ARTIFICIAL INTELLIGENCE FOR ECONOMIC DEVELOPMENT IN NIGERIA

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Executive Summary

Artificial Intelligence (AI) has been identified as a potentially less costly and far-reaching tool in the work to eradicate poverty and achieve the UN Sustainable Development Goals. However, a great deal of work needs to be done in and by developing countries to take advantage of the opportunities provided by AI and close the inequality gap.

This paper assesses various sectors of the Nigerian economy and highlights technological innovations that can address some of the development challenges (such as increasing rates of poverty, high maternal mortality rates, low levels of energy access and decaying physical infrastructure) faced by the country; and identifies areas of opportunity driven by the rapid population growth, large potential labor force, and high youth population. Finally, we set out an ethical framework to guide the development and deployment of AI technologies in a sustainable and inclusive manner. In Nigeria, AI can provide sustainable and scalable innovations in key sectors including in:

- Agriculture by providing smallholder farmers with the tools to engage in high-yield, large-scale farming.
- Healthcare by providing digital healthcare services for diagnosis, public health monitoring and disease management.
- Energy by providing technologies for the generation, distribution, storage, and disposal of energy and power.

Difficulties in developing and deploying local AI solutions are driven by a poor public education system with little emphasis on technical and entrepreneurial skills; the absence of an adequate data ecosystem; and low broadband penetration in the country, despite the high rate of mobile phone penetration. To resolve these issues the Nigerian Government should:

- Invest heavily in the education system by embedding ICT infrastructure into primary and secondary education to encourage digital literacy and an interest in STEM disciplines from an early age. There should also be investment at the tertiary level in research and engineering laboratories that can create solutions to pressing social and economic issues.
- Expand the broadband network through partnerships with local and international companies able to provide low-cost access across the country.
- Improve the employability of the young labor force by providing work-based training opportunities.

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INTRODUCTION

The development of Artificial Intelligence (AI) systems and technologies in what has been referred to as the "4th Industrial Revolution" has ushered in new opportunities and threats to developing countries.[1] On the one hand, AI provides opportunities for the "global south" to leapfrog development and attain economic growth and prosperity. While it is forecasted that AI could add over US$15 trillion to the global economy in just 10 years, it is clear that the benefits of this 4th revolution will not be evenly accrued by developing countries and in fact, may bypass them altogether without deliberate policies, strategic action, and collaboration between relevant stakeholders.[2]

AI systems are machine-based systems that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy.[3] Throughout this paper I use the umbrella terms 'AI' or 'AI system' to refer to digital and/or data-driven technologies, such as those used for automated decision making, diagnosis, predicting and forecasting, and pattern recognition.

According to the International Finance Corporation, AI is an integral part of the solutions for eradicating poverty and increasing shared prosperity as it lowers the cost of and barriers to providing private sector solutions, has greater reach than traditional solutions, and drives investment opportunities in emerging markets.[4] AI technologies are already contributing to resolving various development challenges such as financial inclusion. AI also holds great promise to address other sustainable development goals (SDGs) particularly those faced by individuals at the "bottom of the pyramid" by providing AI-as-service solutions or generating data on micro-levels using mobile phones and other electronic devices.[5]

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1 Schwab, Klaus. The Fourth Industrial Revolution: what it means, how to respond (2016)

2 PWC. Global Artificial Intelligence Study: Exploiting the AI Revolution (2017)

3 OECD. Recommendation of the Council on Artificial Intelligence (2019)

4 IFC. Artificial Intelligence in Emerging Markets: Opportunities, trends and emerging business models (2020)

5 The bottom of the pyramid refers to the bottom of the global economic system with individuals who have capita incomes of less than $1,500 annually (Prahalad and Hart, 1998).

AI also provides a useful tool for assessment of needs and the targeted delivery of development interventions.[6]

With AI potentially speeding up global progress towards the achievement of the SDGs, countries that are unable or unwilling to take advantage of the opportunities may find themselves falling even further behind, thereby exacerbating global inequality.[7] Various surveys of global readiness for AI innovations have found African countries, particularly those in sub-Saharan Africa, to be mostly not ready to take advantage of the technology revolution for economic growth and development. In Oxford Insight's 2020 AI Readiness Index, which assesses how well governments are positioned to take advantage of AI transformation, Nigeria ranked 138 of 172 countries.[8]

This project is therefore an attempt to take stock of the Nigerian economy and highlight a few sectors in which AI innovation could be beneficial for the attainment of its development goals as well as provide a framework within which the potential risks of AI can be avoided.

6 USAID. Reflecting the Past, Shaping the Future: Making AI Work for International Development (2018)

7 Results for Development. Artificial Intelligence and International Development (2019)

8 Oxford Insights. AI Readiness Index 2020. https://www.oxfordinsights.com/government-ai-readiness-index-2020

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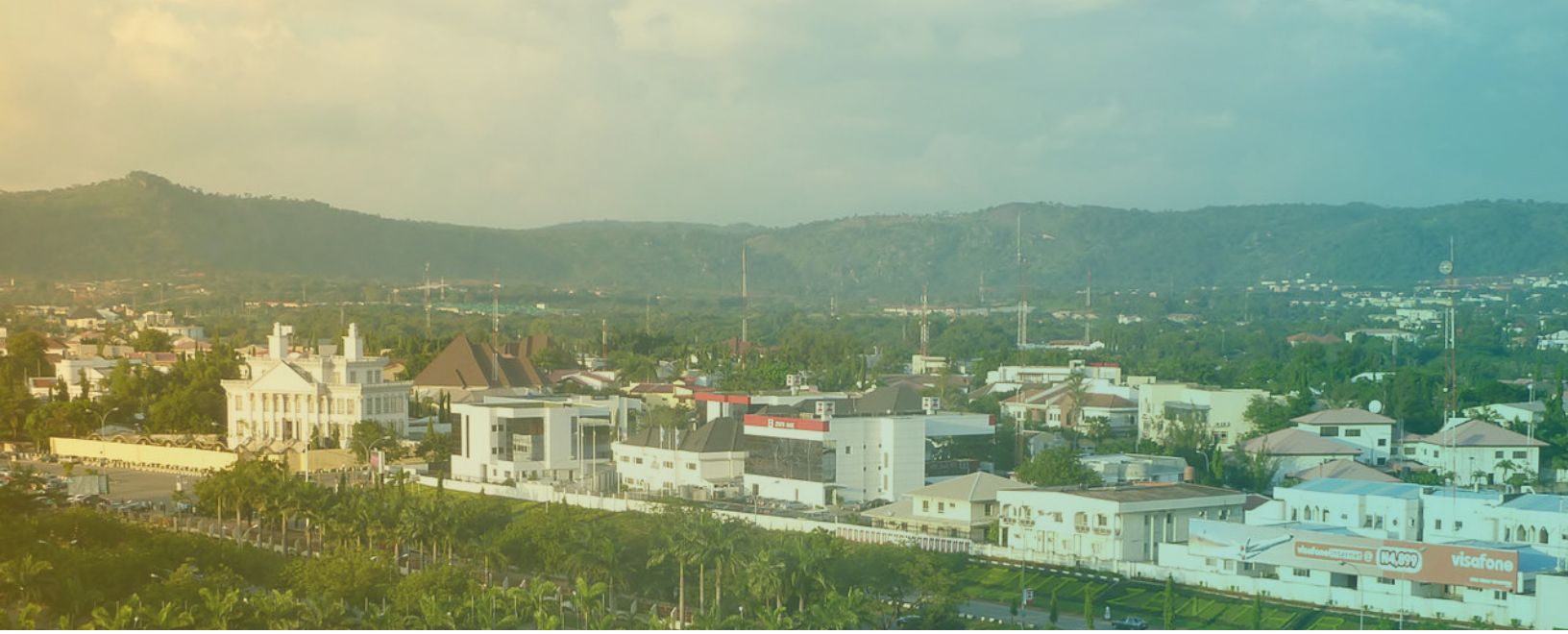
THE NIGERIAN CONTEXT



