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NIGERIAN COMMUNICATIONS COMMISSION

CHALLENGES OF TECHNOLOGY PENETRATION IN AN INFRASTRUCTURE DEFICIT ECONOMY (NIGERIA PERSPECTIVE)

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EXECUTIVE SUMMARY

This Research study was carried out by the Emerging Technologies Research Unit of the Research and Development Department, Nigerian Communications Commission. It spotlights Nigeria's technological antecedence and the factors that hinders technological growth/penetration with a view to proffering solution for a robust technological and industrialized structural framework, as a way forward to achieving sustainable technological growth in Nigeria.

The Research specifically examines the various challenges of technology penetration in Nigeria due to requisite infrastructure deficit and the role Public Private Partnership and Government can play in closing the gap if a conducive environment is created. It also identifies factors that may threaten its success, as well as, policy frameworks that will enhance its success and suitability in Nigeria.

The Study revealed that over the years, the Nigerian Government has put in place various initiatives to tackle the issue of infrastructure deficit in Nigeria. Notably, the 2013 National Integrated Infrastructure Master Plan (NIIMP) expected to cost $3trillion and covering core infrastructure such as energy, Housing, Water and ICT. The plan is expected to run from 2013-2043. In year 2013, according to the former Minister of Finance Dr Ngozi Okonjo-Iweala's presentation to the AFB, Nigeria needs $14.2billon annually for the next 10 years to fund infrastructure and the Federal Government is expected to provide $10.6 billion, Nigeria was spending only $5.9billion on federal infrastructure need, leaving a substantial deficit of $4.6billion[1]. In addition, in year 2019 according to the World Bank, the NIIMP Nigeria now faces a $100 billion annual investment

[1] https://nairametrics.com/2019/09/24/nigeria-needs-100-billion-annually-to-fix-infrastructural-deficit-finance-minister/

gap in infrastructure[2]. Others estimate Nigeria as having a17million housing deficit. The total price tag for infrastructure in these sphere amounts to $3.7billion a year.

It also revealed that the ICT Sector in Nigeria has recorded tremendous growth since liberalisation in 1992. As at September 2020, Nigeria has 205,252,058 active telephone lines, 107% teledensity, 151,512,122 active internet subscription, and 86,714,978 broadband subscription representing 45.43% of the population. Yet, despite all these achievements, the ICT Sector in Nigeria also witnesses infrastructure deficit with only 54,000 kilometres of backbone and middle-mile fibre deployed with significant duplication, and 2G, 3G and 4G deployed at 89%, 75% and 45% respectively.

Having used the descriptive research method, the Research revealed that technology and economic development are interconnected concepts with similar objectives geared towards improving the lot of the society. It was further discovered that Nigeria's technology base has not yet been able to provide sustained economic development for the nation. Furthermore, it revealed that technological advancement factors are not being adequately addressed as key enablers of economic development. It was discovered that Nigeria has inadequacies in its technological development efforts. These were discovered in areas of technology transfer agreements, Research and Development (R&D) funding, technical education, corruption and other economic development factors. However, these shortcomings could be remedied in order to make technology a tool in enhancing the nation's economic development.

These infrastructure inadequacies have affected growth and development of Nigeria's economy, and acted as a barrier to the rollout of Nigeria's technological and industrial aspirations. Some of the mitigating challenges to Technology Infrastructure rollout in Nigeria include the following:

[2]https://www.researchgate.net/publication/326155186_NIGERIA_AND_THE_MENACE_OF_INFRASTRUCTURE_DEFICIT_LEVERAGING_PUBLIC-PRIVATE_PARTNERSHIP_UNDER_A_CRUNCH_FINANCIAL_REALITY-_2018 -

- Price Wars- Efforts by the MNOs, Civil Society Groups and other MDAs
- Right of Way Permits
- Damage to existing fibre infrastructure
- Poor National Infrastructure
- Interconnect Debts
- Call masking and Call Refilling
- Increased Collocation and Infrastructure Sharing
- Ongoing challenge of Delineating Telecoms Infrastructure as Critical national infrastructure
- Uniform Right of Way Fees
- Proprietary Focus of MNOs in Infrastructure Roll Out
- Internal Security
- Weak monitoring and evaluation of infrastructure projects and Contractors
- Inadequate Funding to finance ICT development in Nigeria

Critiquing the role of Government in infrastructure providing, the following are some of the initiatives it was noted that Government had put in place over the years to grow ICT infrastructure build out in Nigeria:

Licensing – Undersea Cable Licensing, Metropolitan Fibre Cable Network, National Carrier, National Long Distance Communications, Private Network Links, and Open Access Fibre Infrastructure Network (INFRACO) licence.

Other ICT Infrastructure Projects - Wire Nigeria (WiN) project, and the State Accelerated Broadband Initiative (SABI).

National Policy and Strategy Documents- Vision 2020, Nigerian National ICT for Development (ICT 4D), Nigeria ICT Roadmap 2017–2020, ICT Sector Policy Nigeria 2012, The National Broadband Plan (2013-2018), The Universal Service Provision Fund (USPF), National Information Technology Development (NITD) Fund, National Digital Economy Policy and Strategy Document 2020-2030, Nigerian National Broadband Plan 2020-2025.

The Study showed that although Government had done well in its efforts, these infrastructure deficit continue to produce socio-economic challenges that constitute negative influences to the technological growth in Nigeria. As a solution, the following are proposed policies and strategies recommendations for Government in addressing these infrastructure challenges:

1. The Commission should actively pursue the implementation of Active Infrastructure Sharing would be an alternative that would lower the cost of network deployment. This will cut down the cost of building and maintaining the infrastructure.
2. In view of the paucity of industry information for policy planning and regulatory rule-making, the Commission should consider the award of a Consultancy on impact of Infrastructure Deficiency on the level of Technology Penetration in Nigeria.
3. The Commission to monitor and sanction Telecoms Operators who fail to carry out their universal service obligations as contained in their Licence Documents.
4. Government and policy makers are encouraged to develop and implement sustainable models that support Government investment in critical ICT/Technology infrastructure.
5. Government and policy makers should also encourage the emergence of regional Infrastructure Companies who understand the regional terrain and can help build out the necessary ICT infrastructure.
6. To improve upon the existing infrastructural base, Governments should encourage more private sector led investments through the provision of necessary incentives and waivers such as import duty concession, reduced bank loan interest rates, amongst others.
7. Government to continue to support and monitor implementation of a Local telecommunications hardware manufacturing industry.
8. Government to invest in Educational Infrastructural Facilities development to grow the capacity of the youth to provide sustainable and indigenous infrastructure.

9. Government to provide incentives that encourage Research and Development efforts by all Public and Private Entities for the benefit of Nigeria.

To achieve the goal of pervasive technology penetration as a prerequisite for national development, the role of the private sector in R&D efforts, the role of Government in policy setting and monitoring must be synced and if implemented, it will help to ensure effective and efficient technology transfer, form a structural framework for technological penetration and development, unlock technological growth potentials and serve as a sustainable development blueprint for the nation.

Challenges of Technology Penetration in an Infrastructure Deficit Economy (Nigerian Perspective)

Chapter One: Introduction

1.0 Background

Technology can be defined as the body of organized knowledge, tools, machines used by man to manipulate his environment and to satisfy his basic needs[3]. It can also be deduced as the harmonious application of organized scientific, socio-cultural know-how to manipulate the environment with the intention of solving problems and satisfying human need[4].

Technological penetration is the rate at which a specific technical innovation becomes adopted into the everyday life of individuals within a social group. One of the indices by which a nation's growth and advancement can be measured is by technological endowment and penetration, not by the level of her endowment in natural and human resources. Simply put, a nation's economic efficiency is determined and ranked by its technological advancement[5].

It is worthy of note that to date, the Nigeria's telecommunications sector has shown its strength in the nation's overall ICT growth and penetration across the country. Its technological advancement is indicative of Nigeria's overall technological advancement as the ICT sector globally remains the catalyst for overall socio-economic development and national growth. We will now look at the growth pattern of Nigeria's telecommunications sector.

As at December 2000, Nigeria had 450,000 connected fixed lines, no conected digital mobile line, 1 national career, 18 operating Internet Service Providers, 9 active licensed fixed-line operators, and 1

[3] Onipede, K., 2010. Technology Development in Nigeria: The Nigerian Machine Tools Industry Experience. *Journal of Economics,* 1(2), pp. 85-90.

[4] Onipede, K. (2010). Technology Development in Nigeria: The Nigerian Machine Tools Industry Experience. Journal of Economics, 1(2), 85-90.

[5]Akhalumeh, P. & Ohiokha, F., 2013. The Place of Physical Infrastructure in Realizing Nigeria's Vision 20:2020. *International Journal of Management and Sustainability,* 2(7), pp. 127-137.

licensed mobile line operator[6]. In the same period, Nigeria had 200,000 internet users[7]. By March 2004, the figure had increased to 888,854 connected fixed lines, 3.8 million connected digital mobile lines, 2 national careers, 35 operating Internet Service Providers, 30 active licensed fixed-line operators, and 4 licensed mobile line operators. In December 2004, Nigeria had 1.5 million internet users, a penetration rate of 1.3% and constituted about 5.6% of the total number of African internet users. Africa itself only boasts of 1.5% of global internet users even though it has 14% of the world's inhabitants[8].

Private investment in ICTs also rose from an almost zero value to about $4 billion between 1999 and 2003[9]. Nigeria's ICT space improved significantly from 400,000 lines in 1996 to over 14 million lines in 2005 owing to independent regulation through the Nigeria Communications Commission, private sector participation, and broadened competition[10]. Teledensity improved from 0.37% in 1996 to 8.5% , several towns and cities estimated at 48% of the population and 18% of the land mass have potential access, grown from one player (monopoly) to hundreds of the active players, and exceeded minimum International Telecommunications Union (ITU) recommended teledensity of 1% to 24.18% in 2006[11].

Furthermore, the most recent figures from the National Bureau of Statistics (NBS) reveals a huge increase in the contribution of the Information and Communications sector to Nigeria's GDP (Gross Domestic Product) in Q4 2019 19.53 trillion[12]. According to the

[6] Englama, A. & Bamidele, A., 2002. Telecommunication and Nigeria's Economic Development: Challenges, Prospects and Policy Suggestions. *Economic and Financial Review,* 40(1), pp. 2-18.
[7] Englama & Bamidele (2002)
[8] Onipede, K., 2010. Technology Development in Nigeria: The Nigerian Machine Tools Industry Experience. *Journal of Economics,* 1(2), pp. 85-90.

[9] Englama & Bamidele (2002)
[10] Adegbite, O. B., 2015. Legal and Institutional Regulation of Mobile Telecommunication in Nigeria: A Comparative Analysis between Nigeria and South Africa. *Journal of Contemporary Legal and Allied Issues,* 6(1).
[11] Englama & Bamidele (2002)
[12] Onaleye, T., 2020. *NBS Report: ICT Contribution to Nigeria's GDP Rises to 17.8% even as Real GDP Drops to N15.89 Trillion in Q2 2020.* [Online]
Available at: https://technext.ng/2020/08/24/nbs-report-ict-contribution-to-nigerias-gdp-rises-to-17-8-even-as-real-gdp-drops-to-n15-89-trillion-in-q2-

report, Nigeria's GDP in Q4 2019 stood at N19.53 trillion and the sector contributed N2.57 trillion. This amounts to about 13.12% of the real GDP of the country in Q4. This represents a 22.20% increase from the 11.34% recorded in Q2 2019 and an 8.50% increase year-on-year (YoY). In 2019 as a whole, the sector contributed about N8 trillion to the real GDP representing 13.04%[13]. This is a 6.28% increase from the 12.2% recorded in 2018. This is in fact a higher margin of increase when compared to the contributions by the Nation's pride commodity 'oil' with 7.32% in 2019[14].

As a subsector, the Telecommunications and Information Services in Q4 2019, had a 10.26% growth rate, slower than the 12.16% recorded in Q3[15]. In 2019, the sector had an overall growth of 11.41%, a slight increase from 11.33% of 2019[16]. This growth most likely came from some improvements in broadband penetration and subscriber numbers, which sees the country presently with over 184 million telecommunications subscribers with 37.80% penetration[17]. However, by 2nd Quarter 2020, the Sector recorded 14.30% contribution to National GDP[18], and in addition, investments into the Telecom sector grew from $38B in 2015, to $70 in year 2020[19]. There are now 205,252,058 million active Telecom lines in Nigeria, and a teledensity of 107.53%[20], 151,512,122 active internet subscriptions[21], and 86,714,978 broadband connections[22], representing 45.43% penetration.

