

The Environmental Impact of Wireless Technologies in Nigeria: An Overview of the IoT and 5G Network

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Abstract—Introducing wireless technologies in Nigeria have improved the quality of lives of Nigerians, however, not everyone sees it in that light. The paper on the environmental impact of wireless technologies in Nigeria summarizes the scholarly views on the impact of wireless technologies on the environment, beaming its searchlight on 5G and internet of things in Nigeria while also exploring the theory of the Technology Acceptance Model (TAM). The study used a qualitative research method to gather important data from relevant sources and contextually draws inference from the derived data. The study concludes that the Federal Government of Nigeria, before agreeing to any latest development in the world of wireless technologies, should weigh the implications and deliberate extensively with all stake holders putting into consideration the confirmation it will receive from the National Assembly.

Keywords—IoT, 5G, ICT, electromagnetic radiation, wave, field, radiofrequency.

I. INTRODUCTION

THE 21st century has witnessed advancement in the way network of machines and digital devices, communicating with one another without requiring human to human or human to computer interactions mediating the process. [1] This real-time signal processing opportunities provided by the internet of things (IoT) ecosystem [2] is now being used in transportation, home and office appliances, health, security, energy conservation, environmental monitoring, and forecasting [3]. Though some scholars argued these opportunities embedded in IoT increases, the quality of life of inhabitants and users of intelligent ambient assisted living (AAL) environment [4]. Other scholars are of the view that these wireless technologies have created more harm than good to the environment because of increase public exposure to broader and higher radio-frequencies electromagnetic radiation (RF EMR) [5].

EMR emits from electrically charged particles referred also as Electromagnetic waves (EMW), produced by the motion electrically charged particles. EMW at low frequencies refers as electromagnetic fields (EMF) and those at high frequencies EMR [6]. Edeh asserted that radiation of all forms makes up one of the environmental determinants of health [7]. The EMF found in 5G wireless technologies produces non-ionizing radiation that gives rise to EMW pollution [8]. In line with this argument, some health experts state that the continuous rise in EMW pollution causes harmful effects on humans, animals, and plants [9].

In a contrary view, some experts insist that animals and plants use EMR for a variety of living activities, giving examples like communication, control, and regulation of various physiological, psychological and behavioral functions [10]. Despite the arguments put forward by various parties, Umair opined that wireless technologies have taken over every part of our technologically advanced society in speed, accessibility, proliferation and empowerment for all demographic [11]. Example is the daily use of cellular technology to enter credit cards and process payments, another is the casual Wi-Fi device, which gives modern computing and mobile devices the ability to go where no Ethernet cable has gone and still stays connected to the internet. These IoT devices and IoT networks rely on wireless technologies to feed data from equipment in homes, offices, warehouses, and vehicles [12].

IoT technology projected to be the basis for such phenomena as “smart cities,” “smart factories,” and “smart homes,” where lights and appliances are programmed and controlled via their connections to the internet [13]. What is being sold to the world is basically to connect all “things” that are sensors, surveillance cameras, etc. to the internet. However, Zhi et al. argue that increases human exposure to pulsed microwave radiation impact both humans and wildlife adversely [14].

Although leaders in the world and industrial giants promote the use of wireless technologies, especially with the advancement of IoT as the panacea for all ills, IoT creates a host of problem to human and the environment [15]. Not minding the ills and goods of IoT, African continent is now slowly adopting to the IoT technology especially with the pictures painted by marketers of this technology that the IoT will shift from the linear to the exponential, creating innovation that can harness its benefits, connectivity, efficiency, convenience, wellness, conservation, and personalization.

Nigeria with an estimated population of 206,139,5589, and 126,078,999 internet users as of December 2019 shows that 61.2% of the population has access to wireless technologies [16]. Little wonder why IoT are now common and longer at the formative stage, as electronic devices are used to verify and process credit/debit card transactions through the use of a telephone line or an internet connection referred to as Point of Sales (POS) for cashless transactions [17].

Nigeria’s advancement in wireless technologies has seen the broadband moved from 2G to now 5G if the authorities approve the upgrade. However, with the three-month trials of super-fast 5G in several cities across Nigeria by the Mobile

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Telecommunication Network (MTN), there are tendencies that the government may adopt the advanced wireless technology. Despite the conspiracy theories that surround the 5G network, for instance, that the 5G network made by the Chinese causes the COVID-19 pandemic ravaging the world; however, with the approved installation of this technology, Nigeria promises to be a country with a faster and smarter city, though 29% of the disease affecting Nigerians derive its energy from the environment. It, therefore, behooves on the authority to carry out a health assessment of the 5G before it gives approval to avoid unnecessary pressures from her citizens.