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THE NIGERIAN CONTEXT

Nigeria is a densely populated country with approximately 200 million people making it the most populous country in Africa and the 6th most populous country in the world. Life expectancy as of 2018 was 59 years.[9] The population demographic in Nigeria skews young with almost 60% of Nigerians below 24 years old leaving the country with a high dependency ratio.[10] Furthermore, the population continues to grow rapidly thanks to an annual population growth rate of 2.5% leaving Nigeria on track to double its population in just 30 years and become the third most populous country in the world.[11]

The country has seen a contraction of its economy over the past few years thanks to declining oil prices and the recent COVID-19 crisis, although it began to rebound in the 4th quarter of 2020.[12]

9 United Nations Department of Economic and Social Affairs World Population Prospects (2018)

10 CIA Factbook (2021). https://www.cia.gov/the-world-factbook/countries/nigeria/

11 United Nations Department of Economic and Social Affairs World Population Prospects (2019). Pg. 25

12 Aitalohi et al. Resilience through Reforms. Nigeria Development Update, World Bank Group. http://documents.worldbank.org/curated/en/389281623682704986/Resilience-through-Reforms

Gross Domestic Product (GDP) is driven by household consumption and as at 2019, GDP per capita, PPP was US$5,100.[13]

Health and life outcomes in the country remain depressed despite past progress. The maternal mortality rate is over 800 deaths per 100,000 live births with less than half of births attended by health personnel, leaving Nigeria responsible for 20% of the global maternal mortality incidence.[14] Infant and under-5 child mortality rates are also relatively high at 74 deaths and 117 deaths per 1,000 live births respectively.[15] Vaccination rates remain low with only 30% of children receiving the full dose of recommended vaccinations.[16]

Nigeria also faces various economic challenges with growing extreme poverty. In 2018, it overtook India to become the country with the highest amount of people living in extreme poverty despite only having a sixth of the population size of India.[17] About 40% of the population now live on less than US$1 per day.[18] It also has a high rate of unemployment and underemployment, with youth unemployment increasing.[19] In addition to the high rate of poverty, there is growing food insecurity due to conflicts in the northern parts of the country and extreme weather fluctuations driven by climate change. Over 20% of the population in Northern Nigeria were classified as being in food crisis or stressed in 2019, a number that is expected to have increased due to the COVID-19 crisis of 2020.[20]

13 World Bank Data, GDP per capita, PPP (Constant 2017 international $) – Nigeria. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD?locations=NG

14 Ope BW. Reducing maternal mortality in Nigeria: addressing maternal health services' perception and experience. Journal of Global Health Reports (2020)

15 UN Inter-agency Group for Child Mortality Estimation (2020). https://childmortality.org/data/Nigeria

16 UNICEF Nigeria. Health Fact Sheet (2019)

17 Quartz Africa. Nigeria has become the poverty capital of the world (2018). https://qz.com/africa/1313380/nigerias-has-the-highest-rate-of-extreme-poverty-globally/

18 World Bank Nigeria Overview (2021). https://www.worldbank.org/en/country/nigeria/overview

19 Bloomberg. Nigeria Unemployment Rate Rises to 33%, Second Highest on Global List (2021). https://www.bloomberg.com/news/articles/2021-03-15/nigeria-unemployment-rate-rises-to-second-highest-on-global-list

20 Global Report on Food Crises: Joint analysis for better decisions (2020). https://docs.wfp.org/api/documents/WFP-0000114546/download/

It is important to note that outcomes in Nigeria vary widely by regions – poverty, mortality rates and food insecurity are concentrated in rural areas and predominantly in the North. Extreme poverty rates for instance, which are as high as 45% in some northern regions are much lower in the South and South-Western parts of the country with cities such as Lagos reporting only 4.5% rate. Economic opportunities are also unevenly disbursed with the vast majority of commerce, technological innovation, and capital investment concentrated in Lagos and other surrounding states.[21]

Artificial Intelligence Landscape in Nigeria

AI in Nigeria has the potential to provide a new frontier of economic opportunity as well as social development and inclusive and sustainable growth. However, AI adoption in Nigeria is still in its infancy despite the growing number of startups and established businesses using AI solutions to deliver customer services. Companies currently offering AI solutions include:

- AirSmat, which provides AI-enabled software to businesses for drone data management.
- Kudi AI, which provides an AI enabled chatbot to assist in the transfer of remittances to family and friends in Nigeria.
- Data Science Nigeria, a foundation working to deliver research which can be transformed to business use applications. It conducts AI and ML bootcamps and competitions.
- Robotics and Artificial Intelligence Nigeria, which provides training in AI, ML and robotics development and automation.

The Federal government, recognizing the potential of AI technology announced last year that it plans to establish a Center for Artificial Intelligence and Robotics focused on networking, research development, and information and communication security.[22]

21 Demographics of Nigeria – statistics & facts (2021). https://www.statista.com/topics/6477/demographics-of-nigeria/

22 Economic Confidential. NITDA Plans Center for Artificial Intelligence, Robotics (2020). https://economicconfidential.com/2020/09/nitda-centre-artificial-intelligence-robotics/

Economic Impact/Opportunity

Major sectors in the Nigerian economy still have a minimal amount of technological innovation. Agriculture—despite being a key contributor to GDP and the labor market—remains predominantly smallholder and subsistence.[23] AI technology can potentially have an outsized beneficial impact on the economy by increasing labor productivity, capital efficiency, and driving growth in sectors such as agriculture, healthcare, education, infrastructure, and energy.

Inclusive Growth

The impact of AI can be transformative and improve the lives and livelihoods of millions of people across a large section of the country. An effective AI strategy should aim to achieve that by ensuring its application benefits and empowers as many people as possible in the society. AI can provide value and scalable solutions in a wide range of sectors:

a) Agriculture: AI can increase the labor and capital efficiency of smallholder farmers in Nigeria, allowing sector growth to enable self-sustainability and food security. AI innovation can also address supply chain issues by measuring indicators of food security (e.g., stock availability, production and consumption levels and commodities costs) on a regional or national level, encouraging "precision agriculture" and automated monitoring solutions for issues such as crop infestation, soil health or animal tracking among smallholder farmers who make up 80% of farmers in Nigeria.[24]

b) Healthcare: AI can be leveraged to deliver medical care in low resource environments. Telehealth tools for diagnosis, which are mediated either by health workers or self-administered, can prevent the escalation of disease or the deterioration of health. The digitization of health records and establishment of a national public health database can also help monitor incidences of diseases and provide early warning notifications of potential pandemics or disease outbreaks.

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23 PwC. Current State of Nigeria Agriculture and Agribusiness Sector (2020) https://www.pwc.com/ng/en/assets/pdf/afcfta-agribusiness-current-state-nigeria-agriculture-sector.pdf

24 The International Society of Precision Agriculture defines precision agriculture as a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.' https://www.ispag.org/about/definition

c) Education: Fully digitized learning at the primary level has not proven to be more effective long term in delivering learning outcomes but providing digitally accessible tools and resources, curriculum, and learning opportunities can ensure that kids have access to quality education that will provide them with the skills and knowledge to ultimately make a decent living.

d) Infrastructure: AI can also be used to address some of the infrastructure issues in the country. With the current administration's focus on expanding the network of roads and railway in the country, digital and satellite data can be used to develop a picture of migration patterns and ensure smarter infrastructure investment that supports urbanization growth such as building affordable housing in areas of current and future high demand, providing adequate sanitation facilities, electrical grids, clean water supply, and public transportation services.

e) Energy: Potential innovation in smart energy infrastructure and power grids can allow for the optimal allocation of energy resources, increasing efficient power supply and usage and reducing disruptions and unpredictability. The adoption of new and renewable technologies for energy generation and storage will also enable the country to move away from fossil fuels energy generation, which still accounts for 80% of energy generation in Nigeria.[25]

Use Cases and Sustainable Development Goals

Healthcare (SDG 3)