In view of the above statistics, it is clear that Nigeria has done well and has set in motion, efforts on growing its telecommunications infrastructure. However, for ICT to lead to national growth, ICT

2020/#:~:text=The%20contribution%20of%20the%20Information,Bureau%20of%20Statistics%20(NBS).&text=Reports%20show%20that [Accessed 6 October 2020].

[13] Onaleye (2020)
[14] Onaleye (2020)
[15] Onaleye (2020)
[16] Onaleye (2020)
[17] Onaleye (2020)
[18] Available at https://www.ncc.gov.ng/statistics-reports/industry-overview#view-graphs-tables-8
[19] Available at NCC 2020; https://www.ncc.gov.ng/media-centre/news-headlines
[20] Available at https://www.ncc.gov.ng/statistics-reports/industry-overview#view-graphs-tables
[21] Available at https://www.ncc.gov.ng/statistics-reports/industry-overview#view-graphs-tables-6
[22] Available at https://www.ncc.gov.ng/statistics-reports/industry-overview#view-graphs-tables-6

infrastructure rollout must be carried out across all sectors of Nigeria's economy to enable interconnection and interoperability with the communications systems of the Telecoms Sector and thereby drive growth. However, infrastructure deficit in any sector impacts both the sector and the nation as a hold.

It's generally agreed that investment in modern and robust infrastructure lays the foundation for economic growth and development[23]. Investment in transportation network, electricity, communication networks, water and sanitation, health and education infrastructure help a society increase its wealth and its citizen's standard of living. In an Infrastructure deficit economy, the infrastructural development does not effectively meet its demand for economy growth. Critics have complained of infrastructure deficit in Nigeria being as the result of a steady decline in Government infrastructure investment and corruption, combined with a steady increase in the cost of building additional infrastructure[24]. They blame decades of under-investment in basic infrastructure have produced a variety of bottlenecks across transportation, water, freight, and communication networks; decades of neglect in the provision of public infrastructure in Nigeria by successive Government as having put the nation's development and economic prospect in jeopardy.

Despite the apparent benefits of a robust infrastructure to economic growth, Nigeria over the years has failed in optimally developing its infrastructure. The power sector infrastructure remains abysmal. As of 2019, power generation in Nigeria stood at about 4,000MegaWatts. This is far below the 15,000MegaWatts required for a population of over 170million people. This is even after about $50billion had been spent on electricity generation within 14 years (1999-2013)[25]. This failure has often been attributable to the endemic corruption, inefficiency, poor technical expertise and poor planning that characterize the public procurement process in Nigeria. According to

[23] Muhammad, et al. (2011)
[24] Muhammad, et al. (2011)
[25] Adegbite (2015)

research by Awoleye, et al, there are eleven thousand, eight hundred and eighty-six (11,886) abandoned projects in the country which are estimated to cost N7.78trillion to complete. As Awoleye, et al[26] noted, if Government does not start any new projects, it will take more than five years budgeting about N1.5trillion annually to complete them all.

In year 2013, it was revealed that for Nigeria to fill its infrastructure gaps, an expenditure of $14.2 billion would be required annually for the next 10 years[27]. $14.2bn would be needed yearly to fund infrastructure and the Federal Government is expected to provide $10.5bn. However, the Government's current spending is $6bn, leaving a huge deficit/shortfall of $4.5bn needed annually[28]. By year 2019, the Nigerian Minister of Finance also noted that Nigeria requires an estimated $100 billion annually for the next 30 years to address infrastructural decay in Nigeria[29].

Moreover, going by the present-day economic reality in the country with the dwindling oil revenue, this deficit is envisaged to widen when the current deficit already has a negative impact on technology expansion. For example, the proposed budgetary allocation for the Federal Ministry of Works for 2015 was slashed from N100bn to N11bn[30]. This reduced sum could only cover 33 out of the then 210 ongoing federal projects. Most recently, Nigerian Communications Commission (NCC) has said Nigeria needs to double its current $68 billion investment in telecoms infrastructure to $136 billion in order to address the infrastructure deficit in the sector[31].

[26] Awoleye, et al. (2012)
[27] Available at https://www.researchgate.net/publication/326155186_NIGERIA_AND_THE_MENACE_OF_INFRASTRUCTURE_DEFICIT_LEVERAGING_PUBLIC-PRIVATE_PARTNERSHIP_UNDER_A_CRUNCH_FINANCIAL_REALITY-_2018
[28] https://www.researchgate.net/publication/326155186_NIGERIA_AND_THE_MENACE_OF_INFRASTRUCTURE_DEFICIT_LEVERAGING_PUBLIC-PRIVATE_PARTNERSHIP_UNDER_A_CRUNCH_FINANCIAL_REALITY-_2018
[29] Available at https://nairametrics.com/2019/09/24/nigeria-needs-100-billion-annually-to-fix-infrastructural-deficit-finance-minister/
[30] Awoleye, et al. (2012)
[31] Adegbite (2015)

1.1 Problem Statement

The Nigerian statistics continue to show positive movement in the provision of services with internet and phone penetrations standing at over 151 million and 205 million subscribers respectively by September 2020.[32][33] With broadband penetration of 45.43 per cent, Nigeria's social media space has continued to thrive and citizens are enjoying access to modern ways of interaction in the cyberspace. Although the rise in telecoms subscription has impacted greatly on the social media space as well as the e-commerce space, the country is still battling with telecoms infrastructural challenges. More than any other sector, poor infrastructure has been the bane of ICT development in the country and a leading cause of deficiencies in the quality of telecommunications services, from broadband penetration to reliability of mobile network services. This infrastructure deficit is preventing many Nigerians from gaining affordable and reliable access to ICT services. These challenges notwithstanding, some indigenous companies are striving to deepen ICT infrastructure in Nigeria, to enable the country deliver better quality of service at lower prices to its teeming population and deserve better support.

This research paper therefore spotlights Nigeria's technological antecedence and the factors affecting her technological growth with a view to proffering solution for a robust technological and industrialized structural framework as a way forward to achieving sustainable economic growth.

1.2 Objectives of the Study

The objectives of the study are:

- To establish the relationship between technology and economic development.
- To find out how Nigeria has fared in developing her economy through technology.
- To examine the factors that hinder technological development and penetration in Nigeria.

[32] Available at https://www.ncc.gov.ng/statistics-reports/industry-overview#view-graphs-tables
[33] Available at https://www.ncc.gov.ng/statistics-reports/industry-overview#view-graphs-tables-6

- To proffer strategies and policies for improving technological development as a prerequisite for enhancing Nigeria's economic development.

1.3 Research Questions

This study seeks to proffer answers to the following questions:

1. What are the factors that hinder technological development and penetration in Nigeria?
2. How has Nigeria fared in developing her economy through technology?
3. How has poor technology penetration affected the socio-economic life of the society?

Chapter Two: Literature Review

2.0 Concept of Infrastructure Deficit

Infrastructure deficit is the situation in which the infrastructural development does not effectively meet the demands of the populace in regards to socio-economic development and growth and general wellbeing of the populace[34]. Infrastructure deficit occurs as a result of steady decline in Government Infrastructure spending, combined with a steady increase in the cost of building additional Infrastructure[35]. A national deficit is likely to grow as state and local Governments, which account for a growing share of Infrastructure spending, face budget cuts, congested roads, antiquated air traffic systems, and clogged ports. These manifestations of an infrastructure deficit are undermining economic efficiency and lowering quality of life. Decades of underinvestment in basic infrastructure have produced a variety of bottlenecks across transportation, water, freight, and communication networks[36].

Infrastructure stands as an important source of competitive advantage. Typically, emerging economies are those that invest in new railroads, highways, ICT for more effective movement of people and goods, while developed nations suffer from poor legacy infrastructure.[37] Infrastructure such as ports, pipelines, hospitals, highways, water, sewage and phone systems matter, provide the bedrock of national prosperity and well-being.

Facilitating a robust transportation system, promoting communication, providing energy and water, boosts the health and education of the workforce and enabling the whole economy to flourish. For a country to be competitive, it needs roads and airports to provide access to markets, power sources to fuel homes and

[34] The Nation, 2019. *Infrastructure deficit cripples telecoms services.* [Online]
Available at: https://thenationonlineng.net/infrastructure-deficit-cripples-telecoms-services/ [Accessed 6 October 2020].
[35] The Nation (2019)
[36] The Nation (2019)
[37] Oxford Business Group, 2019. *Telecoms growth in Nigeria supported by reforms and infrastructure.* [Online]
Available at: https://oxfordbusinessgroup.com/overview/paving-way-reforms-listings-and-infrastructure-support-mobile-growth [Accessed 20 October 2020].

businesses, reliable water to generate productivity. The costs of building infrastructure are vast, but the costs of failing to make such investments are incalculable[38].

In today's globally connected world, information and communication technologies (ICTs) are increasingly important, with growing empirical literature on how ICTs facilitate innovation and impact firm and country productivity by giving decision makers more complete information[39]. Improved infrastructure produces abundant benefits for the economy, environment and social progress, unlocking growth and generating economic and social benefits and progress. Infrastructure projects are a source of major employment, catalyze local economic growth, develop skills at all levels in the workforce which then provides the underpinning for developing new products and services, opening access to new markets and reducing waste and environmental impact[40].

2.1 Infrastructure Deficit in Nigeria

In the face of increasing budgetary constraint, population growth, greater expectation, and demand from Nigerians, the Government is under huge pressure from its citizenry to deliver new and robust infrastructure. However, the huge financial outlay required to meet this demand far outstrip the resources available to Government[41]. It is pertinent to emphasize that the future of Nigeria as an emerging economy depends on its ability to build and modernize its infrastructure.

In its effort to tackle this infrastructure crisis, the Nigerian Government in 2013 put together an ambitious 30-year plan known as National Integrated Infrastructure Master Plan (NIIMP)[42]. It focuses on core infrastructure including energy (power, and oil and gas), transport (road, rail, ports and airports), housing, Water and

[38] Oxford Business Group (2019)
[39] Turban & Volonino (2010)
[40] Lodder, A. & Zeleznikow, J., 2010. *Enhanced dispute resolution through the use of information technology.* Cambridge : Cambridge University Press.
[41] The Nation (2019)
[42] Isioto, N., F, P.-k. & Rachael, D., 2017. Roadmap towards Nigeria's Independence.. *International Journal of Engineering and Technological Scientific Discovery,* 2(2).

ICT. The plan is expected to run from 2013-2043 and is estimated to cost $3trillion. The breakdown of the plan shows that energy will gulp $1billion, transportation $775billion, agriculture, water and mining $400billion, housing and regional development $350billion and ICT $325million, social infrastructure $150billion and vital registration and security $50billion[43].

This Plan paints a vivid picture of the huge investment gap in Nigeria infrastructure development. For instance, the $775billion required for the transport sector portrays the dire state of the nation's transport infrastructure. The experts estimate that Nigeria has a 17million housing deficit. This can be bridged if the nation can provide 1 million housing unit per year for the next 17 years, but for which they do not have the financial resources.[44]

These statistics are indicative of how far behind Nigeria is in infrastructure development. Resources wise, the Federal Government cannot bridge this gap without private investment. It recognizes this challenge in its National Policy on Public Private Partnership by admitting that it needs to make massive investment beyond the means available to it in order to bridge the infrastructure gap[45]. And that it believes the private sector can play an important role in providing some of this additional investment through Public Private Partnership.

Table 2.1: Indicative Infrastructure spending needs in Nigeria for 2006 to 2015[46]

US$ million per year			
Sector	Federal needs		National needs
	Capital Total Expenditure	O&M	Total

[43] Isioto, et al. (2017)
[44] African Development Bank Group (2014)
[45] Isioto, et al. (2017)
[46] Foster, V. & Pushak, N., 2011. *Nigeria's Infrastructure: A Continental Perspective. Africa Infrastructure Country Diagnostic (AIC) Country Report,* s.l.: World Bank.

ICT	1,960 2,063	103	 2,063
Irrigation	145 145	0	 939
Power	4,903 7,593	2,690	 7,593
Transport	404 661	256	 1,222
WSS	0 0	0	 2,340
Total	7,414 10,462	3,050	 14,158

Meeting these illustrative infrastructure targets for Nigeria would cost $14.2billion annually through 2015, most of it for Federal infrastructure spending. According to the African Infrastructure Country Diagnostic Report, the bulk of the identified annual spending requirements ($10.5billion) relate to these federal infrastructure assets[47]. The remaining areas of infrastructure, including water and sanitation, secondary and tertiary road networks and small-scale irrigation are assumed state or municipal level responsibilities. The total price tag for infrastructure in these sphere amounts to $3.7billion a year. However, at present Nigeria is spending only $5.9billion on federal infrastructure need leaving a substantial deficit of $4.6billion[48].