For this research, the paper aimed to discuss an overview of the environmental impact of wireless technologies pointing its radar to the 5G network and IoT. In the study's cause, the paper will look at a conceptual definition of the subjects, overview of wireless technologies in Nigeria, relationship between wireless technologies and IoT, environmental impact of wireless technology as it relates to IoT, discuss the challenges of using wireless technologies in Nigeria regarding IoT.

II. METHOD

We used a qualitative research method using secondary data from books, journals, newspapers, conference paper, UN publication, etc., to summarize the literatures on the environmental impact of wireless technologies in Nigeria.

III. THEORETICAL FRAMEWORK

There are quite several theories and models on technologies written by various scholars these include but not limited to systems theory, the Social Construction of Communication technology that facilitates interactions with social agents which eventually controls the effects of technologies in social system [18], Actor-network theory used to appreciate the complexity of reality [19], and the technology acceptance model (TAM) introduced in 1986 by David [20]. For this study, the researcher picked the TAM. This is because TAM best suits the purpose of the research because of the advancement in technology and the 'perceived' love for IoT.

A. TAM Theory

TAM is developed by Davis in 1989, though, extended by Venkatesh and Davis [21]. The name changed [22] in 2000 to TAM2, because of the limitations of the TAM in terms of explanatory power (R^2). TAM2 is later named TAM3 in 2008 with Venkatesh as the lead anchor partnering with Bala. This was because TAM2 was to keep the original TAM constructs intact and include additional key determinants of TAM's perceived usefulness and usage intention constructs for robustness. In 2008, the team added TAM3 because it presented a complete nomological network of the determinants of users' Information Technology System adoption.

TAM is an information systems theory that models with two primary factors used to describe how users come to accept and use a technology as a perceived ease of use. That is the degree to which a person believes using a particular system would enhance his or her job performance and perceived

usefulness. This talks about the degree to which a person believes that using a particular system would be free from effort by conquering the barriers [23]. Situating it to the Nigerian context, if the Nigerian government perceives that the advancement in wireless technologies will enhance job productivity, ease ways of doing things through the instrumentality of the IoT, the government will embrace the technology wholeheartedly despite the protest from those who think that the country's advancement of its wireless technology from 4G to 5G may cause more harm than good to the environment. Once the government approves 5G installation, especially if the benefits outweigh the risk, the government will do everything to install the technology. Already the country experienced the installation of demos tested in six locations and three states; Lagos, Abuja and Calabar have tested the possibility of 5G technology in the country. The Nigerian Communications Commission (NCC) has worked on policy for the deployment of 5G in Nigeria [24].

IV. CONCEPTUAL CLARIFICATION

Wireless Technologies

Krishnamurthy & Rajashekar explained wireless communication as transferring information over a distance without the use of wires bringing fundamental changes to data networking, telecommunications, and making integrated networks a reality. This definition is not appropriate for the study because it did not explain the subject [25].

According to Matin, wireless technologies are communication devices that use radio waves or frequency and infrared to transmit data over the air without a physical cable. Wireless network technology is using radio waves to transmit high-speed Internet and eliminates unsightly cables [26]. For this research, the study will adopt this definition because it gives a broader picture of the subject.

IoT

Global Standard Initiatives defined IoT as the network of physical devices, objects, buildings, vehicles and other items embedded with electronics, software, sensors and network connectivity which supports these objects to collect and exchange data [27]. As Misra in rightly puts it, IoT Wireless Technology requires a radio capability that can receive and broadcast radio waves to transmit signals or data. This definition is suitable for the study [28].

V. LITERATURE REVIEW

A. Overview of Wireless Technologies in Nigeria

Historically, transmitting information wireless dated back in 1890, where signals and audio communication sent using electromagnetic radiation as wireless telegraph and telegraph lines were impractical or unreliable. Electromagnetic radiation was the term introduced by Heinrich Hertz, to describe early radio. Later other term like electric waves, Hertzian waves, ether waves, spark telegraphy, aerography and wireless were used at the beginning of the 20th century [29].

Eshekels Associates opined that internet became available and used in Nigeria in 1991 when a few pioneering groups offered limited e-mail services [30]. Adomi recorded that the internet users paid to access and sent emails based on duration of the service [31]. Yusuf explained that the advancement of the internet in Nigeria has given platform to students to access information on the go, making the internet an essential part of education [32]. This platform gave education a boost as the internet brought about profound change in the education sector in Nigeria. With introducing wireless network in the late 90s and the introduction to the Nigerian market, wireless became the primary usage in 2000, because of the advent of Global System for Mobile Communication (GSM).