Healthcare is an important sector in the Nigerian economy with significant potential for societal impact and revenue generation. With a population of approximately 200 million people, the market size of this sector was estimated to be over US$15 billion in 2018 and expected to reach over US$18 billion in 2023.[26] However, there are substantial challenges facing the sector including:

25 International Trade Administration. Country Commercial Guides, Nigeria – Electricity and Power Systems (2021)

26 Companies Export. Healthcare Resource Guide: Nigeria (2019). https://2016.export.gov/industry/health/eg_main_130219.asp

A shortfall of medical personnel including doctors, midwives, and nurse

There are only 0.38 physicians per 1,000 people, a much lower ratio than the 1 doctor per 1,000 people minimum recommended by the World Health Organization.[27] In 2018, the total healthcare worker to population ratio (including doctors, nurses and midwives) was 1.95 to 1,000.[28] In total, there are an estimated 100,000 midwives and 20,000 physicians working in the country.[29] There is also a current exodus of health workers, particularly doctors out of the country to developed nations.[30]

Lack of physical access to health services

There are only about 24,000 hospitals in Nigeria with five beds per 10,000 population.[31] Tertiary healthcare services are highly concentrated in urban areas and most hospitals are concentrated in the southern part of the country.[32] As such, even though there is a general inadequacy of healthcare services across the country, there is disparity in access to services between the North and South, and rural and urban areas.

High cost of healthcare services

Public expenditure in healthcare is currently approximately less than 4% of GDP.[33] With the government only spending $83 per capita on healthcare, Nigerians bear the majority of their healthcare costs out of pocket.[34] Over 75% of healthcare costs is out-of-pocket expenditure, with the poor and disadvantaged hit the hardest.[35] The high cost also means that patients often avoid seeking healthcare services in the first instance and will often not attend a hospital or medical facility until their health has deteriorated or the disease advanced which ultimately reduces the rate of recovery or survival.

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27 World Bank Data. Physicians (per 1,000 people) – Nigeria (2018). https://data.worldbank.org/indicator/SH.MED.PHYS.ZS?locations=NG

28 Global Health Workforce Alliance. https://www.who.int/workforcealliance/countries/nga/en/

29 United Nations Population Fund. The State of the World's Midwifery (2014). https://www.unfpa.org/data/sowmy/NG

30 All Africa. Nigeria: Doctors in Mass Exodus Amidst NARD Strike (2021). https://allafrica.com/stories/202108230029.html

31 World Bank Data. Hospital beds (per 1,000 people) – Nigeria (2004). https://data.worldbank.org/indicator/SH.MED.BEDS.ZS?locations=NG

32 Makinde et al. Distribution of Health Facilities in Nigeria: Implications and Options for Universal Health Coverage. International Journal of Health Planning and Management (2018)

33 Techcabal. The State of Health Tech in Nigeria. https://techcabal.com/reports/the-state-of-health-tech-in-nigeria/

34 World Bank Data. Current health expenditure per capita (current US$) - Nigeria. https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD?locations=NG

35 World Bank Data. Domestic private health expenditure (% of current health expenditure) – Nigeria. https://data.worldbank.org/indicator/SH.XPD.PVTD.CH.ZS?locations=NG

Low take-up of health insurance

The rate of health insurance take-up remains low in Nigeria due to a combination of factors including a lack of awareness and lack of trust in corporations.[36] In addition, a significant portion of health insurance is provided through employers thereby excluding those who are unemployed or employed in the informal sector.[37] According to a study by the International Labour Office, in 2018 93% of all employment in Nigeria was informal – with 50% working independently.[38] The Federal Government of Nigeria as well as various state governments have sought to address some of the healthcare access issues by collaborating with the private sector and international community to encourage enrollment in health insurance, increase access to and expand health services. The Federal Ministry of Health announced its plans to build 10,000 primary health centers across the country with a minimum of one center per political ward.[39] The Nigerian National Petroleum Corporation also plans to build 14 medical centers and expand to intensive care units across the country.[40] At the state level, the Lagos State Government announced its intention to build a 150-bed medical park to provide cutting-edge medical services.[41]

AI-driven solutions and interventions can assist in addressing some of the challenges set out above by providing access to digital health services and diagnostic services. Globally, the healthcare sector is seeing advanced AI innovation in areas such as treatment, diagnosis, and research that is growing the revenue potential of the market and helping improve the quality of life and disease outcomes for millions of people.[42]

36 Ibid, 35

37 The Guardian. Over 170 million Nigerians without health insurance (2020). https://guardian.ng/features/over-170-million-nigerians-without-health-insurance/

38 International Labour Office. Women and men in the informal economy: A statistical picture (2018). https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_626831.pdf

39 International Trade Administration. Country Commercial Guides, Nigeria – Healthcare (2021)

40 Nigerian Investment Promotion Commission. NNPC to Build Hospitals in 14 States (2020). https://www.nipc.gov.ng/2020/05/19/nnpc-to-build-hospitals-in-14-states/

41 The Guardian. Lagos govt finalises medical park project to boost quality healthcare delivery (2021). https://guardian.ng/news/lagos-govt-finalises-medical-park-project-to-boost-quality-healthcare-delivery/

42 USAID. Reflecting the Past, Shaping the Future: Making AI Work for International Development (2018)

Solutions

Access to Healthcare (Telehealth Services)

AI can be used to provide medical services in health deserts by augmenting the efforts of medical practitioners in those areas. Incorporating AI solutions that leverage language and image processing technologies into local health centers can allow medical workers to provide care that would otherwise be absent. Phone and video telehealth services will provide access to specialists and general practitioners who can provide advice and coordinate treatment remotely.

AI can also be used to provide services to patients more effectively. It can be leveraged for initial triaging services which access symptoms of patients in the first instance to determine the severity of their ill health and the most effective and efficient service to provide. This system can be operated on a mediated and self-service basis with self-service provided through mobile phones or automated interfaces at health centers. Non-emergency cases can be referred to pharmacies, health workers or general practitioners (if available) while more serious cases can be directed to Accident and Emergency or other Urgent Care services. This system will ensure that already stretched hospital services begin to see more streamlined cases which do in fact need medical intervention. In other cases, people can receive initial care and medical advice thereby reducing the chances of deterioration of minor conditions.

Diagnostic and Treatment Services

Nigeria faces increasingly high prevalence of chronic diseases worsened by the dearth of specialist services and care. The Nigerian Medical Association estimates that there are less than 50 consultant oncologists, 40 neurosurgeons and 50 neurologists in the entire country.[43] Only seven states have any form of specialist cancer care. As such, diagnosis of chronic diseases is often not obtained at all or only received at the advanced stages of disease progression. As such, there is great need for diagnostic services across the country. AI solutions can provide clinical diagnosis using image capturing and deep learning models in the first instance before patients are able to visit a physician. Examples of such diagnostic services include the Parasight platform[44] for computerized malaria diagnosis and Excelscope.[45] In Nigeria, the mobile app Aajoh aims to enable users to input. their health symptoms via text, images, or verbally for instant diagnosis.[46]

43 Pharmaccess Foundation. Nigerian Health Sector, Market Study Report (2015). https://www.rvo.nl/sites/default/files/Market_Study_Health_Nigeria.pdf

44 Eshel, Y et al. Evaluation of the Parasight Platform for Malaria Diagnosis (2017)

45 https://vimeo.com/202413138

46 Aajoh. https://www.f6s.com/aajoh

Secure Electronic Data Management

Healthcare providers should adopt secure digitized data management systems to enable proper patient record management. Having nationally integrated electronic data management systems which emphasize data privacy and security will allow easy transfer of patient casefiles between healthcare providers thereby enabling seamless delivery of healthcare services. Patient data can either be stored directly on cloud servers in regions with adequate power, broadband and computing bandwidth or stored on physical servers and transferred to cloud servers at regular intervals in regions where cloud capabilities are not fully developed. Patients should also be granted access to their own medical records in a format simple enough for them to understand via computer and mobile devices. Electronic data systems can also be programmed to encourage preventive medical use by incorporating a patient alert system for regular medical checkups and follow ups.