These needs are not unmanageable when viewed against the size of the national economy which is currently the largest in Africa and stands at $519billion. The country overall needs would absorb 12 percent of GDP while federal spending needs alone amount to 9 percent[49]. According to the World Bank, The National Integrated Infrastructure Master Plan (NIIMP), Nigeria, faces a $100 billion annual investment gap in infrastructure, even as the World bank's portfolio in Nigeria stood at $11 billion invested across all sectors,

[47] Foster & Pushak (2011)
[48] Foster & Pushak (2011)
[49] Foster & Pushak (2011)

and the IFC's portfolio stood at over $1 billion in sectors including manufacturing, financial services and infrastructure[50].

The level of broadband and communications deficit in Nigeria is discussed below:

In order to assess the current state of broadband infrastructure capacity in Nigeria today, it is useful to evaluate infrastructure availability against a broadband value chain that categorizes the building blocks for broadband service delivery as the First Mile, Middle Mile and the Last Mile as represented in Fig 2.8 below[51].

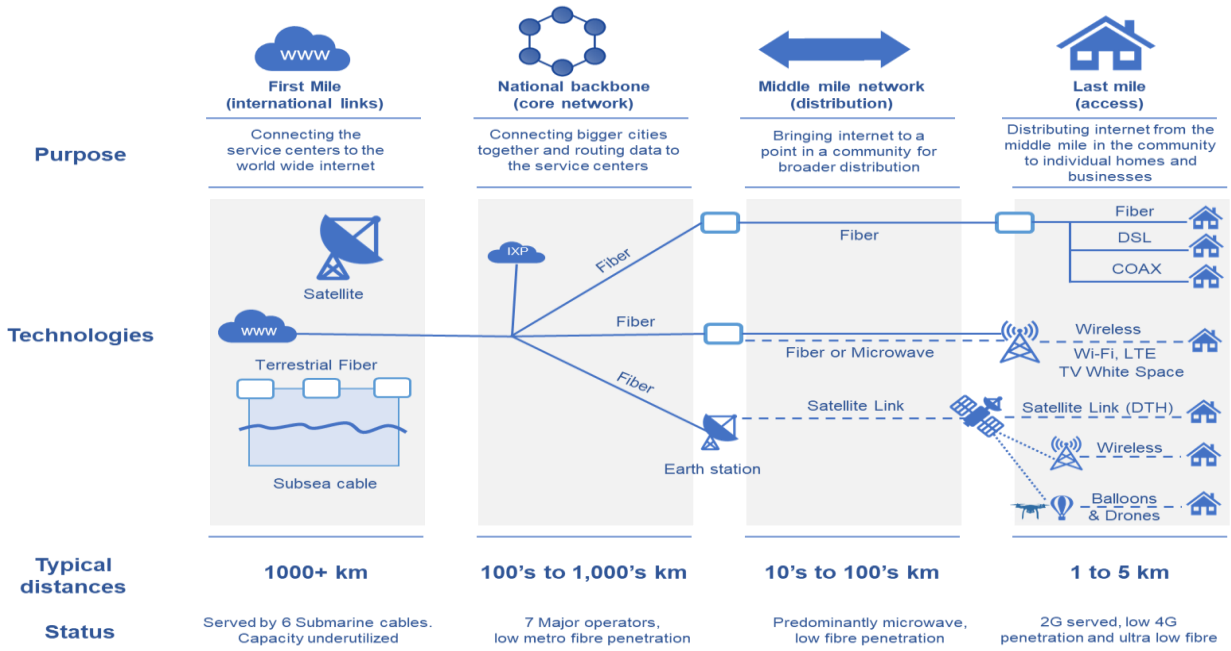


Fig 2.8: Three (3) Tier Broadband Architecture Framework. Source: World Bank/NBP Committee

A. The First Mile:

The First mile infrastructure providing international and inter-continental connections to Nigeria are equipped with over 40Tbps of capacity given by 6 submarine cables, all landing in Lagos, as well as up to 55 licensed satellite operators delivering services across the country as at January 2020. These services connect Nigeria to

[50] Available at https://nairametrics.com/2019/09/25/world-bank-ifc-to-assist-in-solving-nigerias-infrastructure-deficit/

[51] Available at Nigerian National Broadband Plan 2020-2025

neiboring states where directly accessible, global destinations as well as the internet. This segment has witnessed significant investment and growth in the last decade and the submarine segment is generally acknowledged to have a glut today with less than 10% of that 40Tbps capacity utilized by the total population due to weak national infrastructure fibre backbone and other limitations across other segments of the value chain. . Fig 2.9 below shows Africa is well covered with adequate capacity sufficient to serve the continent well into the next decade.

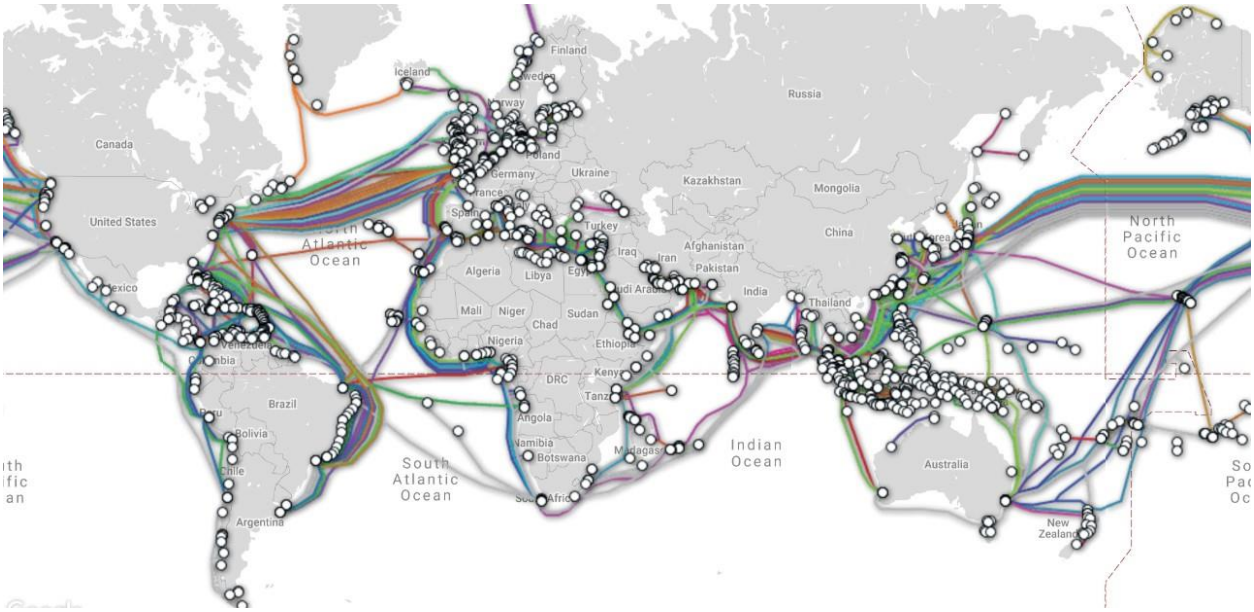


Fig 2.9: World Deep-Sea Backbone connection Source: FCC

B & C. The National Backbone (National Backbone/Core/Distribution Network) and Middle Mile:

The middle mile consists of the National backbone, Core and Distribution Network links, which brings the internet closer to communities in Nigeria for wider distribution, featuring proprietary fibre-optic and microwave networks owned by various operators, including the MNOs, National long distance Operators (NLDOs) and government agencies. Total backbone and middle-mile fibre distance deployed in the country is approximately 54,000 kilometres, largely backhauling traffic between major cities with significant duplication

of routes across service providers as shown in the fibre route map Fig. 2.10.

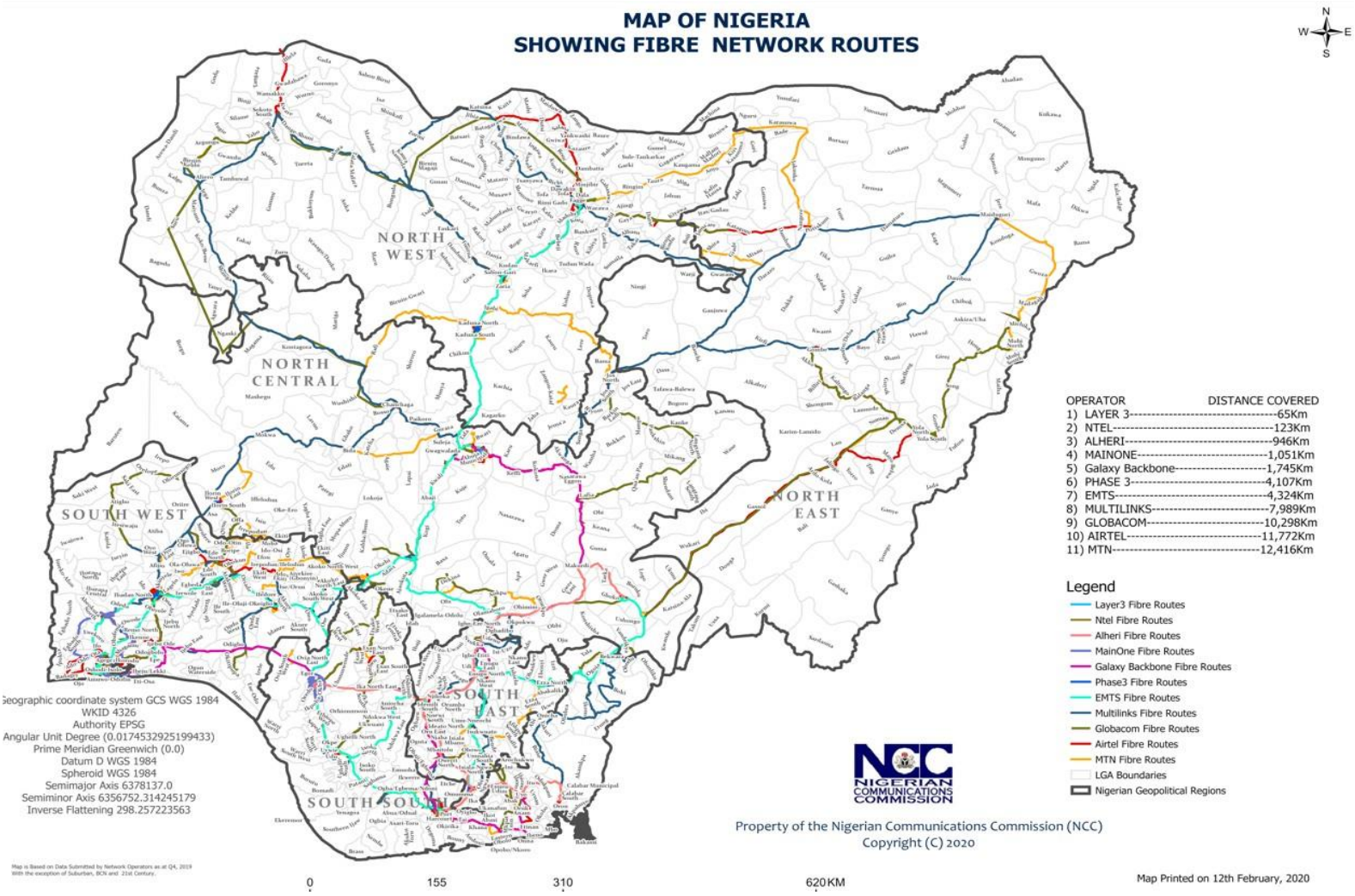


Fig 2.10: Map of Nigeria Fibre Network Routes Q4, 2019 Source: NCC
Map is based on data submitted by Network Operators as at Q4, 2019 with exception of Suburban, BCN and 21st Century

Nigeria's fibre links are mainly owned by the MNOs, with other players serving niche areas in terms of coverage, and one major network previously owned by Multilinks not effectively accounted for. Metro fibre networks currently account for less than 25% of the total fibre distances in the country with concentration in major cities such as Lagos, Abuja, Port Harcourt, and within Edo and Ogun states, while other areas remain unserved or underserved. Access of fibre networks within 5 kilometers of the population currently stands

at an average of approximately 39% reach, with a high of 85% in Lagos State and a low of 12% in Jigawa State as shown in Fig 2.11 below. Last mile FTTx connection rate is low and Fibre to the Tower connection rates are also low in comparison to other African countries.

