforts to develop communication infrastructures, with the goal of enabling African countries, including Nigeria, to foster ways of achieving long-term and sustainable development.

More so, there has been the development of big data analytics, cloud computing, artificial intelligence, internet, and other next-generation ICT solutions with industrial sectors around the world at the critical stage of integration with the digital economy. Digital transformation has gradually become a new pathway for the sustainable development of industrial economy, and digital technology has become the driving force of economic growth. However, environmental quality has been declining in industrialising countries, and the environmental performance of manufacturing enterprises in these countries tends to be poor.

There is consensus today that environmental sustainability is a key theme in the sustainable development agenda. The relevance of this theme to sub-Saharan Africa can be articulated along four constructive lines, notably: the comparatively high economic growth record in the sub-region; growing energy crisis; poor management of energy crisis and negative externalities from global warming. In Nigeria, the ever-growing dependence on electronic products has paved the way for an emerging environmental concern called electronic waste. While the problem of electronic waste seems to have emerged only recently, it has been building up since the first computer or electronic product was manufactured. According to PPCC (2006), "electronic waste is an unwanted electronic or electrical appliance that has been discarded by its original user such as old and outdated computers, laptops, televisions, cellular phones, MP3 players, telecommunications equipment, keyboards, mouse, photocopiers, typewriters, etc." Electronic equipment contain hazardous materials, which can affect human health and the environment if not properly managed, but the good news is that majority of electronic waste contain materials that could be recovered and reused for new product development. The underlying literature has been dominated by the use of ICT in controlling environmental pollution.

For example, Jereb et al (2021) opined that ICT can be considered a solution for reducing pollution, especially when interacting with road freight transport to increase energy efficiency through innovative practices, such as e-ticketing, smart transport, and reservations. Likewise, Atu (2008) posited that users of computers can watch presentations on deforestation, pollution, loss of wildlife and habitat and then learn about ways to care for the environment. In the same context, Sahoo et al (2021) reported the favorable impact of mobile phones and the internet in dampening carbon emissions in India between 1990 and 2018. A fundamental shortcoming in the highlighted studies is that they collectively failed to explore the possible negative contributions of ICT to environmental pollution in order to proffer best practices for mitigating any challenges.

To make this assessment, internet, computer and mobile phone penetrations were used to assess their effect on CO2 emissions. The net impact would be reported from both the conditional and unconditional effects of ICT. Thus, the inquiry steers clear of recent ICT literature which has fundamentally focused on, amongst others, economic prosperity, banking sector progress, living standards, externalities in welfare, Africa's information revolution from the perspectives of production networks and technical regimes, life for all, and sustainable development in developing nations. Accordingly, while socioeconomic and human development benefits from ICT have been well established in the literature, very little is known about the nexus between ICT emissions and environmental pollution in Nigeria. Hence this study hopes to:

1. Establish the linkages between ICT and environmental pollution.
2. Uncover the effects of ICT emissions on environmental pollution.
3. Identify best practices to mitigating the impact of ICT emissions on the environment.


Figure 1: Interaction Between ICT, Carbon Emission and Pollution

## Linkage Between ICT and Environmental Pollution

The conceptual framework depicted in Figure 1 shows the interaction between ICT and environmental pollution. ICT comes with several tools such as GSM, computers, base transfer receivers and telecommunication masts. These ICT tools in some way contribute to pollution. For example, pollution, specifically noise and air, are the consequential effect of hazards from mast installations. Noise from generators combined with horns from vehicles pollute the peace that characterises the atmosphere and serenity of residential areas. Also, residents who live close to installed masts experience continuous disturbing sounds from generating sets that are used to power base stations which cause noise and environmental pollution. Some of these telecommunication masts are indiscriminately located within residential areas. Justifying this assertion, Aderoju et al (2014) noted that telecommunication masts were erected in some areas in Abuja without recourse to the provision of infrastructure in the community master plan. The implication of this trend on human health is obviously significant.

In addition, the components and constituent solid waste is another major effect of the abandonment of telecommunication masts gadgets which are hazardous and injurious to human health. The hazardous nature of this waste endangers human health, water, soil, and the entire ecosystem by posing serious health risks. It is also an eyesore in the environment.