Public Health Management

As noted above, the current system of allocation of scarce medical resources in Nigeria is very inefficient. AI can be leveraged to manage the allocation of staff and equipment ensuring that resources are located where the demand/need is present. AI solutions can also ensure that this allocation remains dynamic and responsive to changes in demand. However, effective allocation requires that an overview of all available resources can be obtained when needed. A national database wherein data on medical resources, use and demand patterns are collected and analyzed assist with the efficient and fair delivery of health services. Such national database can also contribute to disease control by identifying and highlighting patterns of outbreaks (by enabling the recording of health interventions and transactions) thereby providing reliable data on which to base response efforts. With outbreaks of Lassa fever, Ebola and tuberculosis seen in various parts of the country in the past few years, a public health database will enable the early detection and containment of such outbreaks. Public health monitoring tools have been successfully deployed to contain Zika and Dengue outbreaks in jurisdictions such as Sao Paulo.[47]

47 A monitoring tool was developed via a partnership between Dalberg Data Insights, the Vector Control Authority, and the Epidemiological Surveillance Center in Sao Paulo

Agriculture (SDG 2)

Agriculture remains one of the largest sectors of the Nigerian economy employing about 40% of the entire labor force and contributing a quarter of the national GDP.[48] About 70% of households in Nigeria practice crop and livestock farming. Major food crops in Nigeria include maize, cassava, guinea corn and yam.[49] Cash crops grown for export include sorghum, palm oil, cocoa beans and cashew nuts, with rice grown as a food and cash crop. Farming in Nigeria remains predominately smallholder and subsistence in nature with most farmers holding less than 2 hectares of land per household. Smallholder farmers also produce 90% of the agricultural produce and are therefore an important stakeholder in ensuring food security.[50] Despite its importance in the economy, it remains a highly challenging sector with various issues including:

Low Productivity

Annual crop and livestock production in Nigeria remains poor, leading to reduced levels of national food self-sufficiency, unrealized export opportunities, and growing tribal conflicts.[51] Crop and livestock farms in Nigeria remain predominantly subsistence and smallholder with continued practice of traditional agricultural practices such as rainfed agriculture and low fertilizer application.[52] With soil fertility and natural resources, such as water tables and rainfall becoming affected by climate change, dependence on these agricultural methods can lead to food insecurity and economic uncertainty.

Low Technology Penetration

There is a low level of technology adoption among smallholder farmers who make up 80% of farmers in Nigeria.[53] This includes very low levels of irrigation development, cold storage facilities, and tractor density.[54]

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48 FAO in Nigeria. Nigeria Agriculture at a Glance. http://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/

49 Statista. Agriculture in Nigeria – statistics and facts (2021). https://www.statista.com/topics/6729/agriculture-in-nigeria/#topicHeader__wrapper

50 PwC. Current State of Nigeria Agriculture and Agribusiness Sector (2020) https://www.pwc.com/ng/en/assets/pdf/afcfta-agribusiness-current-state-nigeria-agriculture-sector.pdf

51 Food and Agriculture Organization. Nigeria Agriculture at a Glance. https://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/

52 Hua Xie, Liangzhi You, Hiroyuki Takeshima. Invest in small-scale irrigated agriculture: A national assessment on potential to expand small-scale irrigation in Nigeria, Agricultural Water Management, Volume 193, 2017, Pages 251-264,

53 Mgbenka, R. & Mbah, E. A Review of Smallholder Farming in Nigeria: Need for Transformation. International Journal of Agricultural Extension and Rural Development Studies Vol.3, No.2, pp.43-54, May 2016

54 PwC Nigeria. Transforming Nigeria's Agricultural Value Chain (2017)

Dysfunctional Supply Chains

There is a lack of functioning end-to-end agricultural value chains, which results in farmer profits remaining low. The value chain remains highly fragmented with farmers suffering from lack of access to services.[55] At the input stage, low quality seeds, poor fertilizer and pesticide adoption and use result in lower farm productivity.[56] There is also a lack of storage capacity which leads to high levels of post-harvest losses and waste.[57] Most smallholder farmers do not have access to a price discovery mechanism leading to price asymmetry, inefficient middlemen and minimal marketing.[58]

Solutions

Crop and Land Management

AI technologies can provide crop and land management solutions that are data driven, which increase farm productivity and reduce costs such as pest control, soil and crop health monitoring, predictive analysis, and microbiome technologies to enhance crop resilience. Data can be collected from local image capture, aerial drones, and remote satellites to monitor crop and soil health.

Vertically Integrated Agriculture Value Chain

AI can solve the supply chain issues by creating a digital ecosystem with data collection, analytics, and predictive modelling to rapidly measure production levels, supply indices, stock availability, consumption patterns, supply chain intermediary efficiency, and price fluctuations. Food sensing technologies can also provide food safety and traceability. The creation of an ecosystem can also provide communities and villages the opportunity to share insights, lessons, and information.

Precision Agriculture Solutions

AI-supported agricultural practices can increase productivity and yield across farmlands in Nigeria. These solutions include:

- Weather forecasting services which use high-resolution weather and remote-sensed data to provide farmers with real-time advisory services on optimal sowing and harvest periods as well as the appropriate variety of crops to plant, which could make rainfed agriculture climate change more resilient. A study by Delerce et al. (2016) showed the potential for observational weather data and climate variability to add value to farming decisions.[59]

55 Ibid

56 Ibid

57 Ibid

58 Ibid

59 Delerce, S. Assessing Weather-Yield Relationships in Rice at Local Scale Using Data Mining Approaches (2016)

- Autonomous products including GPS-enabled tractors to plough land in a sustainable and economical manner, smart drones for aerial land surveying and dispersal of pesticides, soil sensors to provide soil health information, and livestock GPS trackers to monitor grazing patterns and the health of livestock animals.

Smart Cities and Mobility (SDG 11)

Nigeria is a rapidly urbanizing country. About half of all Nigerians currently live in urban areas, with an annual urbanization rate of over 4%.[60] There are therefore significant population clusters scattered throughout the country with urban areas in the South and Southwest being the highest density areas. As of 2020, there were 7 cities with more than 1,000,000 inhabitants and 80 cities with between 100,000 and 1,000,000 inhabitants.[61] With the country on track to be the third most populous nation in just 30 years, it is envisaged that the urbanization rate will remain high. Despite this high migration rate to urban areas, there has been no commensurate increase in social services. As a result, urbanization has led to over population, congestion, high rates of homelessness and crime, and poor standard of living.

Most of the transportation and mobility in Nigeria is carried out by road. There is no extensive railway network across regions of the country and the minimal network that exists has historically been poorly maintained. There is less than 5,000 kilometers of railway in the entire country and as of 2018, there were only six operational locomotives for passenger travel.[62] Although most of the travel is conducted by road, the road networks have also been poorly maintained. Of the 200,000 kilometers of road available in the country, an estimated 135,000 of them are unpaved.[63] The World Bank estimates a financing need of US$30 billion for rail and road infrastructure for Nigeria to close its infrastructure gap and bring it up to an acceptable level.[64]
With the decaying transport networks, there is a great deal of congestion and traffic. The economic and human cost of this congestion is significant

60 World Bank Data. Urban Population. https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=NG

61 World Population Review. Population of Cities in Nigeria (2021). https://worldpopulationreview.com/countries/cities/nigeria

62 CIA Factbook – Nigeria (2021). https://www.cia.gov/the-world-factbook/countries/nigeria/

63 Infrastructure Concession Regulatory Commission. 135,000km road network in Nigeria is untarred (2017). https://www.icrc.gov.ng/135000km-road-network-nigeria-un-tarred-icrc/#:~:text=%E2%80%9CNigeria%20has%20about%20195%2C000%20km,about%2060%2C000km%20are%20paved.