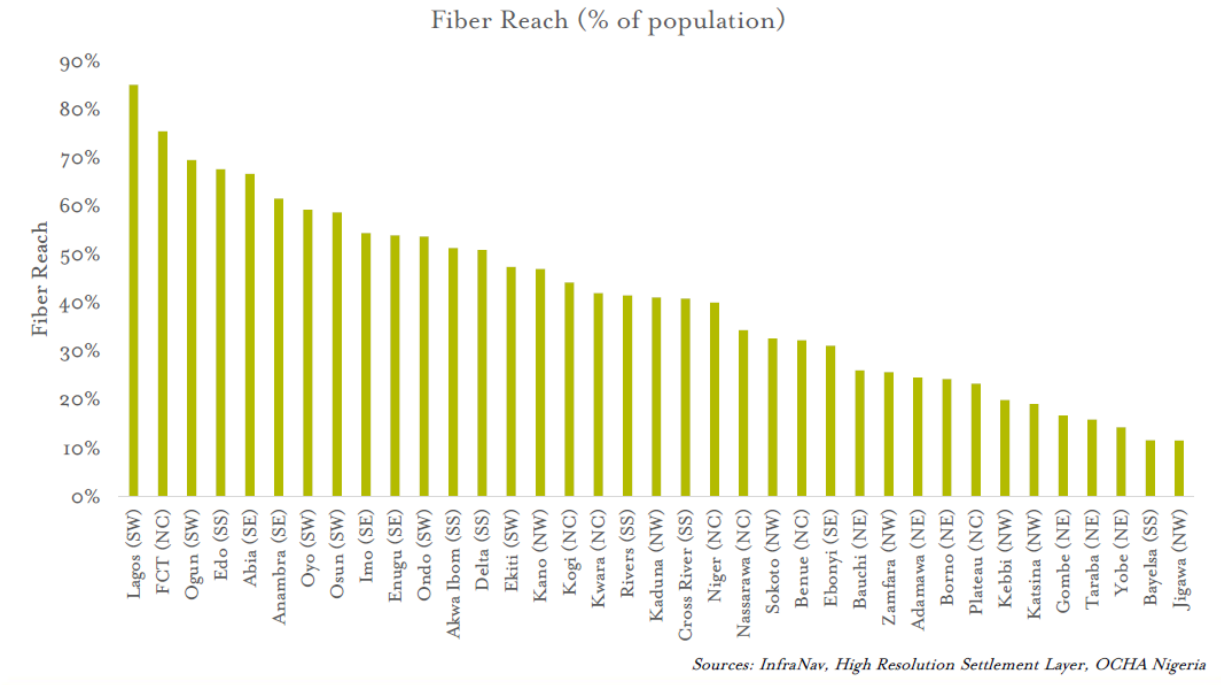


Fig 2.11: Chart of % of Population within 5Km of Fibre Reach in each Nigerian State Source: HIP Consult

A large volume of traffic within the middle mile networks is still backhauled using microwave equipment which while adequate for narrow-band voice communications, it is no longer adequate for the effective delivery of video and bandwidth-intensive broadband applications, and the use of fibre which is insufficient- for backhauling traffic within middle-mile networks is critical.

D. The Last Mile:

Last mile connectivity in Nigeria is largely mobile with comparatively lower investments made in fixed lines infrastructure within the past two decades. Nigeria's DML licenses initially deployed 2G technology to provide voice services and effectively covering greater than 89% of Nigeria's population today. Demand for internet access and availability of spectrum has stimulated the growth in 3G services

which covers about 75% of the population. 4G deployments have been limited to deployments in the major urban areas within the past 3 years and are currently available to approximately 45% of Nigeria's population. The maps below, (Fig 2.12-2.14), show the network coverage and indicate that even with 3G coverage most areas of the country are only being served by one of the operators while 4G remains sparse beyond the very largest urban areas and state capitals.

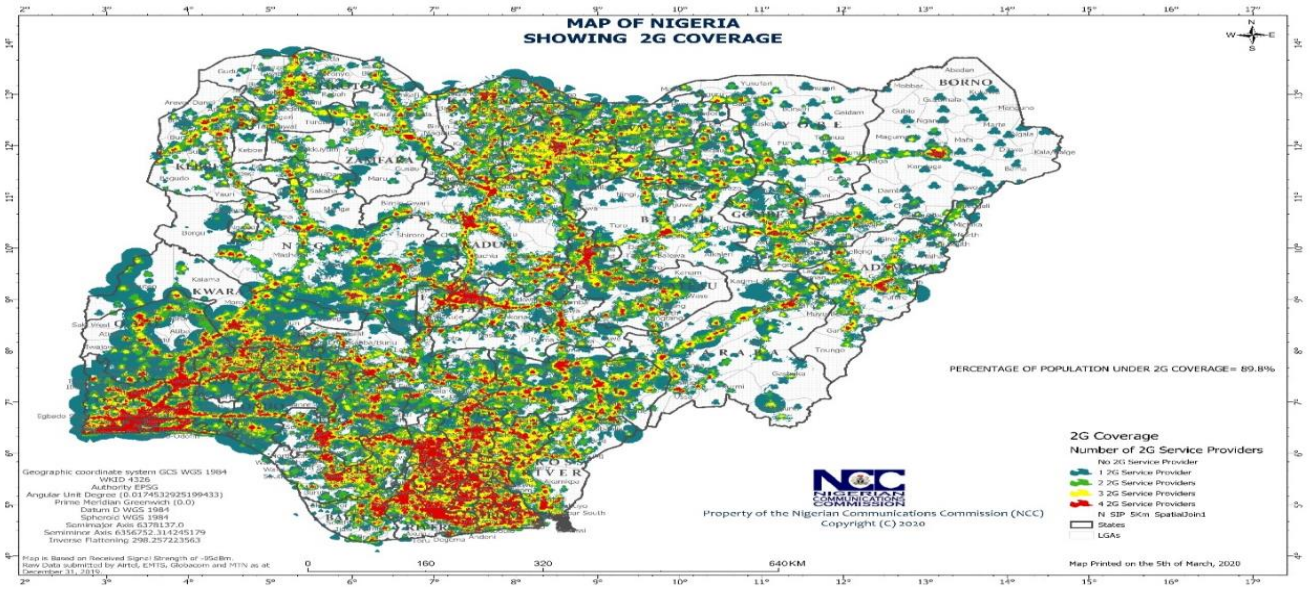


Fig 2.12: Nigeria's 2G coverage map as at Q4 2019 Source: NCC[52]

[52] Coverage means received signal strength of (-95dBm) at cell edge. Spot verification exercises are carried out to validate signal strength