Continuous diesel-burning for powering telecommunication sites, in addition to other extreme activities such as a change in land use and poor waste management, has the potential to impact the environment, leading to a destructive increase in intensity, duration, and frequency of heat waves. Ladipo and Gbenga-Ilori (2020) in a study conducted in Lagos showed that all the telecommunication sites visited were associated with different sources of unwanted noise, as heavy-duty generators are always on, accompanied by noise from the RBS 6102 or RBS 6103 which are the common outdoor macro BTS in the RBS 6000 series. It is obvious that continuous noise from telecom operations can be harmful to one's health, causing illnesses such as increased stress levels, headaches, loss of sleep and diverse hearing defects to the people staying close to these sites, particularly so for sites that are situated very close to residential premises.

The continuous emissions from the dependence of telecommunication service providers on diesel fuel for their operations result in air pollution and the study from Olowoporoku et al (2012) revealed the relationship between cardiovascular infections, heart and respiratory diseases and air pollution in Lagos. Uncontrolled burning, disassembly and disposal can cause a variety of environmental problems such as ground water contamination, atmospheric pollution or even water pollution. Dumping of information and communication technology waste in any environment occupies space, disorganises the environment and has negative health consequences, such as leaching toxins into the soil, air and ground water, which in turn affect crops, animals and human body systems, causing physical injury, skin disorder, interference with regulatory hormones and pollution.

Information and communication technology waste contain heavy metals, such as lead, zinc, chromium, cadmium, mercury and in trace amounts, germanium gallium, barium, nickel, etc. According to Greenpeace (2010), there is an increase in information and communication technology waste and this increase is disturbing especially when coupled with the fact that waste management processes and regulation have not caught up to the digital age. Outdated waste disposal methods are still employed throughout much of the world. This leads to polluted water, contaminated soil, air pollution and high cancer rate in people who work and live around recycling dump sites, due to the burning of plastics and other contaminants. Unfortunately, the disposal and recycling of computer waste in institutions has become a serious problem, since the methods of disposal are very rudimentary and pose grave environmental and health hazards. Medical experts have warned that exposure to these substances can cause damage to blood and nervous systems, DNA, immune systems and kidneys, leading to respiratory and skin disorders, and lung cancer, as well as interfering with regulatory hormones and brain development.

BTSs are designed to enhance communication radio-frequency network signals for the rapidly expanding digital telecommunication users in urban and rural communities. It also facilitates the extension of communication network accessibility to suburban and rural communities lacking access to telecommunication services. Typical BTS consists of telecommunication masts with installed radio frequency transmitters and receivers, powered by digital electronic boosters which are installed in shelters within the BTS site. The introduction of this technology has resulted in a number of environmental issues. This includes the indiscriminate siting and erection of BTSs all over Nigeria. A conservative estimate of over 20,000 BTSs are scattered around the country. Many of the BTSs are sited within residential, commercial, industrial and transit routes. Aside from the risk of chronic human and environmental exposure to radiation and other

environmental and safety matters, air quality damage appears to be of priority.

The GSM no doubt is the most rapidly growing contributor to waste generation around the world due to the growing range and short lifespan of communication devices such as computers and mobile phones. However, GSM base stations pose a number of major environmental challenges. The GSM constitutes toxic materials, and when indiscriminately disposed, pollutes the environment. The GSM operation is also the fastest growing contributor to greenhouse gas emissions, currently contributing around 2.5% of global emissions, with these increasing at a rate of 6% per annum. This growth is attributable to the energy used as a result of the spread of ICT networks and devices, the growing number of devices used by individuals, businesses and organisations, and the increasing length of time each day during which devices are in use. These direct impacts on greenhouse gas emissions result from the beneficial use of ICT to access information, enable social and business interactions and, ultimately, develop knowledge societies.

The compositions of ICT waste are generally diverse and fall under hazardous and non-hazardous categories. Generally, they contain ferrous and non-ferrous metals, glass, plastics, wood and plywood, concrete, ceramics, printed circuit boards, rubber and other items.