The overwhelming 'comfortability' that GSM brought to every household in Nigeria made it oblivion to people to check the unprecedented environmental impact this wireless technology will have on a global scale [33]. The continuous dependence on wireless technology and internet by Nigerians revolutionized the telecommunication industrial from first generation (1G) until now, the trial of the 5G technology with increasing technological progress exposing the public to broader and higher radio frequencies of millimeter waves [34].

B. Relationship between Wireless Technologies and IoT

GSMA established a relationship between wireless network and IoT through a widely distributed, locally intelligent network of smart devices [35]. The IoT has the potential to enable extensions and enhancements to fundamental services in transportation, logistics, security, utilities, education, healthcare and other areas, while providing a new ecosystem for application development. Vandana & Gayathri believe that the IoT is a major source for technology solutions and considers Wireless Sensor Network (WSN) as the mainstay for the emergence of new technology [36].

Lazarescu opines that WSN recognizes key enablers for the IoT paradigm since its inception. The WSNs are a resilient and effective distributed data collection technology, but issues related to reliability, autonomy, cost, and accessibility to application domain experts still limit their wide scale use [37]. Fujino et al. stated that the development of innovative network technologies will be essential for IoT from the standpoint of mobile communication networks. They described the wireless devices such as wireless local area network (LAN), Bluetooth, Zigbee, mobile communication systems such as 3G, 4G link wireless front networks that accommodate IoT devices such as terminals and sensors [38].

Muhammad et al. speak of the several wireless technologies that will play a pivotal role IoT ecosystem. However, according to them, traditional popular wireless technologies such as classic Bluetooth, Wi-Fi cannot adequately support the envisioned IoT communication networks [39]. From the foregoing, the paper has established the relationship between IoT and wireless technologies, however, just like the last reviewer envisaged, emerging wireless technologies like Bluetooth Low Energy will replace the traditional Bluetooth device that consumes high energy. This is because it will be relevant for the new Smart Home, Smart Meter, Smart

Healthcare, Smart Vehicles, Smart Building, Smart Grid, Smart Industry, Smart Security, etc. The IoT and the advancement of wireless technologies from 5G to perhaps 6G and so forth will introduce a wave that is extremely high frequency with a specific part of the radio frequency spectrum between 24 GHz and 100 GHz, which have a noticeably short wavelength. This is the point of agreement by scholars that there are biological effects of radiation emitted by wireless network.

VI. ENVIRONMENTAL IMPACT OF WIRELESS TECHNOLOGIES

While some scholars are of the view that there are no adverse health effects that are not terminally related, others think otherwise. These controversies relating to the harmful nature of the technology have continued from 2G to 5G and it is all part of the wireless technologies. The argument put by Russell is that 5G radiation will contribute negatively to the environment because of its radiofrequency radiation (RF) which may cause environmental pollution [40].

Halim et al. posit that the IoT is one of the most sophisticated technologies with flexibility that suit many types of plants in the greenhouse. They believe that the system allows for monitoring of the condition of irrigation, soil moisture, humidity, temperature, and radiation of light which all the sensors collected periodic acquisition data in the greenhouse and send the data to the micro-controller [41].

Burrell posited that the new 5th generation wireless technology is not restricted, though, offers higher speed and call volume [42]; however, its low-level wireless radio frequency radiation exposures have an adverse biological effect on human [43]. He listed the 5G as having features like DNA single and double breaks, oxidative damage, disruption of cell metabolism, increased blood-brain barrier permeability, melatonin reduction, and disruption to brain glucose metabolism generation of stress proteins.

The World Health Organization (WHO) in 2011, through one of its agencies, International Agency for Research on Cancer (IARC) classified Radiofrequency EMFs as possibly carcinogenic to humans. Carcinogenic radiation has potential to cause cancer because it alters the cellular metabolism or damaging DNA directly in the cells, which interferes with biological processes and induces the uncontrolled, malignant division, ultimately leading to the formation of tumors [44].

Heroux, a Professor of Electromagnetic Toxicology at the Faculty of Science, McGill University opined that 5G network though increases wireless communications created by IoT, promotes smart cities that will lead to a comfortable life but 5G-IoT deployment carries significant health risks [45]. He further mentioned the protest by 180 scientists and physicians from 35 countries that signed a call to action demanding a moratorium on 5G deployment until it proves its radiation levels safe, particularly for children and pregnant women. All these inter-connected objects would significantly increase radiation from EMFs in our environment. Thomas 2020 opines that the radiation found in cell phones, Wi-Fi etc. have proven to have biological effects on human causing health issues [46].