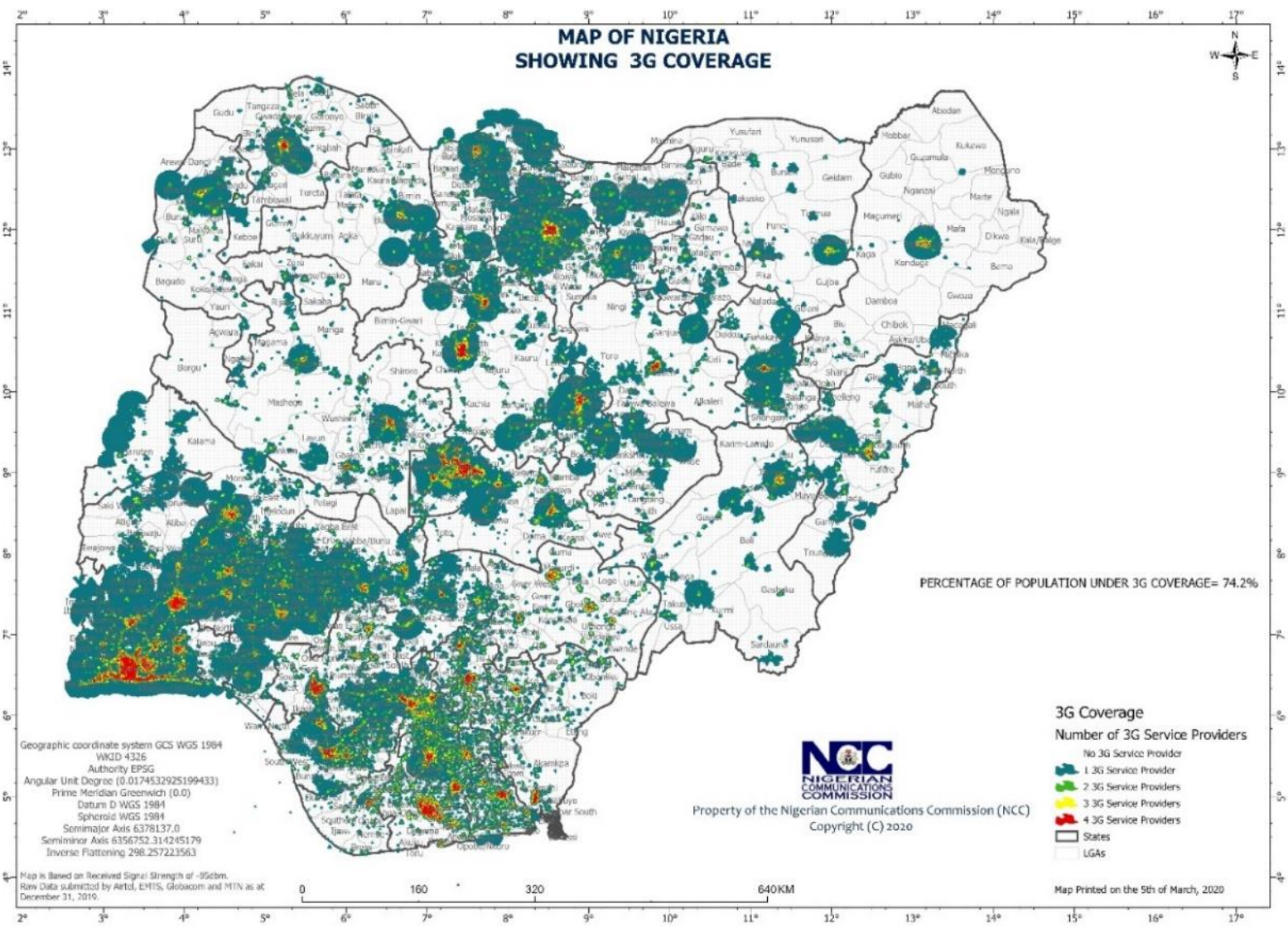


Fig 2.13: Nigeria's 3G coverage map as at Q4 2019 Source: NCC

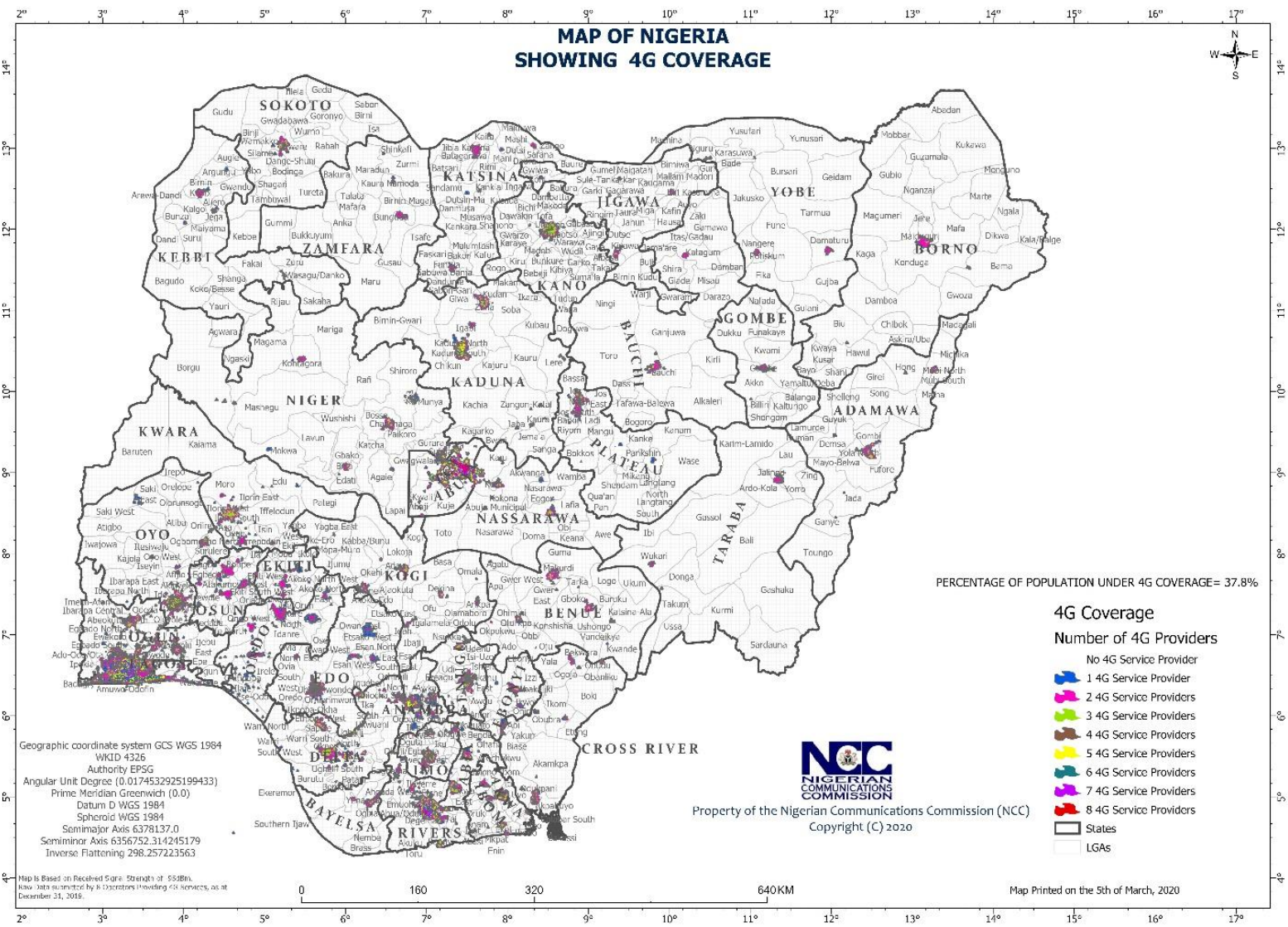


Fig 2.14: Nigeria's 4G coverage map as at Q4 2019 Source: NCC

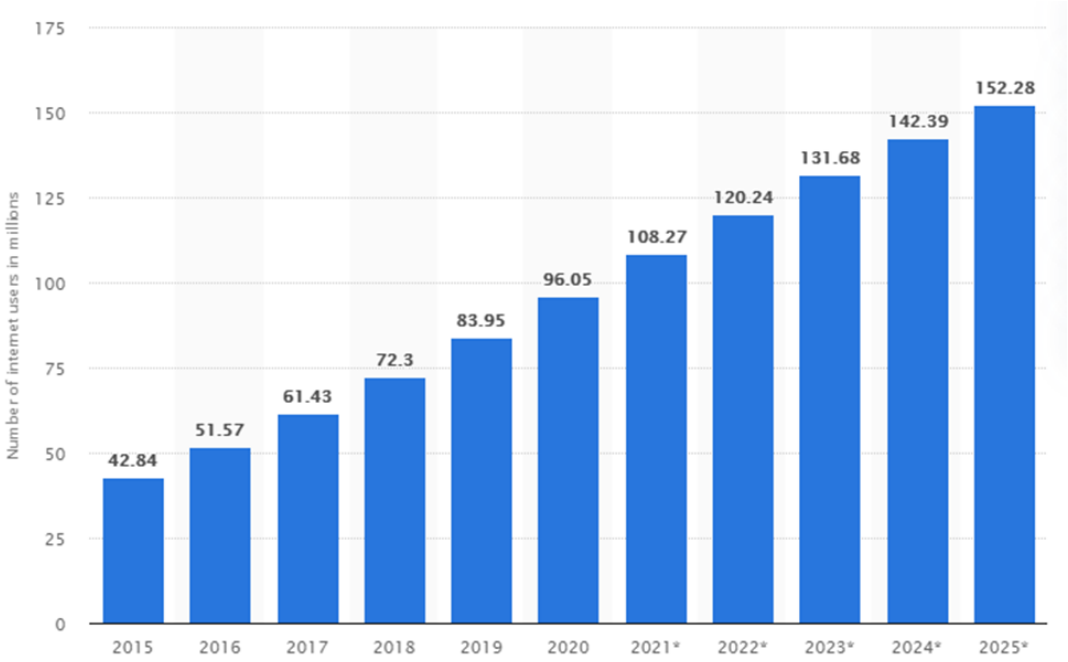
2.2 Technology Penetration in Nigeria in the ICT Sector

There is no specific definition or description of technology penetration nevertheless it can be described as the rate at which a specific technical innovation becomes adopted into the everyday life of individuals within a social group. The Internet Penetration Rate corresponds to the percentage of the total population of a given country or region that uses the Internet. An Internet user is anyone currently with capacity to use the Internet: (1) The person must have available access to an Internet connection point, and (2) The person must have the basic knowledge required to use web technology[53].

The Nigerian telecommunications market is fully liberalized, highly competitive, and evolving with time. Since 1992, a wide range of regulatory initiatives has been undertaken to open up the market to private operators to provide products and services across the entire spectrum of ICT market segments. These initiatives, particularly in relation to market entry, have resulted in an impressive 53% compound annual growth rate (CAGR) in overall fixed and mobile subscriptions since 2001[54]. Quarterly telecommunications sectorial growth is up to 35%, and the sector's annual contribution to GDP was estimated at 6.73% in 2012. Looking at the Figure below, in 2020, Nigeria had 96.05 million individual internet users. This number is projected to grow to 131.7 million individual internet users in 2023. The internet penetration amounted to 46.6 percent of the population in 2020 and is set to reach 65.2 percent in 2025[55].

[53] Internet World Stats (2020). Experiences in Collaboration in Distance Education from the Caribbean, Looking Beyond Electronic. Usage and Population Statistics, http://www.internetworldstats.com/surfing.htm).
[54] Statista, 2020. *Which brand or type of smartphone do you have?.* [Online]
Available at: https://www.statista.com/statistics/387227/market-share-of-smartphone-manufacturers-in-the-uk/ [Accessed 5 March 2020].
[55] Statista (2020)

Figure 2.1: Internet Adoption in Nigeria[56]



Source: Statista (2020)

The internet adoption in Nigeria has continued to grow as shown in the figure above indicating more people are getting engaged and involved in various internet platforms. In the most recently measured period, there were almost 85 million mobile internet users in Nigeria, and mobile phone internet usage is particularly popular[57]. The country is considered a mobile-first market where infrastructure and online usage development skipped wide-ranging desktop PC adoption and went straight to mobile internet usage via inexpensive smartphones instead. With almost three quarters of Nigerian web traffic being generated via smartphones, Nigeria ranks at the top of the list of African countries based on the share of traffic via mobile. Other African markets with a similar share of mobile online traffic are the Sudan and Ghana.

However, in spite of the widely publicized successes, Nigeria, as highlighted in the Research ICT Africa (RIA) Sector Performance Review (SPR), lags behind many other African countries with respect

[56] Statista (2020)
[57] Adegbite (2015)

to a number of market indicators[58]. Using nationally representative household survey samples, RIA's 2012 ICT Access and Usage Surveys in 12 African countries focused on household, individual and informal business ICT access and usage. Among RIA ICT Survey countries, Nigeria ranks 5th with respect to mobile penetration and 5th in terms of industry perception of the effectiveness of domestic telecommunications regulation[59]. In terms of RIA's broader Pricing Transparency Index: Prepaid Mobile for 2012, Nigeria ranks 17th out of 46 countries in terms of the affordability of the cheapest prepaid mobile product from a dominant operator, and 13th out of 46 for affordability of the cheapest mobile prepaid product from any operator.[60] The 2012 RIA Nigeria ICT Access and Usage Survey found that there is a general paradox in Nigeria's telecommunications market (of performance on the one hand and deficiency on the other) and that this paradox exists across all the subsectors of the market[61]. For example, mobile telephony is experiencing huge growth simultaneous with a fixed sector in a downward spiral.

According to another Research by RIA, after the Telecommunications sector advancement in Nigeria led to its identification as a continental ICT leader, the telecommunications sector in Nigeria over the last few years has seen negligible network investment reflecting the decline of the sector, against the backdrop of the economic recession of 2015/16, resulting in dramatic slump in crude oil prices, affecting exchange rates negatively, leading to high Government-set USD/NGN exchange rates, further increasing forex scarcity and constraining sectoral investment. This caused an escalation in the cost of equipment and a reduction in imports on which telecommunications infrastructure expansion depends[62].

Although currently, Nigeria has sufficient 2G coverage, she is still behind in 3G and 4G coverage and the requisite infrastructure. In

[58] Odufuwa, F., 2014. *Understanding what is happening in ICT in Nigeria,* s.l.: Research ICT Africa (RIA).
[59] Odufuwa (2014)
[60] Odufuwa (2014)
[61] Odufuwa (2014)
[62] Available at https://researchictafrica.net/wp/wp-content/uploads/2018/12/After-Access-Nigeria-State-of-ICT-2017.pdf

addition, Nigeria lags the required infrastructure necessary for adequate broadband deployment in Nigeria. This poor development of broadband infrastructure, resulting from low levels of investment and the disenabling economic and other environment issues, has resulted in suboptimal policy outcomes and in low levels of Internet penetration and use[63].

According to recent RIA surveys in Nigeria[64], data rates are high while browsing speeds slow and unreliable. The quality of voice and data services is also uneven according to geographical location. Multiple levels of taxation by the Federal, State and Local Governments, as well as the lack of political will on critical sectoral issues has impacted negatively on the massive growth and use of ICT in Nigeria.

Today in Nigeria, the penetration of fixed telephony is a meagre 65,914 households, or 0.3% of total households in the country[65]. As a result of this the fixed sector has been experiencing a persistent downward slide, while the mobile networks have at times been overloaded and overburdened with voice and internet traffic, resulting in poor QoS matrix. This is because Operators are financially unable to fund the roll out costs required for fixed telephony.[66].

Internet uptake appears strong, but at the same time computer penetration is limited and fixed household internet is virtually non-existent. The RIA Nigeria ICT Survey of 2012 found that only 3.4% of households, or 747,025, have a fixed internet connection, and 62% of internet users go online primarily via their mobile phone[67].[68]. The poor penetration of fixed household internet is directly linked to absence of the fixed lines over which internet access products are

[63] Available at https://researchictafrica.net/wp/wp-content/uploads/2018/12/After-Access-Nigeria-State-of-ICT-2017.pdf
[64] Available at https://researchictafrica.net/wp/wp-content/uploads/2018/12/After-Access-Nigeria-State-of-ICT-2017.pdf
[65] Odufuwa (2014)
[66] Isioto, et al. (2017)
[67] Odufuwa (2014)
[68] StatCounter Global, 2013. *Mobile vs. desktop in Nigeria from Nov 2011 to Nov 2012.* [Online]
Available at: gs.statcounter.com/#mobile_vs_desktop-NG-monthly-201111-201211
[Accessed 1 November 2020].

typically delivered; low penetration of computers; and inadequate power supply[69].

The RIA Nigeria ICT Survey found that the majority (62%) of non-internet users were eager to use the internet if it could be made available within roughly 30 minutes' walking distance from where they reside[70]. And 50% of mobile subscribers surveyed said that cost is the main limitation on increased calling activity while 60% of mobile subscribers said they would make more calls if costs were lowered. The bandwidth situation is also paradoxical[71] as a massive 2,705% increase in wholesale submarine bandwidth capacity, via landings at the country's coastal city of Lagos[72] have been dormant due to poor terrestrial domestic networks to carry these links inland[73].

Some have faulted the Nigerian Communications Commission for some of the Industry infrastructure challenges such as massive universal service rollout[74] and for the dearth of fixed telephony in Nigeria[75]. However, it must be considered that globally the move to mobile telephony had already commenced by the time telecommunications was deregulated in Nigeria. In addition, the Commission continues to pursue universal access for all both through mandating the Mobile Network Operators to fulfil their universal service obligations as contained in their License Documents, but also through the efforts of Nigeria's USP fund.

[69] StatCounter Global (2013)
[70] Odufuwa (2014)
[71] Odufuwa (2014)
[72] Odufuwa (2014)
[73] Odufuwa (2014)
[74] Odufuwa (2014)
[75] Odufuwa (2014)

2.3 Review of Previous Empirical Studies

Hodrab et al.[76] examined how the drivers of economic growth can be categorized under the following; Information and communication technology (ICT), population growth, gross capital formation, openness and inflation in developing countries, using Arab countries as a case study. They examined within the scope of 1995-2013 the effect of the suggested factors on the economic growth of 18 (eighteen) Arab nations using Econometric analysis. The research revealed an outcome which suggested that ICT and other suggested factors affect the 18 Arab nations' economic growth.

Oladimeji and Folayan[77], reviewed the growth benefits that the ICT sector has provided and its impact on the Nigerian economy and postulated that the growth rate as an apparatus to the progression of economies of emerging countries like Nigeria in the 21st century. ICT and ICT related facilities aid in the development of markets, decrease in transaction costs and increased productivity and management in both public and private sectors of the Nigeria economy. They postulated the numerous impacts of ICT in the four major sectors of the Nigerian economy, suggesting the prospects of the wireless technology platform in fostering economic and social impact for the populace.

Albiman[78], reviewed the long term effect of ICT on economic growth in the Sub-Saharan African (SSA) region. The analysis of the impact of ICTs use was assessed for a 27-year period (1990-2014), before the Millennium Development Goals (MDGs) era (1990-1999) and during the MDGs era (2000-2014). The nonlinear effect of ICT in the economic growth and their threshold values were also examined. The research showed that mobile phone and internet were found to have triggered economic growth. The results indicated that, except for

[76] Hodrab, R., Maitah, M. & Lubos, S., 2016. The Effect of Information and Communication Technology on Economic Growth: Arab World Case. , 6(2),. *International Journal of Economics and Financial Issues,* 6(2), pp. 765-775.