64 Adam Smith International. Promoting public-private partnerships as a financing option for Nigerian infrastructure development. https://adamsmithinternational.com/projects/accelerating-the-delivery-of-new-infrastructure-projects-in-nigeria/

and is continually on the rise.[65] The congestion is made worse by the lack of reliable or comfortable public transportation resulting in local preference for private vehicle ownership. The deteriorated state of the roads also leads to a high incidence of traffic accidents and a significant number of injuries and deaths with an estimated 39,000 Nigerians dying from road traffic accidents annually.[66]

The government has made a series of announcements recently to demonstrate its commitment to restoring the country's infrastructure. It established, with seed capital from the Nigerian Sovereign Investment Authority, the African Finance Corporation and the Central Bank of Nigeria, the Infrastructure Corporation of Nigeria and has announced roughly 600 road construction and repair projects across the country.[67] This includes the construction of a 35-kilometer expressway to connect the Apapa Port with the Lagos-Ibadan Expressway.[68] The Presidential Infrastructure Development Fund was also launched by the government and tasked with the construction and/or repair of the Lagos-Ibadan Expressway and the second Niger Bridge among others.[69]

Solutions

Establishing smart cities across the country will allow for improvements and redevelopment with smart solutions that will drive economic growth and improve the quality of life.

Smart solutions can ensure the proper categorization and efficient use of land allowing for open spaces, sustainable buildings, and climate change resilient infrastructure. AI technologies such as 3D modeling and modular construction can also help reduce the cost of housing construction and provide cheaper housing for urban dwellers.

The deployment of smart utility meters can help resolve issues of leakages, inefficient or wrong billing, ineffective allocation of resources and high costs of administration.

Private power distribution companies and public water corporations continue to be loss generating despite years of reform due to low billing recovery and high administrative costs. The use of AI to deliver services based on predictive service demand and other trend analysis as well as the auto-

65 Danne Institute for Research. Connectivity and Productivity in Lagos Megacity (2021)

66 WHO Africa. Fifth United Nations Global Road Safety Week (2019). https://www.afro.who.int/news/fifth-united-nations-global-road-safety-week-nigerian-government-re-commits-road-safety#:~:text=Every%20year%2C%20over%2039%2C000%20Nigerians,100%2C000%20deaths%20stood%20at%2021.4.

67 African Business. Nigeria Invests Billions in New Infrastructure Drive (2021). https://african.business/2021/04/technology-information/nigeria-invests-billions-in-new-infrastructure-drive/

68 Ibid

69 Ibid

mation of administrative and management services will contribute to the profitability of utilities companies.

AI technology can assist in the resolution of the congestion and safety issues associated with mobility and transport in Nigeria.
Solutions include the collection of traffic pattern data to provide real-time travel advisory services and provide efficient traffic flow management. Sustainable public transportation such as smart buses can also be established with digital scheduling systems and predictive traffic management, which can help mitigate congestion and overcrowding on roads. FLIR Systems recently developed AI-enabled traffic cameras to optimize traffic flow on roads and intersections.[70]

AI-based intelligent traffic control systems with signalized pedestrian crossings, lane monitoring, and accident heat maps can help reduce the occurrence and severity of accidents.

Power and Energy (SDG 7)

While electricity access has improved to over 60% of the population, electricity penetration in rural areas remains poor with only 30% of rural areas having access to electricity, compared to over 90% of urban areas.[71] As a major crude oil producer, most of the electricity capacity in Nigeria is generated from fossil fuels with less than 20% generated from hydroelectric plants.[72] Electricity generation remains low, and the energy sector remains underdeveloped due to challenges such as:

- Lack of adequate energy generation capacity leading to insufficient supply of power.[73]

- Inefficient transmission and distribution infrastructure that result in leakages, increased CO2 emissions, and reduced investment opportunities.[74]

- High incidence of informal or unofficial connections to power grids across Nigeria, which result in loss of revenue for power companies, inaccurate assessment of power use, and higher costs for consumers

70 Teledyne Flir. FLIR Systems announces artificial intelligence traffic cameras for predictive traffic management (2020). https://www.flir.com/news-center/public-safety/flir-systems-announces-artificial-intelligence-traffic-cameras-for-predictive-traffic-management/

71 CIA Factbook – Nigeria (2021). https://www.cia.gov/the-world-factbook/countries/nigeria/

72 Ibid

73 Federal Republic of Nigeria. Power Sector Recovery Programme: 2017-2021 (2018)

74 Ibid

formally connected to the grid.[75]

Solutions

Establish AI-managed smart grids supported by measurement units that monitor energy use in real time and can respond to demand fluctuations to efficiently transmit electricity and provide undisrupted power supply to consumers.

Real-time measurement of energy demand and supply allows for better grid management and improves reliability, security and efficiency of energy transmission and distribution.[76]

Encourage the collection, storage, and analysis of energy demand and consumption data via smart meters and sensors for energy forecasting, predictive maintenance, and quality assurance purposes.

The use of drones and other remote sensor technologies can also provide infrastructure monitoring services to ensure that energy infrastructure such as transmission wires are monitored for fault, decay or wear and tear, and to determine repair or replacement needs.[77]

Enable the adoption of smart infrastructure, including consumer energy management tools (e.g., smart meters) that allow consumers monitor their energy consumption and respond in real time to price fluctuations.

These smart devices provide the opportunity to optimize energy consumption and increase cost efficiency for consumers. It can also empower consumers when choosing energy providers and services to make choices that are best suited to their individual or household consumption patterns.[78]

75 Center for Public Policy Alternatives. Mitigating Electricity Theft in Nigeria (2018). http://cpparesearch.org/nu-en-pl/mitigating-electricity-theft-nigeria/

76 Makala, B. & Bakovic, T. Artificial Intelligence in the Power Sector (2020)

77 Ibid

78 Ibid

Key Challenges to AI Adoption in Nigeria

As set out above, AI technology has the potential to transform key economic and social sectors in Nigeria. However, there are general challenges that prevent the effective adoption and deployment of AI at scale. These include:

The Lack of a Data Ecosystem

Data collection and digital storage in Nigeria remains poor despite the explosion of tech startups in the country. Cloud computing uptake for instance remains low due to cost barriers, security, and other infrastructure concerns.[79] At present, there is only one local data storage provider, Galaxy Backbone who provides cloud services to the government which meet localization requirements.[80] Private sector actors opt for international service providers such as Amazon Web Services or Azure.[81] Cloud computing remains hampered by poor internet service provision, unreliable power supply and the absence of a regulatory framework.[82]

Low Broadband Penetration

Nigeria is one of the largest telecommunications markets in Africa with high mobile phone penetration. Almost 90% of the population now have coverage for voice services and a majority of mobile phone subscribers are also connected to internet services.[83] The majority of internet services are however provided on 2G and 3G networks with 4G coverage available to less than 40% of the population.[84] In addition, download speeds in Nigeria are uncompetitive on speed and cost when compared to contemporaries. Broadband penetration is low, with approximately 65,000 fixed broadband subscriptions in the country in 2018.[85] Broadband costs are also expensive with Nigeria ranking 141st of 182 countries in respect of fixed broad-

79 OC&C Strategy Consultants. Tech Entrepreneurship Ecosystem in Nigeria (2018) https://www.occstrategy.com/media/1307/tech-eship-in-nigeria.pdf

80 OC&C Strategy Consultants. Tech Entrepreneurship Ecosystem in Nigeria (2018). https://www.occstrategy.com/media/1307/tech-eship-in-nigeria.pdf

81 Nnadozie, C. "The Challenges of Cloud Computing Adoption in Nigeria", World Academy of Science, Engineering and Technology International Journal of Computer and Information Engineering Vol:10, No:11, 2016

82 Ibid, 77

83 Nigerian National Broadband Plan 2020 – 2025. https://www.ncc.gov.ng/accessible/documents/880-nigerian-national-broadband-plan-2020-2025/file

84 The Guardian. Subscribers consume 125,149.86TB of data as 4G coverage hits 37% (2020). https://guardian.ng/technology/subscribers-consume-125149-86tb-of-data-as-4g-coverage-hits-37/#:~:text=5G%20Mobile%20Technology%E2%80%A6-,Fourth%2DGeneration%20(4G)%20mobile%20network%20coverage%20in%20Nigeria%20currently,succeeding%203G%2C%20and%20preceding%205G.