The Cathode Ray Tubes (CRTs) which are found in some monitors and television are composed of as much as 8% lead by weight. This amounts to about 2–4 kg of lead each. The CRTs in computers create disposal problems because of their increasing magnitude in waste streams and their role as major sources of certain metals such as lead, mercury, cadmium and beryllium. In addition, electrical and electronic products contain polymers, polychlorinated biphenyls and brominated flame retardants which are commonly found in Municipal Solid Waste (MSW). Mobile phones contain more than 50 different components, including base metals (copper, tin), special metals (cobalt, indium, antimony) and precious metals (silver, gold, palladium). The most common metal component in use in electrical and electronic equipment (EEE) is copper (9g), while the most common precious metals in increasing order are palladium (9mg), gold (24mg) and silver (about 250mg).

The lithium-ion battery found in mobile phones contains about 3.5 grams of cobalt. Steel and iron constitute about 50% of the waste, plastics 21%, non-ferrous metals 13% and other constituents. Some ICT components and the pollutants associated with them are summarised in Table 1. The potential occurrence of elements such as lead, cadmium, selenium, arsenic, mercury, hexavalent chromium and flame retardants beyond allowable quantities, make e-waste dangerous in nature. Upon disposal, they cause pollution as a result of their toxic nature.

**Table 1: Chemical Components of ICT Wastes and their Environmental Effects**

| Chemical | ICT sources | Environmental and health effects |
|---|---|---|
| Lead (Pb) | A glass of Cathode Ray Tubes in television sets/computer monitors, acid batteries, Polyvinyl Chloride (PVC) cable | Lead (Pb) accumulates in water bodies and soil organisms leading to poisoning. Pb can enter the human body through food intake, water and air as such can be found in food like fruits, vegetables, meat, grain, and seafood.<br><br>Lead can cause several unwanted effects, such as disrupting the biosynthesis of haemoglobin and anaemia, kidney damage, miscarriages, increase in blood pressure, disruption of nervous systems, brain damage, declined male fertility, etc. |
| Beryllium | Connectors, mother boards and finger clips | When inhaled, beryllium compounds can lead to an irreversible and, sometimes, fatal scarring of the lungs-berylliosis or Chronic Beryllium Disease (CBD) and can affect other organs, such as the lymph nodes, skin, spleen, liver, kidneys and heart. |
| Polychlorinated biphenyls (PCBs) | Electrical transformers, capacitors of TV sets, computer monitors & radios, Polyvinyl Chloride (PVC) | Chloracne and related dermal lesions have been reported in workers occupationally exposed to PCBs. Others are pigmentation disturbances of skin and nails, erythema and thickening of the skin, and burning sensations. Reproductive function may be disrupted by exposure to PCBs, and neurobehavioral and developmental deficits have been reported in newborns exposed to PCBs in utero. |
| Mercury (Hg) | Batteries, flat screen TV sets, switches, relays, computer housing | When products and waste containing mercury are improperly disposed, mercury is released into the air, ground or water. Mercury is persistent in the environment - it never breaks down or goes away. Exposure to mercury can affect thinking, memory, attention, language, fine motor skills and visual spatial abilities. |
| Barium | CRT, Vacuum tubes | As a result of extensive use of barium in e-waste, its concentration in air, water and soil may be higher than naturally occurring concentrations in many locations. Most of the health risks that people working on e-waste are exposed to include paralysis and, in some cases, even death. |
| Cadmium | Steel housing of CPU, chrome plating and in metal ceramics | The uptake of too much chromium can cause health effects as well, for instance, skin rashes, upset stomachs and ulcers, respiratory problems, weakened immune systems, kidney and liver damage, alteration of genetic material, lung cancer and even death. |

| Chemical | ICT sources | Environmental and health effects |
|---|---|---|
| Cadmium (Cd) | Switches, solder joints, housing coatings, cathode ray tubes, rechargeable batteries | High exposures to cadmium can occur, especially to people who live near e-waste sites or factories that release cadmium into the air. When cadmium is released into the environment and people breathe it, they stand a chance of having severe lung damage and this can lead to death. Cadmium accumulates in the kidney damaging its filtering mechanisms. Other health problems are diarrhoea, stomach pain, severe vomiting, damage to the central nervous system and the immune system. |
| Nonylphenol (NP) | Insulators, housing, casing | The toxicity of NP is said to be low in humans. However, NP is highly irritating and corrosive to the skin and eye. In the environment, NP is highly toxic to fish, aquatic invertebrates, and aquatic plants. |