[77] Oladimeji, T. & Folayan, G., 2018. ICT and Its Impact on National Development In Nigeria: An Overview. *Research & Reviews: Journal of Engineering and Technology.*

[78] Albiman, Z., 2016. The role of ICT use to the economic growth in Sub Saharan African region (SSA). *Journal of Science and Technology Policy Management,* Volume 7.

financial development, human capital, institutional quality and domestic investment were the main growth enhancing transmission channels of ICTs use in the economy.

Jakhar[79], postulated that ICT play a major role in economic growth and economic development of India. He examined and analyzed how ICT has driven economic growth of India.

Oju and Onyebuka[80], investigated the major roles that ICT can contribute in enhancing the economies of rural areas in emerging countries, with its main focus on rural areas. They further postulated that in the last ten years, because of the quick spread of mobile phones, ICT has had a great impact on the economic development by enhancing the business activities of rural areas. ICT has provided access to information for the market men and women with financial services at the doorsteps of rural consumers and helped in the exchange of business know-how and thereby linking themselves. They also proffered practicable solutions in the disparity between the drivers of technology and the inherent beneficiaries in rural areas of developing countries and also the opportunities generated as a result of convergence of ICTs.

2.4 Demarcation

Looking at the literature, majority of the studies focused on how ICT have been a panacea to economic backwardness and the extent at which it fosters development and growth. Much focus has not been directed towards understanding the extent at which infrastructural development have impacted ICT penetration to achieve this growth. The literatures have highlighted the Challenges in infrastructure, potential for ICT penetration and more but have not evaluated relationship between the two factors. This study will therefore focus on the challenges of ICT penetration arising from infrastructural deficit in Nigeria.

[79] Jakhar, S., 2016. Role of ICT in Economic Growth of India. *International Journal of Science and Research,* 6(9).
[80] Oju, O. & Onyebuka, C., 2016. ICT For Sustainable Economic Development And Growth In Rural Areas. *International Journal of Computer Science and Mathematical Theory,* 2(1).

2.5 Challenges to Technology Infrastructure Roll out in Nigeria

Without connectivity, people, be it as consumers, workers or entrepreneurs, are excluded from participating in the economic and social networks that permeate modern societies. Empirical findings suggest that investment in telecommunications infrastructure is causally related to the nation's total factor productivity and that contributions to aggregate and sectoral productivity growth rates from telecommunications advancements are substantial[81]. Some of the mitigating challenges to Technology Infrastructure rollout in Nigeria include the following:

- Price Wars- Efforts by the MNOs, Civil Society Groups and other MDAs. They have driven retail prices down by lifting or amending the Regulator's voice and data price floors, thereby pleasing politicians and their constituents, but leaving scant profits for the massive investments required to rollout broadband networks.
- Right of Way Permits - The long delays in processing right of way permits as well as their arbitrary costing models have resulted in the prohibitively high costs of leasing transmission infrastructure.
- Damage to existing fibre infrastructure – This is as a result of cable theft; road works and other operations.
- Poor National Infrastructure -The lack of reliable, clean electricity supply; constrained investment in the industry; and the limited existing backbone infrastructure inhibit further expansion of ICT Technology.
- Interconnect Debts – The current interconnect debts in the Industry owed to the MNOs and the Collocation Companies which is estimated at over N30b, have impeded the growth of better networks and further investment in infrastructure. Although the Commission has often intervened in the manner, the ongoing indebtedness has been a ban on the growth of the networks.

[81] (Kenny and Kenny, 2011; Katz and Koutroumpis, 2013).

- Call masking and Call Refilling – These illegal activities which show foreign calls as local calls, have negatively impacted upon the tax revenues accruable to Government for infrastructure build out, whilst also stealing revenues from the MNOs in an already financially stretched market.
- Increased Collocation and Infrastructure Sharing – the NCC in 2006 released the Guidelines on Collocation and Infrastructure Sharing to provide a framework under which telecommunications companies can negotiate Agreements and share passive infrastructure and reduce wastage. The more MNOs collaborate and save on capital expenditure by using a middle man infrastructure provider, the more available resources they have for infrastructure deployment.
- Delineating Telecoms Infrastructure as Critical national infrastructure – A draft Bill has been ongoing in the National Assembly for years and its conclusion would ensure adequate protection for Telecoms infrastructure in Nigeria, which will further act as incentives for future FDI into the Sector.
- Uniform Right of Way Fees – Efforts are being made to ensure all State Governments align with the approved N145 per linear meter for the deployment of fibre optic across States. Where some States still charge arbitrary sums up to N6,500 per linear meter, it prevents any future roll out of ICT technology infrastructure.
- Proprietary Focus of MNOs on Infrastructure Roll Out – Most of the ICT infrastructure in Nigeria is Privately Owned Infrastructure, owned by the MNOs. As business entities with proprietary interests, they have mostly built their own transmission capacities to carry traffic generated on their mobile networks. And where they have rolled out fibre options for new data services, these have been done only in a few urban centres where they are sure of return, thus, resulting in duplication of fibre in niche markets and none in the vast majority of Nigeria's land mass.
- Internal Security – Cases of internal security in various parts of Nigeria have resulted in both destroyed ICT infrastructure, as

well as unwillingness in Service Providers to build infrastructure in those areas or repair those destroyed.

- Weak monitoring and evaluation of infrastructure projects and Contractors – Contractors are sometimes able to provide inadequate infrastructure, goods and service in the face of weak monitoring.
- Inadequate Funding to finance ICT development in Nigeria – Inability of successive Governments to provide adequate funding for infrastructure in the State and National Budgets in Nigeria.

2.6 National Efforts at Technology Infrastructure Roll out in Nigeria

Licensing

Since 2010, there has been 2705 percent increase in the wholesale submarine bandwidth capacity available to Nigerian telecommunications operators, due to the launch of three new undersea cable systems with landing points into Lagos through MainOne (2010), Glo-1 (2011), WACS (2012), and ACE (2014) – with a combined overall capacity of some 40tbps. These national initiatives in allowing these private corporations provide these service, have increased the potential to change the landscape of Internet service provisioning and data connectivity in Nigeria through lowered wholesale international bandwidth prices and higher speeds. Since then there have been increased variety in the range of available Internet products and solutions, whether delivered by traditional ISPs or mobile operators.

However, with poor national transmission to carry the bandwidth, only about 4% of international bandwidth is distributed across Nigeria resulting in 96% wasted capacity; connectivity is limited and expensive is still limited and relatively expensive where available. Thus, while it is true that submarine cables have expanded the capacity of overall international bandwidth, inland locations within

the country are yet to experience any significant lowering of broadband prices[82].

The biggest consumers of wholesale bandwidth are MNOs, transmission companies, major resellers, ISPs, and educational institutions. MainOne is the leading supplier of wholesale bandwidth[83].

While mobile voice telephony in Nigeria has grown at unprecedented rates, data capabilities lag because of the dearth of the national fibre transmission backbone infrastructure. To address this, over the years, various initiatives have been undertaken by the Regulator in licensing of Fibre build out companies, to roll out regional, and or national fibres. Some of these initiatives include the Wire Nigeria (WiN) project; the State Accelerated Broadband Initiative (SABI) Metropolitan Fibre Cable Network, National Carrier, National Long Distance Communications, Private Network Links and most recently, Open Access Fibre Infrastructure Network (INFRACO) for the provision of a fibre network in Nigeria.

Due to regulatory promotion of infrastructure sharing, coupled with the global trend of outsourcing, the majority of base station sites Market structure 44 are now under the management or outright ownership of two major tower sharing companies, IHS Towers (IHS) and American Towers. IHS manages about 15 000 towers, while American Towers owns about 5 000 towers. IHS and the MNOs are currently aggressively connecting tower locations to fibre optic cables to reduce the dependence on microwave backhauling. This should deepen the national communications infrastructure and may result in improved speeds and a greater range of services.

At the core of access networks is 2G, which covers 89 percent of the entire Nigerian population. However, 2G is an old technology that is

[82] (Gillwald, Odufuwa and Rademan, 2016).

[83] while WACS and ACE lag behind in the market, partly because ACE is playing catch-up and appears to be struggling to win business, and WACS has minimal presence due to issues arising from what is said to be shareholder disagreements. Glo-1 supplies all of Glo's wholesale data needs and provides redundancies to ISPs and third-party resellers. SAT-3 was recently transferred to a private entity by the national government in its privatisation of the fixed telephone company, NITEL, now rebranded nTEL and has limited patronage beyond the operator

generally inefficient in the handling and management of voice and data connections. Today, 3G and 4G coverage currently stand 74% and 457% respectively. The reliance on older access technologies is at the heart of poor mobile data reliability, which, at the moment, is quite pronounced throughout the country. As a NCC licensee, in view of challenges with road fibre, Phase 3's fibre-over-power-lines infrastructure appears to be the most suitable option for delivering massive and more affordable traffic across Nigeria from a landing port in Lagos. Phase 3 operates a 4 000 km fibre network that is delivered through aerial deployment on pylons along the country's power transmission corridor[84].

The biggest infrastructure companies with significant network assets are, in descending order, MTN, Glo, IHS, Airtel, 9Mobile, Phase 3 and nTEL (formerly NITEL)[85].

National Policy Documents

Nigeria's Vision 2020- This is a strategic document that identifies the long-term developmental objectives with the aim of achieving accelerated and sustained economic development. By 2020, Nigeria was envisaged to have a large, strong, diversified, sustainable and competitive economy that effectively harnesses the talents and energies of its people and responsibly exploits its natural endowments to guarantee a high standard of living and quality of life to its citizens[86]. Vision 2020 recognises the importance of ICT skills development and greater diffusion of ICT across sub-sectors within the economy, including education, finance, farming, trade, manufacturing, services, oil and gas and the public sector. In line with this objective, Vision 2020 will:

• promote development of local capacity to meet the needs of the ICT sector in order to develop and industrialised-based economy;

[84] Available at https://researchictafrica.net/wp/wp-content/uploads/2018/12/After-Access-Nigeria-State-of-ICT-2017.pdf
[85] Available at https://researchictafrica.net/wp/wp-content/uploads/2018/12/After-Access-Nigeria-State-of-ICT-2017.pdf
[86] National Planning Commission, 2009

• ensure the development and availability of affordable ICT infrastructure and services;

• encourage research and development within the ICT sector; • promote private sector-led ICT investment, entrepreneurship, innovation and local capacity development; and

• Government will facilitate and be a catalyst of ICT sector initiatives[87].

These would be achieved by providing the appropriate incentives to drive the development of ICT infrastructure and telecommunications services to rural and underserved urban areas; mainstreaming ICT into the education curriculum; encouraging local production of ICT components and sub-systems by providing incentives for manufacturers for major ICT projects; facilitating the development of a national multimedia super highway; establishing a national (spatial) ICT bone Connectivity and Bandwidth Aggregation Solution.

Nigerian National ICT for Development (ICT 4D) strategic action plan – Implementing it by establishing a national digital library with access points strategically located in both rural and urban areas; promoting e-learning, e-governance, e-business, e-commerce, e-banking, e-management, etc. providing regular and affordable access to Internet resources in all educational and research institutions; creating legal and regulatory frameworks to support e-business and ICT enabled activities in Nigeria; providing appropriate incentives, including tax benefits and improved infrastructure, with a view to creating an enabling environment that encourages investment, innovation and exploitation of ICT enabled services; and ensuring coordination and consistency between ICT policy strategies and national development policies[88].

Nigeria ICT Roadmap 2017–2020- In 2017, the Federal Government of Nigeria released the Economic Recovery and Growth Plan, recognising the central role ICT plays in driving economic growth and

[87] National Planning Commission, 2009
[88] Government of Nigeria, 2009

development[89]. In line with this, the Federal Government developed an ICT which articulates the strategic direction on four pillars namely: Governance; Policy, Legal and Regulatory framework; Industry and Infrastructure; Capacity Building[90]. The Roadmap further provides guidelines for a multi-stakeholder approach to ICT sector development in order to accelerate national development through the inclusion of women, the youth and vulnerable groups with the overarching vision to make the "ICT sector the main pillar of the Nigerian economy and to mainstream ICT into all aspects of national life".

ICT Sector Policy Nigeria - Issued by the Ministry of Communications in June 2012, the policy articulates the nation's ICT objective as a "knowledge-based globally competitive Policy, legal and regulatory framework 24 society" by 2020 integrating ICTs into the socioeconomic development of the country for national transformation.