85 World Bank Data. Fixed Broadband Subscriptions. https://data.worldbank.org/indicator/IT.NET.BBND?locations=NG

band costs as a percentage of national income.[86] The average monthly cost for basic broadband in Nigeria amounts to more than half the national minimum wage. Internet speed is also poor at 3.9 megabits per second, far below the global minimum standard.[87]

Low Literacy Rates

Primary education enrolment is relatively high in Nigeria with a gross enrolment ratio of 87% in 2018.[88] This ratio falls rapidly by the time children reach secondary school age with a gross enrolment rate of 43% for secondary education and 10% for tertiary education.[89] The average age of students dropping out is nine years for men and eight years for women. The literacy rate in Nigeria has improved over the decades with 62% of the population over the age of 15 now able to read and write.[90] However, this rate varies widely between regions and only about 52% of women nationally are literate.[91] In addition, public spending on education is limited at a mere 5.6% of GDP in 2020, resulting in a poor public education system with poor learning outcomes.[92]

Reports show that more than half of students who take the secondary school leaving certificate examinations typically fail five or more subjects.[93] These poor learning outcomes are driven by the lack of adequate multigrade classrooms, leading to overcrowding and large variations in knowledge and abilities. The teaching culture in Nigeria also remains highly rote-based with minimal interaction or customization. The curriculum taught at secondary and tertiary level is outdated and does not provide students with the skills demanded by employers in the job market.[94] Universities are poorly equipped and generally do not support innovation or entrepreneurial skills.[95]

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86 OC&C Strategy Consultants. Tech Entrepreneurship Ecosystem in Nigeria (2018). https://www.occstrategy.com/media/1307/tech-eship-in-nigeria.pdf

87 Ibid

88 World Bank Data. Primary School Enrollment. https://data.worldbank.org/indicator/SE.PRM.ENRR?locations=NG

89 World Bank Data. School Enrollment. https://data.worldbank.org/indicator/SE.SEC.ENRR?locations=NG

90 World Bank Data. Literacy Rate. https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=NG

91 World Bank Data. Literacy Rate, Adult Female – Nigeria. https://data.worldbank.org/indicator/SE.ADT.LITR.FE.ZS?locations=NG

92 World Bank Data. Government Expenditure on Education. https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS

93 The Guardian. Poor education and Nigeria's future (2016). https://guardian.ng/opinion/poor-education-and-nigerias-future/

94 OC&C Strategy Consultants. Tech Entrepreneurship Ecosystem in Nigeria (2018). https://www.occstrategy.com/media/1307/tech-eship-in-nigeria.pdf

95 Ibid

Absence of AI Research Capacity

There is generally a dearth of a culture of Research and Development in government and academia. Expenditure on R&D is miniscule – with government R&D spending estimated at less than 0.5% of GDP and private sector spending estimated at 0.1% of GDP.[96] There is also an absence of collaboration between the private sector and academic research institutes that generates research output that can be commodified and brought to market. The World Economic Forum Competitiveness Index ranked Nigeria 133rd of 137 countries in terms of university-industry collaboration in R&D. [97]

Lack of a National Identification System

The National Identity Management Commission noted in 2020 that over 100 million Nigerians currently have no form of identification.[98] This is despite efforts to establish a national identity program whereby every citizen is granted an identification card, which contains biometric information, a national identification number, as well as other personal information. The national identity program has so far seen a relatively low take-up with only about 66 million Nigerians registered as of November 2021.[99]

Solutions

Extend the broadband network outside of Lagos by allowing the deployment of fiber optic cables across the country.

To support this, land tenure rights and licensing requirements should be relaxed to reduce the cost to companies.

Collaborate with private sector actors such as tech startups, cloud computing providers, and finance institutions to accelerate the digital transformation and broadband penetration in the country.

Microsoft recently announced its intention to extend its Airband Initiative to Nigeria, which seeks to improve internet penetration in underserved communities by tapping into unused TV white space broadcasting frequencies. [100]Other partnerships like this should be pursued and implemented by the government.

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96 Ibid

97 World Economic Forum, Executive Opinion Survey, Global Competitiveness Report 2018

98 Olowogboyega, O. Getting a national ID card takes up to 4 years in Nigeria: going digital will not solve the problem (2020). https://techcabal.com/2020/08/20/national-id-card/

99 National Identity Management Commission. FG urges citizens and legal residents to enroll before the end of the year (2021). https://nimc.gov.ng/fg-urges-citizens-and-legal-residents-to-enrol-before-the-end-of-the-year/

100 Microsoft News Center. Microsoft collaborates with the Nigerian government to accelerate digital transformation in the country (2021). https://news.microsoft.com/en-xm/2021/05/03/microsoft-collaborates-with-the-nigerian-government-to-accelerate-digital-transformation-in-the-country/

Establish national research laboratories with academic-industry partnership focused on addressing local challenges and building prototype solutions in key sectors that are ultimately deployed to the market.
Such laboratories should be associated with universities across the six geo-political zones in the country and provide key practical training to university students studying STEM degrees.

Encourage the adoption of technology in primary and secondary education.
Although fully personalized education technologies have not been found to have long-lasting impact on learning outcomes, supplementing curriculum delivery and providing administrative support with AI technologies such adaptive learning tools can assist teachers to deliver better targeted education content.

Establish ICT infrastructure in primary and secondary schools. Teachers would also have to be trained to software programs that customize and provide interactive experiences to students.
Familiarity with technologies from an early stage will increase digital literacy in Nigeria and provide young kids with an interest in STEM education.

Establish public-private sector collaborations to design and deliver work-based learning and training.
There are several private enterprises already providing STEM education in Nigeria including:

- Co-creation hub, which creates interactive content and uses digital labs to teach students science concepts.[101]
- Andela, which provides computer coding, software development training, and employment opportunities to young people.[102]

The government should intensify its efforts to register all citizens and provide them with a national identification card by moving away from a solely designated centers approach to deploying field workers to political wards, villages, and towns to encourage enrolment in the program.
The Nigerian government's efforts to create a national identification program has met with a significant amount of logistical and other challenges.[103] Registration occurs at various enrolment centers such as National Identification Management Commission offices, local government secretariats, other government agency offices (such as Inland Revenue Service of-

101 https://cchubnigeria.com

102 https://andela.com

103 Nigerian Tribune. ID Card of Frustration? Why the National ID Project is not on a fast lane (2019). https://tribuneonlineng.com/id-card-of-frustration-why-the-national-id-project-is-not-on-a-fast-lane/

fices) and 'front-end' partner centers such as banks, telecommunications companies and other business addresses.[104] Although efforts to register all citizens improved in 2021, only fifty-four million Nigerians had been registered by May 2021.[105] Implementing mobile registration by deploying field workers to non-urban areas will help increase the rate of enrolment and ensure that most Nigerians are registered.