Myrtill & Mattsson have a contrary opinion regarding the

health effect caused by 5G wireless. They claimed, having analyzed 94 relevant publications, performing *in vivo* or *in vitro* investigations, that there was no consistent relationship between power density, exposure duration, or frequency, and exposure effects. Although they admitted that change in the exposure to EMFs of humans and the environment causes low level RF exposure which may not cause symptoms ("Idiopathic Environmental Intolerance attributed to Electromagnetic Fields", IEI-EMF), but its exposure does not make up a health hazard for the exposed personnel [47].

Concerning the cancer risk in exposed workers who work in the field, there is a possibility for certain therapeutic applications. It is necessary to build a higher network density because higher frequencies have shorter ranges. Having looked at both arguments, there is a possibility that exposure to radio frequency, electromagnetic radiation may influence human and the environment, however, if stringent measures put in place by WHO to reduce the harm that these radiations may cause, the benefits of having the IoT and the latest 5th Generation technology are enormous and outweigh the disadvantages.

Kelechi opined that the Global System for Mobile Communication (GSM) and the internet which are operative in Nigeria at present, have brought convenience, mobility and portability in the information and communication process [48]. The point to note is that every technology comes with its own risks and therefore, we cannot avoid using advanced technology that will bring ease in the way activities carried out regardless of the disadvantages.

VII. CHALLENGES OF USING WIRELESS TECHNOLOGIES IN NIGERIA REGARDING IOT

Nigeria started using wireless broadband since 2001 and the various network work service providers like Airtel, MTN, GLO and 9mobiles, Smile, Spatranet etc. use wireless technology. The assertion by Fielding Smith that MTN has the highest broadband network service provider that makes it easy for them to upgrade their networks from 3G networks to 4G is close to the truth because MTN is the biggest network provider in West Africa if not Africa [49].

Implementing wireless technologies has its challenges; however, Rasaki et al. opined that if implemented in Nigeria, it will revolutionize commerce between Nigeria and the rest of the world [50]. According to Amadin et al., in a research carried out in Nigeria on the impact of IoT on people, organization and society at large, the result revealed that there are impacts of IoT towards Agriculture, transport, power, security and health sectors. However, fair adoption of IoT technologies will improve the living standard of the people [51].

Samaila et al. wrote about the vision of the IoT which is to ensure everything from everywhere, completely connected to the Internet with Internet Protocol (IP) [52]. They foresee several obstacles to fully realizing the IoT vision, stating security and privacy as major challenges. Kumar & Patel critically examined the security concerns in the IoT that is privacy in device, privacy during communication, privacy in

storage and privacy at processing and studied threats associated with the different layers for example, frontend sensors and equipment, network and backend of Information Technology (IT) systems [53].

Bringing it to the Nigerian Context, in terms of implementation of IoT, Iwayemi opined that apart from the global challenges faced, Nigeria has its own peculiar challenges among which are power supply, religion, government, tools and cost. Power supply and governance have higher precedence to implement anything in Nigeria than any other thing [54].

Kelechi et al. looked at wireless network challenges Nigeria may likely face because of its inherent vulnerabilities making it almost impossible to have a perfect secured network. They pointed to so many factors among which are eavesdropping on non-secured channels that are illegitimate interception and reception of information transmitted over a wireless communications system [55].

Electromagnetic interference means signal fading and disruption of wireless signals because of a long distance between the transmitter and the receiver, atmospheric conditions or metallic surfaces which reflect the radio waves. Denial of Service (DoS) makes wireless intruders to flood the network with either valid or invalid messages affecting the availability of the network resources using a powerful transceiver to interfere effects on the WLAN network.

VIII. CONCLUSION

The paper reviewed two arguments on environmental effects of wireless technologies which included the traditional Bluetooth device, Wi-Fi, and other technologies like GPS units, garage door openers, wireless computer mouse, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones. Particularly, the paper laid emphasis on the 5G technology, controversy surrounding the radiofrequency electromagnetic radiation and how various scholars have given their opinion regarding IoT. The paper looked at privacy and security challenges of wireless network and concluded that every development comes with risk. However, the ability to manage the risks brings out the success in a technology. In conclusion, the paper therefore recommends:

1. For any latest development in the world of wireless technologies, the Nigerian Government should weigh both the cost and effects of such technologies before they send it to the National Assembly for confirmation.
2. The paper recommends a committee set up by the President that will critically look at issues before it imposes new technology on the citizenry.
3. Stockholders at various strata of the economy should join hands together to determine the creditability of the 5G network before approval in Nigeria.

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