The National Broadband Plan (2013-2018) [91] - recognizes the positive linkages between increased broadband penetration and GDP growth and has as its key: promoting pervasive broadband deployment; increasing broadband adoption and usage; and ensuring availability of broadband services at affordable prices, along with an envisaged fivefold increase in Internet and broadband penetration, from 6 percent in 2013 to 30 percent in 2018. In addition, the provision metro fibre infrastructure in all state capitals and urban cities, and fibre to the home to estates and business districts within major cities. Although the overall Broadband Plan has not been achieved, several of the targets appear such as 30 percent broadband penetration were met.

The Universal Service Provision Fund (USPF) - was established in 2006 to support the rollout of telecommunications infrastructure into rural and underserved areas. The USPF programmes consist of two broad categories: access and connectivity. The current programmes

[89] Ministry of Budget and Financial Planning, 2017
[90] Federal Ministry of Communications, 2017
[91] Ministry of Technology and Communications, 2013

include: School Knowledge Centres (SKC): Under this project, 396 public secondary schools have been provided with connectivity, computers and power backup. Teachers and students are taught how to use ICT as part of the project, as well as one-year technical support, warranty and remote ICT management. The USPF is also supporting the development and deployment of local content under this programme. E-Accessibility Project: The project provides ICT tools and Assistive Technologies (ATs) to the blind, deaf, dumb, crippled, cognitively impaired, and other categories of people living with disabilities. The project is designed to assist in improving the quality of life of people living with disability.

National Information Technology Development (NITD) Fund- The law compels telecommunication companies, banks and insurance companies with an annual turnover of more than NGN 100 million. To pay one percent (tax-deductible) of their net profits to the NITD Fund for the development of IT capabilities within Nigeria.

National Digital Economy Policy and Strategy Document 2020-2030 – Is focused on achieving digitalization and growth in ICT uptake across Nigeria by focusing on 8 key Pillars of change, namely; Pillar #1 : Developmental Regulation; Pillar #2 : Digital Literacy and Skills; Pillar #3 : Solid Infrastructure; Pillar #4 : Service Infrastructure; Pillar #5 : Digital Services Development and Promotion; Pillar #6 : Soft Infrastructure; Pillar #7 : Digital Society and Emerging Technologies; and Pillar #8: Indigenous Content Development and Adoption[92].

[92] Available at https://www.ncc.gov.ng/docman-main/industry-statistics/policies-reports/883-national-digital-economy-policy-and-strategy/file

Nigerian National Broadband Plan 2020-2025 – Continuing from the successes of the previous plan, this new plan The new Broadband Plan is designed to deliver data download speeds across Nigeria of a minimum 25Mbps in urban areas, and 10Mbps in rural areas, with effective coverage available to at least 90% of the population by 2025 at a price not more than N390 per 1GB of data (i.e. 2% of median income or 1% of minimum wage). In order to achieve these ambitious targets, the plan is focused on recommendations in the following 4 critical pillars as shown in Fig 1.1:

- Infrastructure
- Policy
- Demand Drivers
- Funding & Incentives

Chapter Three: Methodology

3.1 Research Approach

There are two kinds of research approach that can be used in a research and they are the inductive and the deductive research. The deductive research is carried out such that the research flows from a generic view to a particular view. On the other hand, the inductive approach is adopted when there is very little or no previous information about the research interest[93]. This form of research is developed to create descriptions to develop research hypothesis, questions and theories.

This study adopts the deductive research approach as it identifies the research questions and develops previous views and existing opinions in guidance of the study.

3.2 Research Design: Qualitative & Quantitative

There are two different forms of research designs and they are the quantitative and the qualitative research and they are described on the figure below:

[93] Chandran, E., 2004. *Research methods: A quantitative approach.* Nairobi: Daystar.

Figure 1: Qualitative and Quantitative Research Design[94]

Qualitative research	Quantitative Research
The aim is a complete, detailed description.	The aim is to classify features, count them, and construct statistical models in an attempt to explain what is observed.
Researcher may only know roughly in advance what he/she is looking for.	Researcher knows clearly in advance what he/she is looking for.
Recommended during earlier phases of research projects.	Recommended during latter phases of research projects.
The design emerges as the study unfolds.	All aspects of the study are carefully designed before data is collected.
Researcher is the data gathering instrument.	Researcher uses tools, such as questionnaires or equipment to collect numerical data.
Data is in the form of words, pictures or objects.	Data is in the form of numbers and statistics.
Subjective – individuals interpretation of events is important ,e.g., uses participant observation, in-depth interviews etc.	Objective: seeks precise measurement & analysis of target concepts, e.g., uses surveys, questionnaires etc.
Qualitative data is more 'rich', time consuming, and less able to be generalized.	Quantitative data is more efficient, able to test hypotheses, but may miss contextual detail.
Researcher tends to become subjectively immersed in the subject matter.	Researcher tends to remain objectively separated from the subject matter.

Source: Bruce (2007)

The aim of this research is to assess the challenges of technological penetration in Nigeria as an infrastructural deficit economy, and the qualitative and quantitative research method will be adopted. Some of the data collected will be in form of words and pictures without interviews or critical data collection process due to the limitations of the study. On the other hand, the study will also adopt a quantitative approach in which the data collected can be measured, evaluated and reported.

3.3 Data Collection Method

There are two forms of research methods that can be used in this study which are the secondary and primary research. The primary research methods collect data directly from the subject of the research. It is a method in which data are collected directly as a result of the purpose of the study and not by third parties. On the other hand, the secondary research is the kind of research that collects

[94] Chandran (2004)

data from already available sources[95]. It collects data that was not specifically collected for the purpose of that research but available in other works, database or archives that are accessible[96]. These forms of data are the kind of data usually available for general use by institutions or individuals.

This study adopts the secondary research method as it will collect data from existing sources to provide explanations of the research interest. Annual data that characterizes the aggregate economy and telecommunication sector were sourced from World Bank Development Indicator Database, Central Bank of Nigeria (CBN) statistical bulletin and Nigeria Communication Commission (NCC) publications. The data set was tailored to the need of the empirical framework and it contained information on economic variable such as gross domestic product (GDP) and key indicators for measuring impact of telecommunication on economic growth which include but not limited to private investment in telecommunication and contribution of the telecommunication to the GDP. The data was sampled between 1999 and 2020.

3.4 Method of Data Analysis

This research will evaluate its results based on a Desktop Research which is based on online review of previous research works of other people, academic journals and articles, personal observations, and personal interactions with people. This are used to understand the current states of infrastructural difficulties for technological penetration in Nigeria. The research also aims to draw a regression model to evaluate the impact of telecommunications on socio-economic growth in Nigeria. In the regression model, economic variables such as the private investment in telecommunication, telecommunication contribution to gross domestic product will be the independent variables while the economic growth measured as GDP becomes dependent variable.

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[95] Bryman, A., 2012. *Social research methods.* Oxford: Oxford University Press.

[96] Flick, U., 2011. *Introducing research methodology: A beginner's guide to doing a research project.* London: Sage.

3.5 Significance of Study

This study is significant because it would contribute in identifying and detailing the level of technological development in Nigeria; factors responsible for any perceived slow pace of development and any negative impact on the economy. Additionally, its findings would assist Government to appreciate the import of technological development as a veritable tool for enhancing Nigeria's economic development. It is also hoped that this study would add to existing literature and body of knowledge on the interrelationship between technology and economic development. Furthermore, this research work is expected to dovetail into additional research work on these concepts.

3.6 Research Limitations

The major limitation for this study is that by the use of only secondary data (online) to analyse the measure of technology penetration in Nigeria, without access to collection of primary data, we are not able to fully carry out a critical evaluation of the real-life impact of infrastructure deficit on challenges in technological penetration.

Chapter Four: Data Analysis

This study seeks to proffer answers to the following questions:

4.1 Research Question One: What are the factors that hinder technological development and penetration in Nigeria?

The current infrastructure base in Nigeria is grossly inadequate in terms of capacity and quality and is not capable of catering for the anticipated industrial development. Nigeria has huge infrastructure deficits, particularly with regards to power generation, Internet access, Roads, limited access to qualified human capital. The finding of this study identified the following infrastructural factors as affecting technological development in Nigeria:

Inadequate power supply

The public electricity power supply situation must improve urgently for Nigeria to enjoy the full benefits accruable from both wired and wired telecommunications deployment, Power backup systems for most ICT devices run between 2 to 8 hours of battery life. A situation where power outages could stretch to 12 to 48 hours and in some cases more, impacts upon the usage and sustainable deployment of ICT infrastructure, and uptake[97].

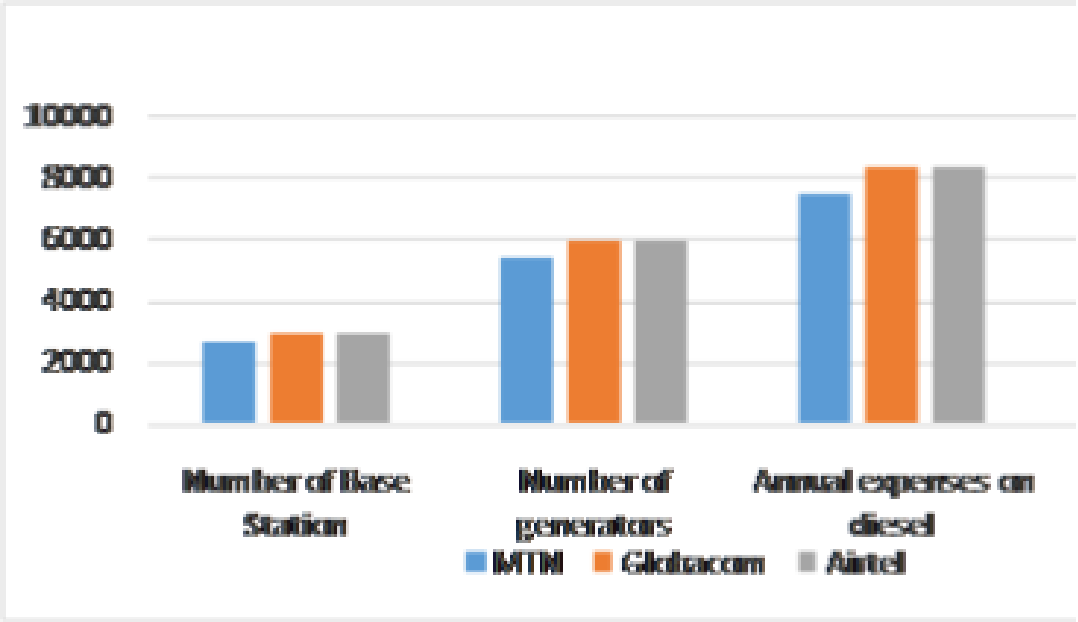
As the electric power provision is inadequate and insufficient to satisfy the requirements of the telecommunications sector in Nigeria, Operators have resorted to powering their Base Transmission Stations (BTS) with generators that have an automatic trigger whenever there is any form of power outage from the mains supply. As a result, diesel storage tanks are built at the sites and supply the generators periodically. Since self-generation electricity constitutes the highest cost of production, the GSM operators charge high tariffs to make up for the cost[98]. Table 4.1 shows the annual cost of generating electricity by the operators while Figure 4.1 also shows the charts of the running cost by the Operators.

[97] Foster & Pushak (2011)
[98] The Nation (2019)

Table 4.3: Annual cost for generating power by the operators

Operator	Number of base station	Number of generators	Annual expenses on diesel
MTN	2,700	5,400	N7.5 billion
Globacom	3,000	6,000	N8.4 billion
Airtel	3,000	6,000	N8.4 billion

Figure 4.4: Graphical Representation of Annual cost for generating power by the Operators



The four leading Operators MTN, Airtel, GLO, and Nine Mobile jointly power over 22,000 base transceiver stations with about 44,000 generators[99]. In addition, the Operators also have to provide security for their equipment which has not stopped hooligans from stealing the generators or the diesel as these operators lose about two generators and over one million liters of diesel daily.

[99] Awoleye, et al. (2012)

Transmission Infrastructure Challenges

This particular challenge is ranked next to the power supply challenge as the most difficult challenge to the GSM companies in Nigeria. MTN Nigerian had to build phase 1 of the Y'helloBahn transmission backbone which produced the biggest ratio of 4:1 backbone in the nation to address the challenge of no dependable terrestrial transmission links. The MTN Y'helloBahn transmission backbone covers a distance of 3,400 kilometers across Nigeria[100].

Inadequate Roads and Social Facilities

The GSM operators sometimes have to shoulder the responsibility of constructing or fixing the roads that lead to their host communities before setting their masts in place. This is due to poor road networks and other social utilities such as pipe-borne water to several rural communities in the nation. Consequentially, the GSM Operators are normally given conditions to make available the same or are faced with the option of denial of access into such villages or communities[101]. The resources required to achieve this always prevents the companies' expansion.