104 NIMC Enrolment Centers. https://nimc.gov.ng/nimc-enrolment-centres/

105 Thales Group. Nigerian National ID Program: An Ambitious Initiative (2021). https://www.thalesgroup.com/en/markets/digital-identity-and-security/government/customer-cases/nigeria-eid

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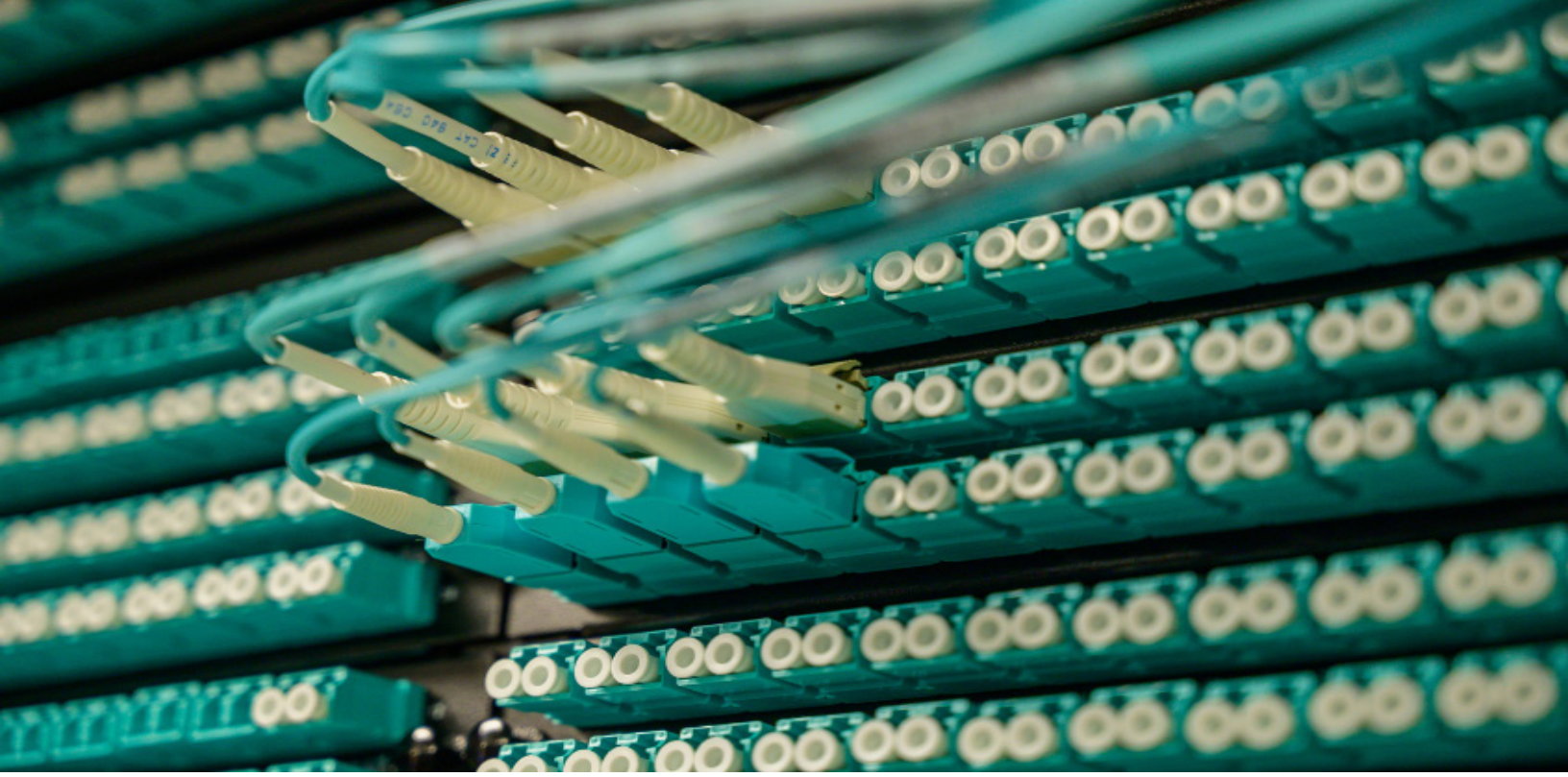
ETHICAL AND GOVERNANCE FRAMEWORK



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ETHICAL AND GOVERNANCE FRAMEWORK

Along with the potential benefits of AI technology, there are also potential harms that can be done deliberately or inadvertently. AI systems can for instance, violate the right to privacy and freedom of expression, freedom of movement or assembly or lead to discrimination against, or exclusion of marginalized individuals and communities and the undermining of democracy and democratic processes.[106] In addition, systems designed for beneficial purposes like electronic health data management, public health monitoring, or crop and land management can be coopted for large-scale surveillance and repression of certain communities such as LGBTQ+ groups, agitating ethnic groups or protesting activists due to integrated data sharing practices between different government agencies and private companies or non-secure data management systems.[107]

106 Feldstein, S. How artificial intelligence could threaten democracy (2019). https://theconversation.com/how-artificial-intelligence-systems-could-threaten-democracy-109698

107 Feldstein, S. We Need to Get Smart About How Governments Use AI (2019). https://carnegieendowment.org/2019/01/22/we-need-to-get-smart-about-how-governments-use-ai-pub-78179

It is therefore important that appropriate structures be put in place to disincentivize unethical conduct, inherent biases and discrimination, and guarantee the security of the ecosystem as well as the protection of vulnerable groups.

The ethical framework should have a human-centric approach and be based on the fundamental human rights enshrined in the constitution and the African Charter on Human and People's Rights.[108] A strong legal framework founded on the rule of law is also important to successfully operationalize the principles and guidelines contained in the ethical framework. The principles that form the basis of human rights laws can help ensure that AI systems deployed are a force of good not harm in society.

Fundamental Rights

The African Charter on Human and People's Rights recognized that civil and political fundamental rights could not be dissociated from civil and political rights and considered one to be required for enjoyment of the other. [109]It also noted the historical traditions and values of African states should be taken into account. Important rights to consider in the development of a framework for an AI ecosystem include:

Human Dignity: There is recognition that individuals possess a dignity inherent in their humanity which must be respected.

Community Rights to Existence and Self-Determination: In particular, peoples are granted the freedom to determine their economic and social development. States are also enjoined to provide assistance against all forms of political, cultural, and economic foreign domination.

Economic Rights: Individuals are guaranteed the right to work under equitable conditions with equal pay and are protected from discrimination.

Personal Freedoms and Liberty: Individuals are generally granted the right to personal liberty and freedom to associate and participate in society.

108 Adopted 27 June 1981, OAU Doc. CAB/LEG/67/3 rev. 5, 21 I.L.M. 58 (1982), entered into force 21 October 1986

109 Ibid

Ethical Principles

Various institutions including academic institutions, multilateral organizations, private companies and government agencies or initiatives have all sought to develop ethical principles that will minimize the incidences of unintended negative consequences from the deployment of AI systems.[110]These existing ethical principles and codes have predominantly been based on Western values and vision.[111] Despite this, they offer a good starting point for the application of universal values of accountability, equality and non-discrimination but must be adapted to Nigeria's peculiar historical and social context in order to be fit for purpose.[112]

Transparency and Accountability

It is important to build a culture of transparency around AI research and development. The processes, capacities, purposes, and benefits of AI systems should be clearly communicated in simple terms to the public. In addition to transparency, AI systems should contain appropriate mechanisms for redress in the event of harmful consequences and provide avenues for explanations and appeals in the case of automated or algorithm-based decisions.

Non-Discrimination

Despite having over 250 ethnic groups existing in the country, the three largest ethnic groups make up about 65% of the population.[113] There are, therefore, a lot of small and marginalized groups in Nigeria. The deployment of AI systems across the globe have highlighted some inherent flaws and discriminatory impact due to systems relying on biased or flawed training data. For instance, researchers in the United States of America discovered that the use of algorithms led to inadvertent discrimination in consumer mortgage lending with Latinx and African American borrowers paying higher interest rates and higher rates of rejection.[114] Furthermore, evidence has shown that discriminatory outcomes do not require prior intent to discriminate or be biased.[115] It is important that equality and non-discrimination principles are established during the development and deployment of AI technologies.