Source:[47]

## Factors Contributing to Poor ICT Waste Management

1. Ignorance about the environmental effects of ICT waste: According to Uwah (2005), ignorance about the danger of these information and communication technology waste to human health, poverty and technological backwardness are fundamental factors that are militating against proper disposal of ICT waste. A greater part of the society (rural and urban) are unaware that many of the diseases they suffer from are caused by these ICT waste. Most people who cannot afford brand new electronic equipment end up using second-hand products, which on one hand, may yield higher emissions if they are not in a good, refurbished state and are not disposed of properly, but on the other hand, may be a positive contributor to sustainable environmental management through reuse. This trend, which has remained unabated, has continued to be a challenge to regulatory agencies.

2. Poor regulation of ICT products in the market: Imohiosen (2007) revealed that products enter the Nigerian market without following proper regulations, thereby making the country a dumping ground for all sorts of electronic devices. According to Puckett et al (2005), 25-75% of the secondhand goods cannot be used and no ICT waste management collection or regulatory programme in Nigeria is functional. This means that a significant amount of ICT equipments really have nowhere to go other than where all wastes go - the waste dumps. These dump sites are often along the roads, where people and domestic animals pass every day.

3. Attitude/behavior gap: Within this attitude/behavior gap exists an inconsistency between one's values and actions. This specifically refers to the discrepancy in people's concern over the environmental harm posed by ICT waste. A variety of factors contribute to an increase in public littering rates, such as a lack of social pressure to prevent littering, absence of realistic penalties or consistent enforcement, and a lack of understanding of the environmental consequences of improper ICT waste disposal.

4. Choice versus Response: Another problem is that many people feel that they have no impact on decision-making processes, and as a result, do not bother to register complaints with environmental authorities. This attitude differs among socio-economic groups. Wealthier socio-economic groups are more likely to feel like they can make a difference in addressing and fixing these environmental problems and are likely to become involved in doing something about them.

## Effects of ICT Emissions on Environmental Pollution

ICT has an ever-growing role in society and brings efficiency to almost every corner of the global economy. However, its relationship to carbon reduction may not be as straightforward. As established earlier, ICT tools and equipments may cause environmental pollution, particularly when not properly handled.

This section, therefore, explores the effects of ICT emission on environmental pollution. Understanding the carbon implications of information and communication technology is critical for tackling climate change challenges in the digital era. The fast growth of embodied emissions in the ICT sector is driven by the large-scale expansion of final demand for ICT products. However, gains in upstream production efficiency have curbed growth.

Studies have shown that telecommunication masts are a major contributor of Nitrogen Oxide (NO2). In line with this, Dallil et al (2016) found that the closer the residents are to the masts, the more the pollutant of NO2 they inhale at 10m radius, which is 500 times the recommended standard. The farther away from the masts, the lower the NO2 pollution. Also, the Total Hydrocarbon (THC) was polluted beyond the recommended standard due to the use of diesel engines. The research further points that the farther away from the mast, the lower the THC pollution.

In addition, lifestyles around the use of ICT equally contribute to greenhouse gas emission. For instance, while the internet is mostly used to send messages, share pictures, download music and stream videos at a touch of a button, people's online habits have a surprising impact on the environment. Each of these activities performed online comes with a small cost—as a few grams of carbon dioxide are emitted due to the energy needed to run such devices and power the wireless networks being accessed. While Dallil et al (2016) noted that the energy needed for a single internet search or email is small, approximately 4.1 billion people, or 53.6% of the global population, now use the internet. Those scraps of energy, and the associated greenhouse gases emitted with each online activity, can add up. The carbon footprint of ICT gadgets, the internet and the systems supporting them, account for about 3.7% of global greenhouse emissions.

The carbon emission from messages sent via the internet varies from 0.3g carbon dioxide equivalent (CO2e) for a spam email to 4g (0.14oz) CO2e for a regular email and 50g (1.7oz) CO2e for one with a photo

or hefty attachment, according to Mike Berners-Lee, as of 12 years ago. These figures have gone up in Charlotte Freitag's estimation, a carbon footprint expert at Small World Consulting, a company which was founded by Mr Berners-Lee. Choosing to send a text message (SMS) is perhaps the most environmentally-friendly alternative as a way of staying in touch because each text generates just 0.014g of CO2e. Ms Freitag also estimates that a tweet may have a footprint of 0.2g CO2e, with messages sent via messaging apps such as WhatsApp or Facebook Messenger, being only slightly less carbon intensive. Again, this can depend on what an individual is sending – gifs, emojis and images have a greater footprint than plain text.