GSM Tariff Rates

Before the change in tariff rates, national calls were accompanied with pulses and the tariffs were dependent on the radial distance between the called party and the caller. The farther the distance, the faster the pulse burns out while the shorter distances had lower charges. Some of the licensed Operators have reported on their fears of sustaining the current low-price regime. Table 2 and Figure 5 depicts a table and graph for Fixed Tariff Trends and GSM tariff trends[102]. The need by the licensed Operators to gain more subscribers crashed the telephone lines and some of the practitioners fear the fact that it may lead to network congestion in the nearest future.

[100] The Nation (2019)
[101] The Nation (2019)
[102] Adegbite (2015)

Import Obligations and Long Authorization Processes

About 95% of the instruments and equipment used by the operators in Nigeria are imported and these imports are subjected to long tedious authorization and clearance processes which in turn delay the network deployment[103].

Over-Taxation

Several licensed GSM Operators are currently struggling with the high demands for levies, taxes and many other charges at all levels and Governmental tiers which most times leads to regressive and double taxations[104]. For example, a 3-million-naira fee was imposed by the Abuja Capital Development Authority on every base station in the city. Furthermore, the umbrella body of the telecommunication operators which is the Association of Licensed Telecommunications Operators of Nigeria (ALTON) were in court with the Lagos State Government over the 500,000-naira fee per base station in the State imposed on the Operators[105].

Destruction and Vandalism of Equipment

Another leading challenge in the GSM market faced by the licensed operators in Nigeria is the often vandalism and destruction of several installed equipment like Automatic Voltage Regulators (AVR), generator sets, diesel, air-condition units etc. by hooligans. Replacing these stolen or destroyed installations constitute a serious deterrent to the operations of the GSM companies[106]. Due to the vandalism of these equipment, one of the Operators had to close down one of their bases in Lagos. Similarly, one of the Operators reported that they could not access about 30 of their sites due to the Niger Delta militant youth[107].

[103] Adegbite (2015)
[104] Oxford Business Group (2019)
[105] Albiman (2016)
[106] Adegbite (2015)
[107] Foster & Pushak (2011)

4.2 Research Question Two: How has Nigeria fared in developing her economy through technology?

The Nigerian real GDP growth was estimated at 2.3% in 2019, marginally higher than 1.9% in 2018. Growth was mainly in the transport, oil and ICT sectors. Agriculture was hurt by sporadic flooding and by conflicts between herdsmen and local farmers[108]. Manufacturing continues to suffer from a lack of financing. Final household consumption was the key driver of growth in 2019, reinforcing its 1.1% contribution to real GDP growth in 2018. The effort to lower inflation to the 6% to 9% range, faced structural and macroeconomic constraints, including rising food prices and arrears payments, resulting in a rate estimated at 11.3% for 2019[109].

The economy of Nigeria shrank 6.1% year on year in the second quarter of 2020 compared to a 1.9% growth in the prior period. It was the first contraction since the Q1 of 2017 and the steepest since the Q1 of 2004, amid still-subdued oil prices and lower levels of global economic activity resulting from nationwide shutdown efforts aimed at containing the Covid-19 pandemic[110].

The oil sector declined 6.6%, after rising 5.1% in the first quarter, amid lower crude oil production (1.81 million barrels per day, down from 2.07 mbpd in Q1 and 2.02 mbpd a year ago). Also, the non-oil sector posted the first decline since the third quarter of 2017 (-6.1% vs 1.6%), as the pandemic hit critical activities such as transportation & storage (-49% vs 2.8% in Q1); accommodation & food services (-40.2% vs -3%); construction (-31.8% vs 1.7%) and internal trade (-16.6% vs -2.8%).On a quarterly basis, the GDP shrank 5%, following a 14.27% plunge in the preceding quarter. source: National Bureau of Statistics, Nigeria[111].

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[108] World Bank, 2020. *Nigerian Economic Outlook.* [Online] Available at: https://www.worldbank.org/en/country/nigeria/overview [Accessed 17 November 2020].

[109] World Bank, 2020. *World Bank Development Indicator.* [Online] Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=NG-GB [Accessed 11 March 2020].

[110] World Bank, 2020. Nigerian Economic Outlook.

[111] World Bank, 2020. Nigerian Economic Outlook.

The current account surplus sharply declined due to increased imports, lower oil revenues, and a smaller than expected improvement in capital flows. Poverty remains widespread with the poverty rate in over half of Nigeria's 36 States above the national average of 69%[112].

Despite all of this, one can postulate that the Nigerian economy has grown thanks to the ICT Technology. For example, the banking sector posted tremendous growth results in year 2020 despite the pandemic. The same was the case for the Telecommunications sector. In addition, the use of technology prompted growth in the following sectoral activities: E-Health, Electronic Governance, E-Business (Business to Business (B2B), Business to Customer (B2C) and Customer to Customer (C2C), Government to Government (G2G), Government to Citizen (G2C) and Government to Business (G2B) models.)), E-learning, ICT in Manufacturing, E-Farming, ICT in National Security, E-Finance.

In its 2nd Quarter 2020 Nigerian Gross Domestic Product Report[113], the National Bureau of Statistics stated that the non-oil sector declined by –6.05% in real terms during the reference quarter (Q2 2020). It was the first decline in real non-oil GDP growth rate since Q3 2017. The recorded growth rate was –7.70% points lower compared to the rate recorded during the same quarter of 2019, and –7.60% points compared to the first quarter of 2020. Nevertheless, non-oil sector output was driven by Financial and Insurance (Financial Institutions), Information and Communication (Telecommunications), Agriculture (Crop Production), and Public Administration, moderating the economy-wide decline. In real terms, the Non-Oil sector accounted for 91.07% of aggregate GDP in the second quarter of 2020, slightly higher than the share recorded in the second quarter of 2019 (91.02%) as well as the first quarter of 2020 (90.50%).

[112] World Bank, 2020. Nigerian Economic Outlook.

[113] Available at file:///C:/Users/fbruce/Downloads/GDP_Report_Q2_2020%20(1).pdf . On the other hand, sectors which experienced the highest negative growth included Transport and Storage, Accommodation and Food Services, Construction, Education, Real estate and Trade among others

The positive impact of ICT across Nigeria's economy and sectors can arguably be proof that Nigeria is steadily growing her economy and GDP using technology.

4.3 Research Question Three: How has poor technology penetration affected the socio-economic life of the society?

The role of ICTs to national and socioeconomic development have long been postulated and agreed upon by Economists. To impact the socio-economic state of a people, a key measure and performance indicator, is the extent to which they enjoy ICT reach and coverage. It is for this reason that accessibility is currently being viewed as a fundamental human right, and it is also the reason the Nigerian Government have developed and implemented various policy and strategy documents to grow access such as the National Broadband Plan, NNDEPS document, amongst others earlier discussed.

One of our measures to analyse this question is how much of the population has access to mobile signal of at least 3G standard. Network coverage is measured by the number of subscribers per base station where the data is available. As earlier noted, about 75% of Nigeria is today covered by 3G network. There is also the need to assess the reach of the backbone and backhaul networks by assessing the extent of fibre rollout and the areas covered. Nigeria currently has about 54,000,00 kilometres of fibre largely backhauling traffic between major cities with significant duplication of routes across service providers. Metro fibre networks currently account for less than 25% of the total fibre distances in the country with concentration in major cities such as Lagos, Abuja, Port Harcourt, and within Edo and Ogun states, while other areas remain unserved or underserved.

Access of fibre networks within 5 kilometres of the population currently stands at an average of approximately 39% reach, with a high of 85% in Lagos State and a low of 12% in Jigawa State. This means the true level of fibre coverage is very low. The low fibre penetration and proliferation of 2G networks across Nigeria mean that most Nigerians are unable to maximize the benefits of technology for their socio-economic life.

Business considerations also impact on the level of the benefits of technology for socio-economic growth across Nigeria. As Telecoms Operators are in the business of making profit, more investments are made in States with the most Return on Investment (ROI) per user. For that reason, they deploy base stations based on demand. Lagos State according to research by RAI had the highest number of base stations (4 369) while Yobe has the least (187). The total fibre optic cable deployed in 2016 amounted to 57 234 km, of which 47 347 km was on-land while 9 884 km was submarine. MTN deployed the largest on-land fibre optics (22 454 km), followed by Glo, which deployed 13 277 km. Submarine fibre optic cables were deployed by three mobile operators, Glo, Airtel and NTEL for the total of 9 884 km, Glo being the leader, with 9 800 km[114].

To ensure adequacy of infrastructure, the requisite technology, and affordable, accessible, and available access to ICT as a human right to universal access, the Nigerian Communications Commission through the USPF as earlier stated, continues to provide access to the communities for which it is not financially viable for the Telecoms Operators to invest in.

In summary, although infrastructure gaps persist, Nigerian investment in infrastructure projects has been extensive and is ranked second after South Africa, with 106 projects valued at USD 100 billion. This was enabled by several initiatives by the Nigerian Government to improve the business climate in the country and make trade simpler.[115].

[114] Available at https://researchictafrica.net/wp/wp-content/uploads/2018/12/After-Access-Nigeria-State-of-ICT-2017.pdf

[115] Available at https://researchictafrica.net/wp/wp-content/uploads/2018/12/After-Access-Nigeria-State-of-ICT-2017.pdf

Chapter Five: Conclusion and Recommendations

5.0 Conclusions

The Telecommunication sector is one of the fastest growing sectors in an emerging economy like Nigeria. There is general interest by the Government and policy makers on how to provide universal telecommunication service to all areas of the country. However, providing the telecommunication infrastructure tends to be halted by many challenges, which may be as the result of poor infrastructure and access to basic amenities like road and electricity. Despite these, there is rapid growth in mobile and internet penetration; there are also clear interdependencies between telecommunications services and economic development.

The study used national level data to analyze empirically the socio-economic effect of telecommunication in Nigeria. Data for the analyses are sampled between 1999 and 2019 from World Bank Development Indicator Database, Central Bank of Nigeria (CBN) statistical bulletin and Nigeria Communication Commission (NCC) publications. The results of this work provided evidence to support the earlier work that telecommunication investments have positive effects on economic performances. Though most studies had focused exclusively on developed countries and the few in developing countries focused on cross-country studies but interestingly, the conclusion drawn from these wealthy countries using cross-countries data are directly relevant and similar to Nigeria case.

The results confirmed the hypothesis that telecommunications investment drives growth. The primary assumption was that telecommunication investments are necessary but not sufficient condition for economic growth. Many factors other than telephone investment were critical to growth, but the lack of this investment hinders growth no matter what resources are dedicated in other areas of the economy. Thus, there is need to create a conducive competitive climate for the growth of the industry in order to allow more private investment. Also, considering the relevance of the telecommunication industry to economic growth and development,

policy makers should ensure that telecommunication policies are transparent and stable. Policies and regulations should be made to promote a conducive and competitive climate for foreign investment so that the capital required for building telecom infrastructure can be met.

5.1 Recommendations

In view of the above findings and analysis on the challenges of Technology Penetration in an infrastructure deficit economy, the following recommendations provide the way forward for the technological growth of this nation Nigeria:

10. The Commission should actively pursue the implementation of Active Infrastructure Sharing would be an alternative that would lower the cost of network deployment. This will cut down the cost of building and maintaining the infrastructure.

11. In view of the paucity of industry information for policy planning and regulatory rule-making, the Commission should consider the award of a Consultancy on impact of Infrastructure Deficiency on the level of Technology Penetration in Nigeria.

12. The Commission to monitor and sanction Telecoms Operators who fail to carry out their universal service obligations as contained in their License Documents.

13. Government and policy makers are encouraged to develop and implement sustainable models that support Government investment in critical ICT/Technology infrastructure.

14. Government and policy makers should also encourage the emergence of regional Infrastructure Companies who understand the regional terrain and can help build out the necessary ICT infrastructure.

15. To improve upon the existing infrastructural base, Governments should encourage more private sector led investments through the provision of necessary incentives and

waivers such as import duty concession, reduced bank loan interest rates, amongst others.

16. Government to continue to support and monitor implementation of a Local telecommunications hardware manufacturing industry.

17. Government to invest in Educational Infrastructural Facilities development to grow the capacity of the youth to provide sustainable and indigenous infrastructure.

18. Government to provide incentives that encourage Research and Development efforts by all Public and Private Entities for the benefit of Nigeria.

To achieve the goal of pervasive technology penetration as a prerequisite for national development, the role of the private sector in R&D efforts, the role of Government in policy setting and monitoring must be synced and if implemented, it will help to ensure effective and efficient technology transfer, form a structural framework for technological penetration and development, unlock technological growth potentials and serve as a sustainable development blueprint for the nation.

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