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110 Kiemde, S. & Kora, A. Towards an Ethics of AI in Africa: Rule of Education. AI Ethics (2021)

111 Ibid

112 Gwagwa, A. Recommendations on the Inclusion of Sub-Saharan Africa in Global AI Ethics (2019)

113 University of Birmingham. CIFORB Country Profile – Nigeria. https://www.birmingham.ac.uk/Documents/college-artslaw/ptr/ciforb/resources/Nigeria.pdf

114 Bartlett, R et al. Consumer-Lending Discrimination in the FinTech Era (2019)

115 Berkeley Haas Center for Equity, Gender and Leadership. Mitigating Bias in Artificial Intelligence: An Equity Fluent Leadership Playbook (2020)

Human-Centric and Locally Relevant Approach

Taking a human-centric approach requires AI technology to have a social orientation, respect human autonomy, and provide the space for human decision making and choice. The systems developed should aim to "augment, complement and empower human cognitive, social and cultural skills."[116] It is also important to be aware of, and factor in local and historical context in the development and deployment of AI. Gender and tribal divisions and conflicts exist in many parts of Nigeria and often influence official policy. The "federal character" representation in federal civil service for instance, is a policy design to ensure broader representation of tribal and ethics groups in the country. Conflicts in various parts of the country (e.g., farmer-pastoralist conflicts) can often devolve along tribal lines. Issues of exclusion or disempowerment of women are more severe in certain regions than in others. As such, it is important that AI systems are developed and deployed in ways that breach the gender and regional gaps as much as possible. For instance, the prioritization of digital literacy for women can contribute to empowering women to engage with AI tools or solutions available in sectors such as agriculture where there has historically been little room for female participation in decision-making[117] or healthcare where it has been shown that female involvement in health-related decision-making and employment improves the likelihood of maternal health care use.[118] All these local issues must be considered in order to build AI solutions that are equitably beneficial to citizens, and more importantly, to avoid exacerbating issues of social conflict, bias, and fragmentation.

116 High-Level Expert Group on AI. Ethics Guidelines for Trustworthy AI (2019)

117 Anderson, J. National Survey and Segmentation of Smallholder Households in Nigeria (2017)

118 Fawole, O. I., & Adeoye, I. A. (2015). Women's status within the household as a determinant of maternal health care use in Nigeria. African health sciences, 15(1), 217–225. https://doi.org/10.4314/ahs.v15i1.28

Data Ethics

For AI solutions to be truly effective, they must be based on accurate and reliable data and statistics. Therefore, an effective AI ecosystem requires the creation of an architecture that allows the acquisition, cleaning, processing, use, storage, and distribution of data across the public and private sectors. Data architecture should be supported by clear ethical guidelines to encourage public trust and participation. In particular, industry participants should ensure that personal data is automatically protected within AI systems by designing privacy as the default setting (known as privacy by design)[119] with a proactive approach to preventing the occurrence of data breaches.[120] Personal data should also be secured throughout its entire lifecycle from collection to destruction.

The collection of increasing amounts of personal and identifiable data such as biometric data, has raised the stakes of privacy concerns. The rise in predictive analysis also increases the risk of data collected and analyzed being used for surveillance purposes. In response, the National Information Technology Development Agency issued the Nigeria Data Protection Regulation in 2019 which requires the collection and processing of personal data to be "adequate, accurate and without prejudice to the dignity of human person."[121] The regulation also requires anyone involved in the processing or control of data to develop security measures to protect personal data such as setting up firewalls, employing data encryption technologies, and restricting access to authorized users.[122] There has also been a proposed Data Protection Bill, which seeks to protect data such as banking, health and academic records; personal or biometric data revealing ethnic origin, political affiliation or religious beliefs and trade union membership. [123]Respect for privacy is fundamental to ensure that people feel free to enjoy their civil and political rights of expression and association and its protection requires the existence of technical data protection systems and protocols that ensures the integrity of data throughout the lifecycle of collection, processing, storage and destruction. At the same time, it is important to ensure that the right balance is struck between competing priorities. For instance, the right to privacy needs to be balanced with the right to be seen, particularly for communities and groups that have been mostly invisible or unrepresented in data especially in the context of social services delivery.

119 Privacy by design requires privacy assurance to be organizations' default mode of operation to ensure personal control over personal data.

120 Covoukian, A. Privacy by Design, The Seven Foundational Principles (2011)

121 Clause 2.1(b) Nigeria Data Protection Regulation (2019)

122 Clause 2.6 Nigeria Data Protection Regulation (2019)

123 Data Protection Bill 2020. https://www.ncc.gov.ng/documents/911-data-protection-bill-draft-2020/file

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RECOMMENDATIONS

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RECOMMENDATIONS

Regulators and policymakers, particularly in priority sectors such as agriculture, health, and education, should be provided training in understanding how AI works. Private sector collaboration and cooperation with regulators should also be encouraged through the creation of regulatory sandboxes. Regulatory sandboxes provide the opportunity for new technologies and applications to be designed, developed, deployed, and tested in a limited, monitored environment before full deployment to the general public.[124] Testing new technologies on a limited basis allows regulators, companies and other stakeholders better understand how such technologies will operate in practice, identify risks or harms that may occasion the deployment and create effective regulations or guidance. However, regulatory sandboxes are limited due to the size of the samples involved and as such, insights derived should be considered carefully before being scaled to the larger society.[125]

AI technologies that are built for public use should be subject to human rights impact assessments ("HRIAs").[126]

124 Article 54 of the European Union Artificial Intelligence Act states that sandboxes will 'provide a controlled environment that facilitates the development, testing and validation of innovative AI systems for a limited time'.

125 EIPA. Sandboxes for Responsible Artificial Intelligence (2021). https://www.eipa.eu/sandboxes-for-responsible-artificial-intelligence/

126 Human rights impact assessment is the process for identifying, understanding, assessing, and addressing the adverse effects of a business project or activity on the human rights enjoyment of impacted rights-holders (Danish Institute for Human Rights)

HRIAs should be benchmarked against relevant rights provided in Chapter IV of the Constitution of the Federal Republic of Nigeria (such as the right to privacy of citizens, their homes, correspondence and communication) [127]as well as the rights guaranteed by the African Charter on Human and Peoples' Rights.[128] They should also involve broad engagement with relevant stakeholders, including individuals and communities whose rights are to be protected, academic researchers and consumer advocates. HRIAs should also be conducted in a transparent manner and include an analysis of likelihood and severity of potential harms and impacts and clear mitigation or remedial actions.[129] This is to ensure that adequate due diligence is conducted for tools that are broadly applicable and affect the lives or livelihoods of a significant portion of the population.

AI application to personal data should not curtail people's rights or liberties. A data protection ombudsman should be created to assess claims made by individuals in respect of the collection, use or storage of their personal data. The ombudsman should sit as an independent entity under the auspices of proposed Data Protection Commission[130] and be empowered to mandate the compliance of corporations and government entities developing or using AI applications to its jurisdiction. Individuals should also have the right to access data collected on them and contest the processing of their data.

Corporations and government agencies that suffer a cybersecurity breach and lose consumer data should be required to disclose the occurrence of such breach in a timely fashion and submit to an audit of their security framework. Breaches that occur as a result of a failure to invest in adequate security frameworks should be liable for fines and other penalties.

Civil society (including researchers, journalists, activists) as well as affected communities should be empowered to query interventions and keep AI systems accountable.

127 Section 37, Chapter IV of the Constitution of the Federal Republic of Nigeria

128 African Charter on Human and Peoples' Rights. https://www.achpr.org/legalinstruments/detail?id=49

129 Danish Institute for Human Rights. Introduction to Human Rights Impact Assessment

130 Section 7, Data Protection Bill (2020)

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CONCLUSION

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CONCLUSION

It is apparent that the potential beneficial impacts of AI in Nigeria is high. There is, however, a lot of work to be done to ensure that the growth and prosperity that arises from this technology revolution is shared and enjoyed by the general population. Investments to establish an enabling environment is the key first step to ensuring that innovations can thrive, and the ecosystem can grow. While this investment may be costly in the first instance, it will yield significant benefits in the long term.

In addition, there are immediate opportunities for the development and adoption of AI technologies in various sectors that the government can take advantage of on its own accord or in collaboration with the private sector. However, it is important to ensure that public-private partnerships in this space do not merely socialize the risks and privatize the profits but are true partnerships between all involved.

It is also apparent that although the average Nigerian may not be able to afford or interact with advanced AI technology, AI-driven services will directly affect their livelihoods. Putting in place appropriate AI oversight and data privacy and security safeguards is critical to ensuring the benefits of this technological revolution are experienced by all.

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