Whilst traditional search engines, like Google and Microsoft's Bing, work hard at limiting the emissions from their services, newer generation search engines such as Ecosia, are planning mitigative and offsetting strategies from the get-go. Although the credibility of these approaches is yet to be proven, there is no data to support the fact that Nigerian companies in a similar space are looking inwards at the impact of their own emission contribution.

Other online activities like watching videos generate as much as 300m tonnes of carbon dioxide annually, which is roughly 1% of the world's emissions, due primarily to energy consumed by the servers and networks that distribute such content.

While ICT players may argue that they contribute only a negligible amount of global carbon emissions and that their industry is easy to de-carbonise due to it being powered by the manageable commodity that is electricity, they have the responsibility to manage these emissions which contribute negatively nonetheless. The same may be said for network operations, data center operations and device usage. Interestingly, the ICT sector and its users could reduce their carbon footprint by as much as 80 per cent if they would switch to using electricity exclusively derived from renewable energy sources.

This gives a great business case for why ICT companies need to invest more in renewable energy to decarbonise their businesses. Thankfully, today, many major ICT companies are investing a lot in renewables and taking action to reduce their footprints; a trend that may be extended to smaller firms through policy and mentorship.

## Mitigation strategies

The main practical implication from this study is that ICT can be consolidated in order to ameliorate globalisation activities that increase CO2 emissions. Therefore, in consonance with the Sustainable Development Goals (SDGs), it becomes necessary to identify best practices in mitigating carbon emissions inherent in the use of ICT in Nigeria. Some of these practices include:

1. Recycle digital technologies: According to Harvard University's Sustainability page's article 'Minimising E-waste is Important', Good recycling practice should:

a. Re-evaluate: Ask yourself, do you really need that extra gadget?
b. Extend the life: Keep your device safe and avoid overcharging the battery.
c. Buy refurbished: Refurbished products reduce the environmental impact of hardware purchases.
d. Buy environmentally friendly electronics: Look for products labeled Energy Star or certified by the Electronic Product Environmental Assessment Tool.
e. Create e-waste recycling programs: Ensure that all e-waste is sent to an appropriate recycling facility.

2. Support better e-waste legislation: Tech companies must endorse proper recycling, disposal of electronic equipment and circular economy action plans and policies to reduce electronic and electrical waste.

3. Raise ICT footprint awareness: It is important that individuals, societies, and governments are mindful of the existing ICT footprint. Increasing awareness in this field can be a game-changer. It is time to monitor our emissions.

4. Implement an ICT green strategy: This will not only enhance reputation, but it will also lower the organisation's environmental impact and reduce costs, as well. It is time to start reducing digital emissions and increasing companies' transparency and reputation. While sustainability has become a priority globally, digital carbon footprint seems to have been neglected by many decision-makers, with the Western world focusing primarily on emissions caused by fossil fuels. The constant rise in digitalisation increases the digital world's carbon contribution to the environment.

5. Eco-message: One of the easiest ways to manage ICT gadgets' carbon footprints is to reduce the number of emails sent. If every individual sent one less "thank you" email, it could save 16,433 tonnes of carbon a year – the equivalent of taking 3,334

diesel cars off the road, according to energy company - OVO. However, this is a simple but challenging method.

6. Use links not attachments: Senders may choose to send links or refer colleagues to cloud servers as opposed to mailing attachments to multiple people. It may also help if people take the step of unsubscribing from mailing lists they no longer read.

7. Go renewable: Africa is blessed with an abundance of photovoltaic and other cleaner fuels and it is important that technology companies switch to renewable resources of energy, limiting dependence on fossil fuels, whilst ensuring that they rely on the green strategy for e-waste management.

8. Regulator national campaign: It is important that government and regulatory bodies, in partnership with business and mediating groups, commence a nationwide enlightenment campaign to educate the populace on the dangers of ICT waste.

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